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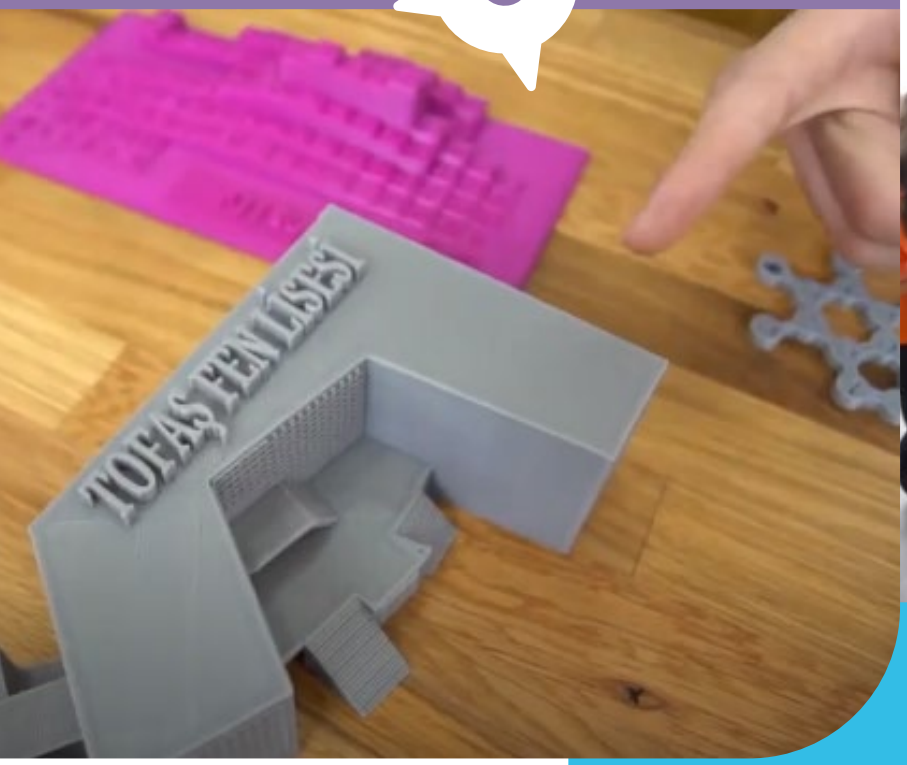
Makerspaces in schools

Practical guidelines for school leaders and teachers

Case Study

Tofaş Science High School,
Bursa, Turkey



European
Schoolnet

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Practical guidelines for school leaders and teachers

Case Study:

Tofaş Science High School, Bursa, Turkey

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Tofaş Science High School, Bursa, Turkey (cover, pp. 4, 5, 8, 10)

Introduction

Makerspaces, which are designed for hands-on, collaborative, creative work, are a fairly recent addition to some schools in Europe and worldwide. Students in school makerspaces can work with materials such as paper, cardboard, wood, metal, plastics, clay, fabrics, electronic components, microcontrollers, construction kits or programmable robots to create many different objects, and complete many different projects, using a variety of tools and machinery.

This case study is one of 15 developed from interviews with school leaders, teachers and other staff who have set up makerspaces in their schools. The schools are located in nine countries i.e. Austria, Belgium, The Czech Republic, Ireland, Italy, Luxembourg, Portugal, Switzerland, and Turkey.

The interviews were part of research carried out by European Schoolnet's Interactive Classroom Working Group and the schools' experiences, the lessons they have learned and the good practice they have developed, have informed the development of a publication "Guidelines on Makerspaces in Schools".

Find the full report and other case studies here: *fcl.eun.org/guidelines*

The national context

In Turkey, "Education Vision 2023" set a specific goal of creating "design and skill labs" in all schools in the period 2018 to 2023. Pedagogical guidelines for teachers are expected to be published to ensure that these goals are achieved. Two groups of labs are envisioned including:

- Labs located in school buildings with activities led by the teachers.
- Labs located in a separate building and coordinated by an independent manager.

Almost every city in Turkey has a STEM Class; makerclasses are a national policy priority and the General Directorate for Secondary Education has funding for some pilots in secondary schools. At local level, schools themselves create and build their labs by searching for funding from sponsors, local development agencies, or The Scientific and Technological Research Council of Turkey (TÜBİTAK).

The school

Tofaş Science High School is an upper secondary school located in the centre of Bursa, a large city in northwest Turkey. Bursa is the home of the Tofas vehicle manufacturing plant jointly owned by Fiat Chrysler Automobiles and Turkish company Koç Holding which makes Fiat, Citroen, Peugeot, Opel and Vauxhall vehicles.

467 students attend the the school, which has 34 teachers and 3 administrative staff. The Principal, Süleyman Şeker, describes the socioeconomic status of the students as *"around average"* and the special focus of the school is the science high school curriculum. The school has good connections with nearby schools and secondary school students, in particular, often visit Tofaş sometimes making use of the makerspace.

Tofaş school has strong connections with, and agreements with, Tofaş Academy and Tofaş R&D. Thanks to these agreements, the engineers in the Tofaş company work closely with the school's students and help them to get proper training. The principal was very pleased that *"when there was an issue with a vehicle last year the engineers worked with 20 of our students to develop an innovative electrical tool to overcome this issue and the students presented the project to the Tofaş Director of R&D in English."*

The school also has a relationship with Uludağ University that allows school students to receive some

training in the university Faculty of Engineering and Faculty of Science and Letters, usually related to students' projects.

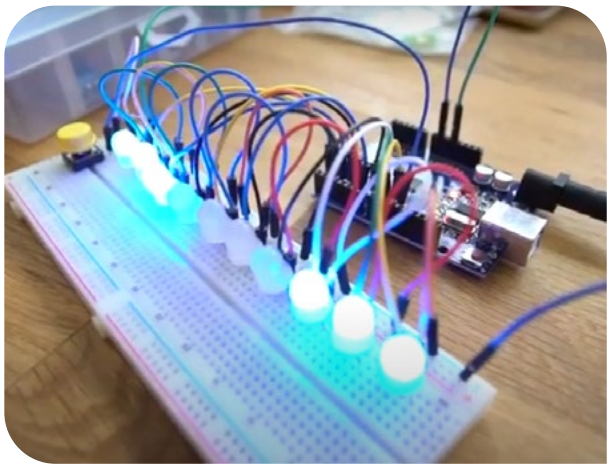
The school has a history of innovation and supports students' projects by paying for the books and materials they need to produce products. Project examples cited by the principal include *"we have created an elevator card in this classroom. We didn't pay anything to a private company and created the card at the minimum cost. We also have a computer game developed by our students"*.

Motivation and aims

The motivation for the makerspace was a desire to increase the career paths for students and to direct individual students towards the best careers for them.

A very high percentage of the school's students are encouraged by their parents to study for a career in medicine but as Kadir Hançer, the makerspace coordinator, observes *"many students don't know what engineering is because they have never had any experience of engineering. Now, many students who have interacted with engineering tools and concepts have realised that engineering is the right choice for them"*.

The original idea came from the school's physics teacher and the informatics teachers undertook the project. They contacted the Tofaş company and obtained funding and support to create the makerspace. Tofaş, have been happy to support students who would like to study engineering and could become future employees.



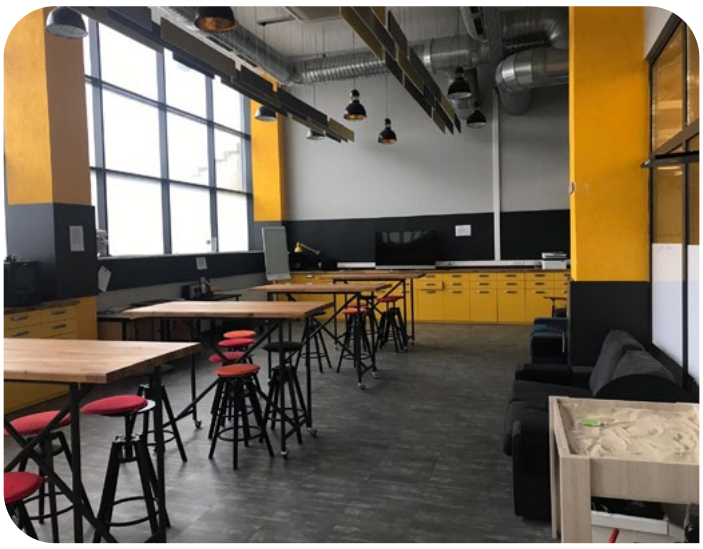
The makerspace is consistent with, and supports, the school's educational goals as both aim to prepare students for higher education institutions or employment.

The implementation timeline

The makerspace coordinator, Kadir Hançer, recalls that it was in 2014 that *"we decided to do some robotics projects with the students and there were 10-15 eager students with whom we worked in our free time but we always wanted a designated space for our project with seats and desks where we could comfortably work with our equipment"*.

In 2016, Özcan, the Physics teacher, suggested trying to create a dedicated innovation space or classroom. The teachers involved with the robotics projects, decided to present the idea to the Tofaş company and to ask if they could provide such a space for the school. To the teachers' surprise, Tofaş was very willing to build the space.

Initially the company did not fully understand what the school was asking for and they suggested that they could provide gaming consoles for the students. The teachers explained that they were happy for the students to play games to relax and that there could be a space for making tea and coffee where they could do this. However, most of the space should be dedicated to students working on innovative projects in which they could create things themselves.



Overall it took a year to plan, design, manage the whole process and complete the classroom. The task which took the longest time was obtaining formal approval from Tofaş to sponsor and finance the project. Then a plan was developed and, following approval from Tofaş, interior designers started to work on the classroom. When the design was completed it took the project team one month to draw up a list of required equipment and materials.

The makerspace was completed in December 2017.

Building and equipping the makerspace

The space chosen for the makerspace had been the school library. Within this space a 100 square metre area was divided off for the makerspace and the new library has been integrated with the makerspace. There is no external entrance to the makerspace which is accessed through the main entrance of the school.

Initially the teachers decided what equipment would be needed, a list was submitted to Tofaş Academy and they provided what was requested. After this, when additional materials are needed that Tofaş does not agree to provide, the school budget is used to cover the cost.

Equipment and technology used

Furniture in the makerspace includes four mobile desks, that can be used separately by different groups or brought together to form one large work top, and drawers in which students can safely store their work in progress. There is a large screen TV, used to display training videos, which is more convenient than using a computer and projector in the makerspace. There are also tea and coffee makers in an area where students can have a break.

Technical equipment includes:

Ardunio uno	PNP transistors	3D printer
Ardunio nano	Resistors	Fusion 360 CAD/CAM/CAE software
Ardunio mega	Light Emitting Diodes (LEDs)	Autodesk 3ds max modeling and
Sensor kits	Diodes	animation software
Brushed DC motor	Buttons	Two desktop computers
Servo motor	Jumper cable	One design computer
Step motor	Light Dependent Resistors	Two laptops
Motor driver cards	Potentiometers	Four tablets
Wheel sets	Power source	One printer
Breadboard	Soldering iron set	Various tools
NPN transistors	Hand tools	3D printer

Unlike many other schools, Tofaş Science High School does not use block coding but prefers students to write computer code directly. Examples of block coding products include Scratch, Snap! or Blockly, which have become popular in schools as a starting point for learning about coding. Block coding uses a series of colorful shapes that snap together on-screen. Each block contains a bit of code and allows a program to run.

Health and Safety

Kadir explains that "We have a week long orientation training for 9th grade students to teach them about occupational safety. In this time the coordinator introduces the equipment and explains how it is used. We have safety equipment, such as goggles, gloves, fire extinguisher and working overalls, and we teach students how and when to use these. We don't have heavy equipment in the makespace and we don't have many sharp objects other than snap off knives and screwdrivers".

Cost and funding

The Tofaş company was the sole funder for the makerspace and they say the total cost was 250 thousand Turkish Liras (approximately 39,000 euros). The school did not receive any money from Tofaş; they gave the company a list of required materials and Tofaş provided these.

Sustainability

The Tofaş company are not willing to provide regular payments to support the makerspace. However, they will often agree to provide materials the school requests, or to fund specific projects proposed by the students. In future this system will continue to operate and Kadir believes students benefit from participating in a process of submitting project proposals which may or may not succeed as this is similar to the way projects are funded in real life.

In the current year the school did not succeed in obtaining much help from Tofaş. The school budget supported the running of the makerspace, costing approximately 10,000 to 15.000 Lira (1,600 to 2,350 euro).

Organisation and management

The is no regular timetable for the makerspace which is used:

by students outside of school hours including in the morning before lessons start, at lunchtime and between 4.30pm and 11pm

by teachers during lesson times, with teachers booking the space by sticking a label on the door stating the days and times when their classes will take place.

There are 30 students in each class and up to 40 students can use the makerspace at the same time. The usual arrangement is that boys sit on the floor and girls use the seats.

Use of the makerspace outside of school hours is not compulsory and the Principal notes that "*students who come to the makerspace are the ones who want to make use of it, which determines the high achievement level" and* Kadir adds *"We used to work there in small breaks as well. However, it is now so popular that students don't want to leave the makerspace to go to their classes".*

The management and running of the makerspace is the responsibility of the makerspace coordinator, Kadir, who is also an ICT teacher. There is also an 11th grade student who has some responsibility for the space. As this student stays in the school's dormitory it is easy for him to conduct regular checks. If there are any problems, he reports these to Kadir.

The makerspace is open to students (sometimes including students from other schools), teachers, parents and engineers from Tofaş and the makerspace coordinator and the coordinating student are responsible for the outside visitors.

For every group that use the makerspace one student is designated as the coordinator. This student looks after the key and is responsible for ensuring the space is left clean and tidy when the group leaves. Some students, especially the younger ones, can be a bit messy with materials and this system encourages them to take responsibility for using the space appropriately.

An aim of the school is for students *to "create an ecosystem among themselves"*. Kadir explains *"we give great importance to peer learning; upper grade students train lower grade students and teachers act as a guide. Therefore, when teachers move to different schools, it is not as important as it is in traditional teaching. Thus students work in a more sustainable way. We have been trialling this for more than 18 months and we plan to work like this completely in four to five years"*.

Networking beyond the school

The school collaborates with parents and has set up a Scientific Advisory Committee of parents who work in academic fields. Consideration and approval by the committee is sought before R&D studies or other projects are proposed to the Tofaş company. Also Kadir and the IT teachers deliver training for parents on demand.

The school do not have contact with any external maker associations or organisations. They have tried to collaborate with other makerspaces but Kadir has found that "people *aren't open to collaborate because they fear others' stealing their ideas or projects"*. The school has helped some other institutions by providing them with initial training. They have also helped to establish makerspaces in six public schools.

Training and support for teachers

The school organises training sessions for teachers regarding the use of the makerspace. This training is not compulsory. Some teachers are not interested but other are interested and eager to learn. The school does not have a programme for developing all the required skills for teachers using makerspaces, nor is it similar to the in-service training centres that deliver training at regular intervals. Training is organised when requested by teachers or parents.

Last year 3D design training was provided for approximately 140 adults and teachers from the school delivered basic electronics and coding training to 36 adults. In the current year there will be courses in basic electronics and coding.

Courses for teachers are delivered in classrooms but, as part of their training, teachers are asked to assign project work their students can complete in the makerspace e.g. modelling cell division with a 3D printer, gamifying calculating the circumference of a triangle, creating a robot or creating a circuit.

Teachers have the opportunity to collaborate with other teachers and all work created is shared during branch and board meetings. What Kadir wants to achieve is giving teachers more knowledge so that they can understand and help to organise the next steps for the makerspace. Some are already very willing to do this.

Kadir wishes to continually improve his own knowledge, so he participates in or organises training courses as much as he can. He gives examples, saying *"I received training on 3ds Max, which helped me to deliver training for the game developing courses"* and *"I will attend to a week-long camp of the Open Innovation Foundation to improve myself more professionally"*.

Teaching and learning in the makerspace

The Geography and Mathematics teachers and the Principal have experience of students working in the school's makerspace and commented on teaching and learning activities in this context.

Many of the students have worked on projects involving 3D printing. These begin with the students having an idea for a project and Kadir says "*Our intention is that children don't only dream and imagine projects but actually transfer their ideas into concrete outputs".* The next step is students using a tool such as Tinkercad, a free, online 3D modeling program that runs in a web browser, known for its simple interface and ease of use, to create virtual objects. Then the 3D printer is used to turn these virtual objects into real world objects.

Ertuğrul, the Mathematics teacher has found that using the makerspace involves collaboration between students and teachers and collaboration with teachers of other subjects. For example, his students want to carry out a project involving electrics and coding and for this Ertuğrul needs help from the Physics teacher.

Ertuğrul consults with his colleagues when planning projects and activities and he says "*We discuss what kind of method we should adopt and how we should create the project. However, we can't assign projects jointly because the system doesn't allow different evaluation".*

He has also observed that often teachers are learning with the students and says "*Sometimes students come up with an idea and teachers need start researching it as well as the students. Then, in this way, we further develop the idea of the project and eventually realise it".*

Principal *Şeker* says the school is encouraging foreign language teachers to use the makerspace for activities like drama or movie script reading. These teachers have hesitated to use the space as they associate it with STEM subjects but the principal would like as many teachers as possible to get involved.

Similarly Ebru, the Geography teacher, thought at first that applied activities were not needed in his subject but he wanted to try and, with support from Kadir and ideas from his students, projects using makerspace activities and tools have been developed. Ebru also collaborates with other teachers when necessary, he says *"When projects have direct connections with physics or chemistry I consult to the relevant subject teachers".*

Ebru, says that the curriculum for the 9th grade includes the topic of contours. Traditionally this involves drawing contour maps in 2D on a blackboard. Now the students can use interactive white boards with animation in the makerspace and each student can play, make changes and explore the topic better.

Ertuğrul says that activities in the makerspace are always closely related to the curriculum as "*the starting point is some aspect of the curriculum but then there is expansion depending on students' vision"* and the teacher often finds that the students *"give you much more complex and sophisticated answers than you expected".* Indeed, he says, *"sometimes students explore ideas so far that the teachers don't even know the topic that well"* but he considers this a great opportunity for both the teacher and students to learn.

Ertuğrul involves groups of two or three students in a makerspace project. He believes that students should come up with ideas for projects they want to work on. Then the ideas are discussed and researched. Sometimes he decides a project could be suitable to submit for Tübitak funding.

Projects may involve 3D objects that can be designed and created in the makerspace and project-based activities may be simple or difficult. Sometimes arranging times to work on a project is a problem due to timetabling of classroom activities and availability of the makerspace. However, students who are really interested will willingly spend their free time working in the makerspace.

Added value and benefits

The Geography, Mathematics and IT teachers were asked what added value or benefits they had observed since the introduction of the makerspace. Their responses can be summarised as:

Students

- Are more creative.
- Learn by doing, not just by remembering what they are told.
- Learn to solve hard and complex problems by trial and error and collaboration.
- Learn to act independently from teachers.
- Are more confident, including with their spoken English as they present projects to the sponsoring company in English.
- Have improved communication skills.
- Enjoy using the makerspace more than traditional lessons.
- Have improved leadership skills, when they have had coordinator responsibilities.
- Learn about master-apprentice or superior-subordinate relationships in preparation for workplace hierarchies and discipline.
- Experience taking responsibility for and completing tasks.
- Have improved team working skills.
- Have clearer ideas about possible futures after school and some are planning engineering careers.

Principal *Şeker* added "*Students in schools with higher rates of achievement, or in science high schools, can be rather selfish. In the makerspace they have to work together as a team and learn to share, this may be the most important benefit".*

Kadir believes that an additional benefit of the makerspace is that it helps the school to achieve its mission of not only producing excellent academic results but helping their students to develop their personal, social and leadership skills.

When asked about the benefits of having a dedicated makerspace instead of an ordinary classroom teacher explained that:

- The makerspace is a more relaxed environment than an ordinary classroom
- The space enables activities that support the topics learned in ordinary classrooms and allows students to apply their knowledge.
- The activities possible in the makerspace enable students to see concepts more clearly than they could by reading descriptions on a board. Some students struggle to understand concepts when they are presented in a two-dimensional way e.g. the properties of a pyramid shape are easier to understand by building a model rather than by looking at a drawing

- In the makerspace teachers are only guides that help students observe how life works and how to approach finding out the information they need to solve problems.

The teachers say the makerspace enables them to employ project and inquiry-based pedagogies in which students learn by doing and experimenting.

Ertuğrul Eşkin says *"One of the reasons that the school was among the top five schools in Turkey is having the makerspace. Students say that they have chosen the school for the innovation classroom"*.

An interesting unexpected benefit has been that sometimes students are able to adapt knowledge gained in the makerspace to solve real life problems. For example, Kadir tells the story of a girl who worked in the makerspace in order to participate in a robotics competition. Later, she told Kadir that during the school summer break there was a leaking tap in her home which she fixed by changing the seal herself instead of calling a plumber. Before working in the makerspace, she would not have been able to work out how to fix the tap or would not have had the confidence to try.

Also, improvements in some students' confidence, communication skills and ability to work independently have exceeded the teachers' expectations. Ertuğrul and Kadir talk about a student called Ibrahim who, whilst working on a makerspace project, contacted Tübitak directly by email about a problem and then called them three or four times until he received the information he needed for his project. Interestingly, this student has previously had an average level of academic achievement, but he has excelled in makerspace projects. So much so that he was chosen to participate in one of the biggest science fairs in the USA.

Challenges

The key challenge identified for the future was finding a way to enable the makerspace to be autonomous both financially and administratively in order to make it easier for the school to administer and staff. This may include partner organisations having specific responsibilities as well as agreements regarding representation and funding.

Future plans

The Principal and Kadir described the school's future plans for the makerspace saying the school will:

- Seek funds from national and international organisations so students can develop more projects to increase their knowledge and skills.
- Seek support from national development agencies and international Erasmus+ projects.
- Plan to organise activities to develop entrepreneurship skills for the future. Seeking help with this, the school has already contacted Genç Başarı (the Young Success Education Foundation).
- Work towards greater participation of parents in makerspace activities.

The case study complements the European Schoolnet's publication "Makerspaces in schools / Practical guidelines for school leaders and teachers" (2020).

Find the full report and other case studies here: **fcl.eun.org/guidelines**

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