Report on the International Seminar

STEM EDUCATION

in innovative out-of-the-classroom learning environments

October the 16th 2019 - Kromeriz, Czech Republic

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About 80 participants from schools, educational organizations, FabLabs, Universities and Universities Colleges took part in the International Artifex Seminar on STEM education in innovative out-of-the-classroom learning environments.

The central issues of the day

-How can ARTIFEX methodologies and assignments contribute to the process of STEM education in the context of innovative out-of-the-classroom learning environments such as FabLabs and Makerspaces?

-How does this kind of STEM education relate to the national curriculum? How confident do teachers feel?

-How to assess 21st Century skills such as entrepreneurship or creativity?

-What should be the role of FabLabs (or other out-of-the classroom learning environments) towards STEM education?

-How to motivate teachers? How to use ARTIFEX in their further learning practice?

-What is the way forward? How to integrate this kind of education in a broader policy on STEM education?

The outcomes of the seminar could have some implications for STEM education. Some of the conclusions will be integrated as part of the ARTIFEX e-book that will be published during spring 2020. The seminar was sponsored by the EU Erasmus+ program. Lead partner is the AGSO, Municipal Education for the City of Antwerp. National Partners are: Euroface Consulting s.r.o. (Czech Republic), H-Farm Education (Italy), Edubron – University of Antwerp (Belgium), Karlstad University (Sweden), Artevelde University College (Ghent), Ellinogermaniki Agogi s.a. (Greece), National Training Centre (Bulgaria).

The participants of the seminar were highly involved in the discussions and appreciated this highly, according to the short evaluation at the end. We all experienced that easy answers to the issues of the day are not so easy to give, given also the difference between countries as well regarding the national schools system as the way STEM education in general is widespread through the countries. Yet there were several themes that were experienced in the same way in the different countries. There was a general feeling that the attempt to find these answers made sense and was significant for the participants. At the end of the seminar the wish was expressed to be able to extend this type of European exchange on STEM practices in a context like ARTIFEX.

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Participants on ARTIFEX

> *"As a result of doing the workshops I changed the layout of my classroom.*
>
> *(Teacher Italy)*

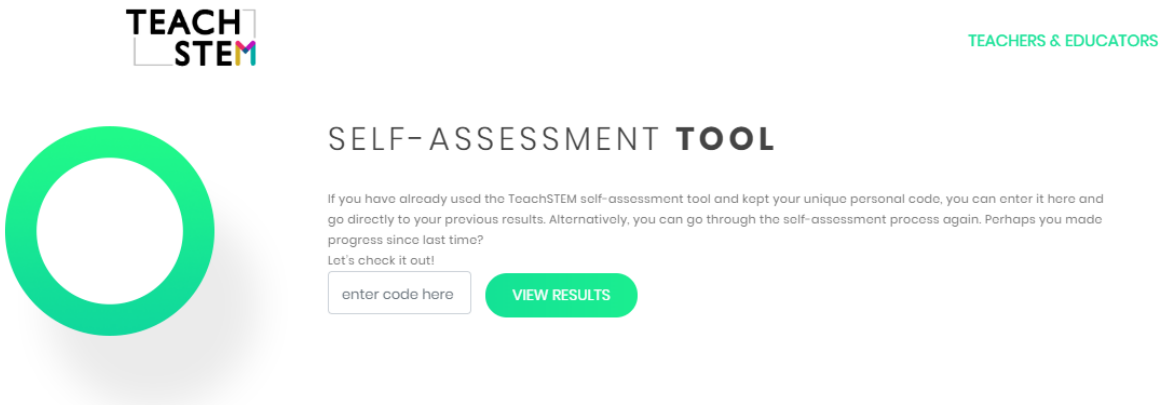
Some of the participants had previously taken part in an ARTIFEX session, for others it was the first introduction. For all participants is was the first acquaintance with the assessment tool.

Some people who already participated in an Artifex workshop expressed how important it was to work in small peer groups, not only doing the workshops but also having to be able to discuss some common interests. Many agreed that it had contributed to new insights in their own class situation.

Presentation of the online tool.

The online assessment tool was first presented before discussions started. Furthermore, the developed workshops were evaluated by the participants.

Participants were invited to visit http://www.teachstem.eu to discover their score.



What is this about?

Artifex wants to provide feedback to teachers regarding their competences to support their students' learning in informal learning environments.

The Big 7

We make a distinction between 7 competencies that support learning in fab labs and maker spaces:

1) problem solving

2) creativity

3) critical thinking

4) group work and collaboration

5) entrepreneurship

6) technology usage

7) teaching in informal learning environments

Through this assessment we generate insight into the score of the teacher on the above competences.

I have confidence in how to…

Teach students about problem-solving

strongly disagree disagree agree strongly agree

Use activities in teaching stimulating students' creativity

strongly disagree disagree agree strongly agree

Teach students about critical and analytical thinking

strongly disagree disagree agree strongly agree

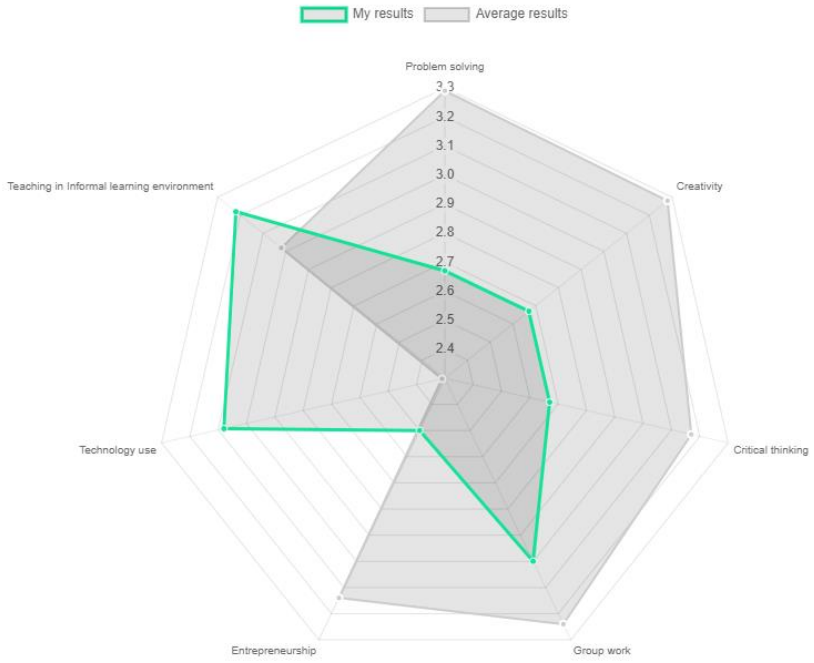
Use activities in which students work in groups

strongly disagree disagree agree strongly agree

Provide students with tasks that have no right answer

strongly disagree disagree agree strongly agree

Promote students' thinking when it is 'out of the box'



Scoring self-efficacy:	My results	Average results*
Problem solving	2.67	3.29
Creativity	2.67	3.28
Critical thinking	2.67	3.17
Group work	3.00	3.24
Entrepreneurship	2.50	3.14
Technology use	3.08	2.31
- of teacher	3.50	2.15
- stimulating students' use	2.88	2.40
Teaching in Informal learning environment	3.22	3.02

* Average results from 381 self-assessments

What's next?

The teacher can then choose two competencies in which he/she wants to improve him-/herself and then the website will propose a workshop with which teachers can strengthen themselves in the chosen competences and build up more self-confidence.

The workshops are all finished, but from the time of the conference, the web developers are still working to link the assessment to the workshops.

Evaluation

Most participants evaluated the assessment tool and workshops as useful and accurate. However some critical concerns were formulated. For a lot of participants the 21st Century skills remain too abstract. In the final design of the learning platform it would be desirable for these skills to be better described. What is meant by 'creativity'? What is for instance the difference in 'problem solving'? What do we understand under 'entrepreneurship' and so on.

Though the link with the workshops was clear for the participants, they formulated nevertheless the desirability of better linking the workshops and the assessment tool with each other in function of the teacher's personal development. Some teachers raised the question how to develop a school policy on STEM by using the learning platform?

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How confident do teachers feel?

"This kind of STEM education is 'a way of understanding' rather than a goal as such. Process is the most important part of it. (Teacher Sweden)

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Nearly all participants agreed that integrated STEM education is a new way of thinking. This applies to both the pupils/students and the teachers. Pupils have to act as designers and this, for many of them, is a new role since they are often familiar with the system of 'getting points', which is less consistent with the evaluation of the 21st Century skills. This is also a new approach for teachers, which is not always easy. '*It is difficult to teach an old dog new tricks'* as one of the teachers formulated it. The teacher has to take a role as coach. He is in the middle of everything, guiding the pupils/students through the process. Moreover a lot of teachers are subject-orientated and all of a sudden, must now have an eye for a multidisciplinary and integrated approach. This is not obvious, also because most national curricula usually only state this implicitly (see later).

A lot of teachers – but not all - don't feel so confident in handling the equipment of makerspaces or FabLabs such as 3Dprinters or lasercutters. Some participants suggested that some teachers have difficulty with the new technologies in general (e.g. IPad, smartphone, robotics) and therefore hesitate to apply it in their classroom practice. On the other hand, it was repeatedly stated that teachers should not know everything. And that a request for support is by no means a strange question. This could be one of the roles of regional STEM centers.

Reference was repeatedly made to the importance that a school has an overarching vision of integrated STEM education. If this is not present, it will be very difficult for the individual teacher to start a trajectory or he/she will feel alone with all the frustrations that this could entail. School management plays an important role here.

Introducing 21st Century skills in education

> *"Let a group of children experiment with daily life situation or let them try to solve problems from the daily practice of companies. The 21st skills will follow automatically."*
>
> *(Belgian teacher)*

The so-called 21st Century skills are prominently present in the ARTIFEX project. Reason enough to discuss this with the participants.

Although the 21st skills are prominent in many European or national policy texts, it remains an abstraction for many teachers once they have to be translated into a classroom practice. Easier said than done, a lot of teachers think. What is meant by 'entrepreneurship', 'creativity' or 'problem-solving'? Are these concepts different according to the context? How to assess them?

Concerning Artifex, we need to define more concretely what we understand regarding these competences.

Furthermore, a lot of teachers point out that these skills are usually considered important but – as said already - are not explicitly present in the curricula. Some teachers experience this as a problem, for others this applies to a lesser extent. There are differences between countries, as will be seen later in this report.

During one of the sessions an interesting question was discussed: Is problem solving the same as creativity? Both concepts have a lot in common but there are of course meaningful differences. Creativity in the strict sense has no rules. An artist is creative but does not need necessarily to have a solution. Engineers have to solve problems while product designers are more creative in the sense of creating. An engineer does not have to be "creative" per se but should be able to think about a problem "outside-of-the-box." You could say that this is a facet of creativity but not the whole picture of creativity. Or should we remember the words of Albert Einstein: *"We cannot solve our problems with the same thinking we used when we created them."*

In general for educators it is more difficult to assess 'creativity' than 'problem solving'.

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Differences between countries

> *"Let pupils as much as possible 'taste' the different subjects and let them choose definitely at the age of 15 years.*
>
> *(Teacher Trainer Greece)*

The conference offered the unique opportunity to compare ARTIFEX and his underlying ideas with the similarities and differences in European education systems.

We start with the two most striking similarities.

In most countries this kind of integrated education fits somewhere in the national curriculum, though most of the time it is not obligatory, nor it is explicitly present in the outcomes. In nearly every country it is rather present in an implicit way. Though there are differences between the European countries, there is actually room in every country. This means that the teacher has to be creative and especially that he or she will have to counter the perception that there is not enough time and flexibility in the curricula. Some teachers consider this as a real challenge, for others the threshold is too high and they are quickly discouraged. With a few exceptions (some pioneer countries) you can speak of a gap between what European policy texts indicate and the daily reality.

The second similarity has everything to do with making a connection between the different actors involved in STEM education in innovative out-of-the-classroom learning environments. All focus

groups mentioned this as important or as something to pursue. This has amongst others to do with something we already mentioned above, namely teachers sometimes feel not so confident about the subject. In addition, teachers feel the need to bring this type of education closer to the needs of society and therefore do not want to teach in a vacuum. It is hoped that cooperation between the business world and schools can offer the possibility of working more 'hands-on', starting from real problems and needs. Teachers are actively seeking support both materially and pedagogically. Some participants also mention that such a 'hub' offers the additional opportunity to bring together sponsors and schools.

There is a need for a (regional) model as will be described in the third part of the Artifex e-book.

Despite these similarities, there are also many differences among the countries of which there were participants present at the conference. There is a considerable difference regarding the accessibility of FabLabs or makerspaces in the different countries. In Sweden there are nearly no FabLabs but they do have some makerspaces spread across the country. In general there are long distances between the school and the makerspaces. In Belgium and the Netherlands you find a lot of FabLabs in most cities which are easily reachable by bike. In Denmark there is a strong link between schools and FabLabs (FabLab@school.dk) as a result of the roll out of a national STEM policy. As a result of this policy, a new curriculum is being developed, incorporating STEM (as integrated teaching) from the age of 6. In Czech Republic there are not so many FabLabs. In the region of Moravia (where the conference was held) there is only one FabLab in the City of Brno. Most FabLabs are private companies. They sometimes rent STEM materials or equipment to schools but this involves money which is not always so easy for schools. Same applies in Italy.

Not all countries stimulate out-of-the-classroom activities in the same way. In Bulgaria, for example, there are a lot of legal requirements before you can leave the school. There is a direct link in some countries with the policy or vision on integrated education (Greece, Bulgaria). Due to all these practical or regulatory problems, there are teachers that prefer to stay in the classroom.

There is also a difference in how the learning career is outlined and this too has an impact on integrated STEM education. This was mentioned a few times during the focus conversation In particular the age at which pupils have to choose their specialties and the flexibility to change afterwards. If things go wrong, this particularly has an influence. Belgium 12-14 y; Sweden; 16 y; Italy 14 y; Czech Republic 15 y; Greece 15 y. In Greece, once you have chosen your subjects (on the age of 15) it is very difficult to change. If they choose wrong, the students are stuck and get demotivated. A solution could be that they could taste more of different (science) subjects at a younger age.

How to motivate teachers?

> *"Show teachers that it is not as hard as it looks. You can do a lot of STEM with simple equipment like paper, spaghetti tower, marshmallow etc. (Teacher Sweden)*

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The conference was attended by very enthusiastic participants who were already convinced of the importance of this type of education. They did acknowledge that they probably belong to a minority and that the problem is how to involve the more passive majority. Everyone was convinced that the bar should not always be set so high. You can achieve a lot with simple materials. You especially have to boost the confidence of teachers. '*The fear of the unknown is the biggest problem'*, a Belgian teacher said. A Swedish teacher added '*good teachers already use a lot of 21st Century skills in their classroom activities, without being aware of it'*. The different workgroups gave several tips on how to convince colleagues. We list a few of them.

- Lead by example. Give teachers the possibility to visit different kind of Fablabs or makerspaces so that the fear of the unknown is removed. This could be part of a regional or national teacher program.
- It is important that teachers realize that they do not have to know everything or do have an answer to everything. E.g., not all teachers should be experts in the maintenance of equipment.

- As a teacher: be and feel as a kid. Don’t lose your sense of curiosity.
- Interesting example provided by Denmark and Sweden. Use Fablab/makerspaces on the road by using small buses. Let them go to the schools twice. The first time teachers and pupils can become acquainted with a Fablab or makerspace. They get an explanation about the possibilities. A few weeks later the van returns and the pupils can get started with their design and fabrication.
- Spread good examples (like they will be present in Artifex) via a network.
- Train the trainer (teacher) in a continuous way.
- Mentoring by an experienced teacher mentors and co-teaching helps. See to it that there are always minimum two teachers of the school responsible to roll out STEM education. If only one teacher is responsible, the chance of demotivation is greater
- All participants acknowledged the importance of kindergarten and primary education but it was recognized also as a problem in many countries. Teachers want to do it but just don’t know where to start. A special effort is needed to stimulate these teachers.

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What is the role of an educator in a FabLab or Makerspace?

> *"Take a FabLab out of its narrow technological agenda and put it in a broader teaching perspective.*
>
> *(*FabLab educator Denmark)

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The participants asked themselves what, from an educational perspective, is the main goal of a FabLab? Teach children how to work with 3D-printers etc.? Or motivate them to do science?

The answer was pretty unanimous. A FabLab is a place that contributes to help teachers overcome their fears and so create more confidence. It has to be more than a physical place for schools. It is a place where you can share materials and especially ideas and pedagogical approaches. A FabLab has to be a hub for sharing materials; for a community that is linked with Municipalities or (regional) education providers. It is a place where culture building is done and a culture of sharing is created. Teachers don't need to be FabLab specialist. They need to learn the possibilities that a FabLab offers and how they can integrate it in the curriculum.

In this educational context, a FabLab educator needs to have the faculties of a train-the-trainer. He or she has to enhance self-efficacy of teachers.

All this requires a number of skills from a FabLab employee.

Without wanting to give a comprehensive profile of a FabLab employee, the following characteristics were stated. He/she has to be able of:

- motivating the teachers;
- helping teachers during sessions in FabLab;
- guiding and coaching teachers/pupils/students during the process of designing;
- helping teachers to start a project (in school) that later can be finished in a FabLab;
- coaching teachers as well as their pupils/students;
- helping teachers to sort out the kind of activities they will do with the kids, adjusted to their level;
- making use of a kind of 'maker passport', including a clear start situation and a description of the process;
- seeing to it that teachers have an active role in the FabLab;
- providing tips and tricks for teaching pupils with disorders;
- offering teachers technical support.

Actually, as said by an Italian teacher, a FabLab has to offer a warm and open atmosphere. *"Mi casa es su casa".* My house is your house.

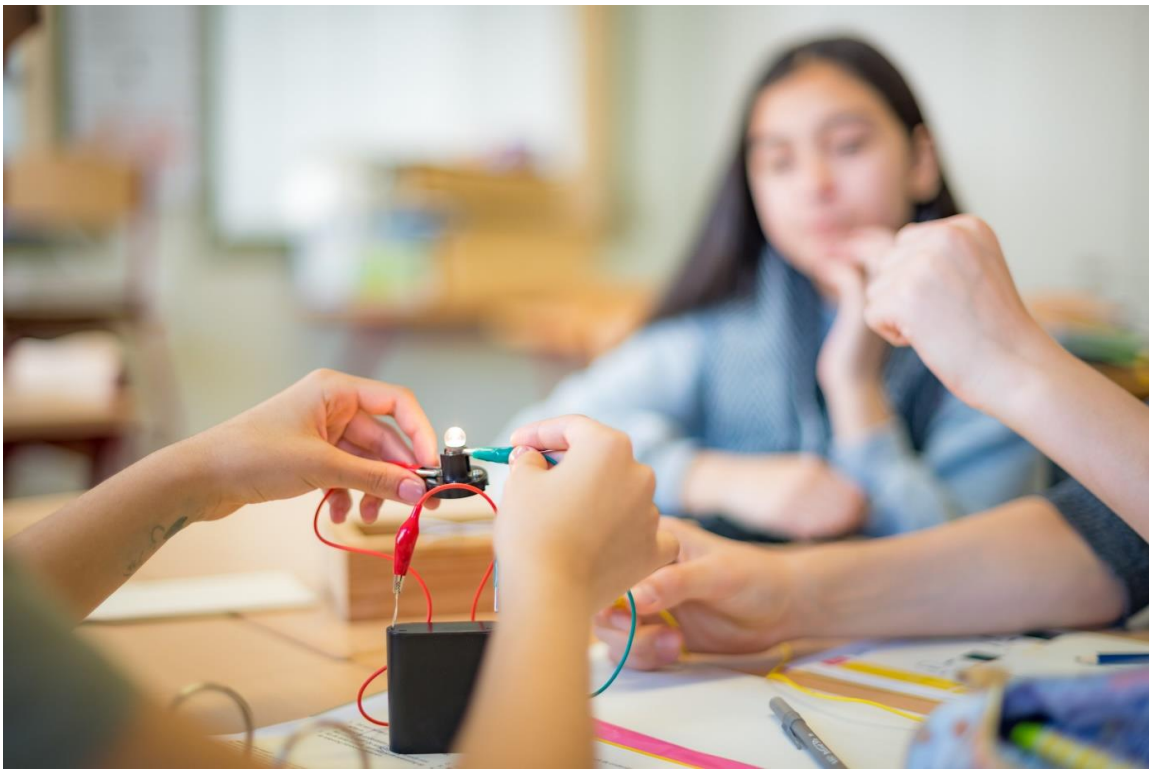
A video impression of the conference can be found on the following link

https://vimeo.com/378161523

The way forward

> *“By sharing experience, teachers feel more comfortable. They will see the fun of it!*
>
> (Czech teacher)

This topic led to a unified conclusion. Let us continue to work and share good practices and experiences in the future. How those networks should be set up depends on the context in the different countries but everyone agreed that this would help them move forward. The need for exchange of ideas is apparently very high. Some placed such networks in a regional context, others saw this nationally or even in an European context. For some participants FabLabs play an important role in the design of such educational networks. They work by definition in an “open source” environment and through them it must be possible to stimulate collaboration. “*It would be good if FabLabs enter into a collaborations within a regional context from which they jointly initiate wider networks”*, suggested a researcher affiliated with a University College. Alone you cannot do much, together you can achieve a lot.



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All in all, the need to create an European network around maker education that's in line with the needs of teachers, turned out to be very prominent present among the participants. Such a network could close the gap between the assumptions that Europe makes and the daily practice of schools. Some participants saw a role for teacher training here because they are better than anyone else capable of translating more abstract policy texts into daily practice.

You need to develop such networks concentrically, starting with regionally anchored collaborations and only then expanding to more national and European collaborations which can support schools better, among other things with the many questions which emerged from the group discussions which are described in this report.