Our Solar Town

GUIDE FOR TECHNICIANS

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Κέντρο Περιβαλλοντικής Εκπαίδευσης Περτουλίου - Τρικκαίων

Solar Heat Europe
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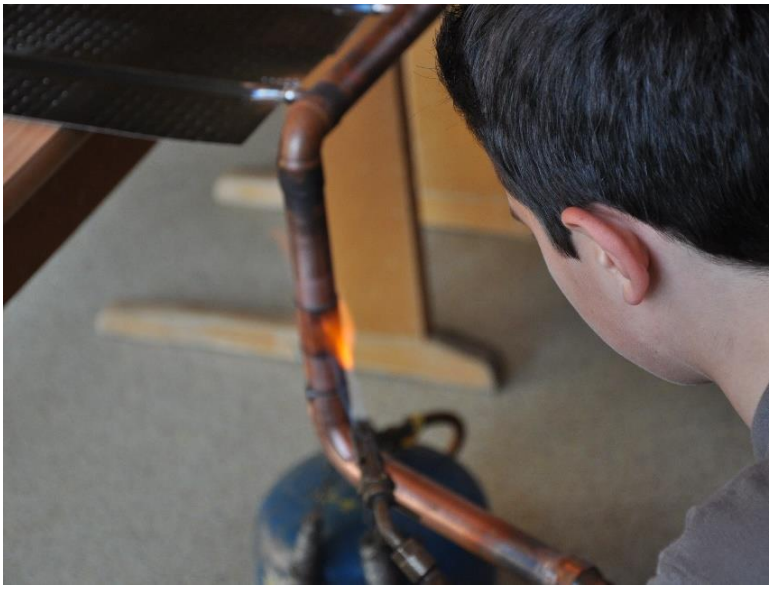
What is “Our Solartown” all about?

Solar thermal energy is a very efficient and relatively easy to understand way of using solar energy. Solar thermal energy is therefore perfectly suited to make renewable energies understandable for pupils. The special feature of the Erasmus+ project ***Our Solartown*** is that pupils aged 10-14 not only study the topic in theory, but can also gain practical experience by building solar collectors. For many pupils, building their own solar panels is something completely new and particularly exciting.



Teaching materials are provided free of charge for the theoretical background and for the practical part - the construction of solar panels. A ***planning tool*** helps to choose the location for the plant and the ***Process Guide*** of ***Our Solartown*** offers support for the project documentation. In this way, we want to make it easier for interested schools and individuals to carry out a solar thermal project and make this exciting method accessible to as many people as possible.
When building solar collectors with pupils, it is optimal if they are guided and supported by a technical expert.

About this Guide

This technical guide is intended to support technicians in the construction of solar collectors with school classes or teenagers.
As technicians, you are of course the experts when it comes to the technical details! However, we offer you information here that we have gained from experience with previous solar thermal projects in schools. We have tried to compile the most important information, but of course we make no claim to completeness.

You can find the following information here:

- You can read about what generally needs to be considered when building solar collectors and what general conditions apply on p. 6.
- You can find out what preparations are necessary before you begin building with the students on page 11.
- Information on the materials and tools needed as well as information on ready-made construction kits can be found on page 12.
- The chapter "***The construction steps***" (p. 14) provides a brief overview of the construction steps in collector construction. More detailed information can also be found in our learning unit **LU 5_1_Practical realization**.
- In Austria, 14 solar systems have already been built with pupils. The chapter "***Working with pupils – experiences, tips and tricks from previous solar thermal projects in schools***" on page 17 provides some helpful additional information for a successful implementation of the project.

We hope this guide will be helpful and we wish you much success and fun in your work with the students.

For more information on the project and the materials and tools provided, have a look at the ***Our Solartown Implementation Guide***

(Download: **https://solartown.eu/symfony/public/download/teaching/89**)

Or visit our homepage:

.**http://www.solartown.eu**

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What to take into account before building the device

Technical Aspects

In addition to the structural requirements of the building, it is particularly important to consider the function and use of the solar system. For optimal use, the right dimensioning, the type of collectors, storage of the generated heat as well as connection and maintenance of the system are important, too.

Which collectors are used?

As part of our Solartown project we built flat-plate collectors. There are ready-made kits for these, which make the purchase of the material and also the construction very easy, as all the parts are already the right size.

Where should the solar system be installed?

Often there are several options for the future location of the solar thermal system. When comparing the options and determining the best location, the ***planning tool*** from ***Our Solartown*** can help you (https://solartown.eu/processmanual/).

Which constructional requirements have to be considered?

- **Size** of the building
- **Type of building** (bungalow, multi-storey, etc.)
- The installation of the solar system in the course of the new construction of a building or renovation is of course particularly efficient.
- **Where** can the collectors be placed? On the roof of the building or an outbuilding? On the ground next to the building? On the facade? It is important to ensure that the distance to the hot water tank is as short as possible in order to keep heat losses to a minimum.
- Where can hot water storage tanks/buffer tanks be located if they are not already present?
- How large is the **area available** for the collectors?
- What is the **inclination** of the roof surface and is it oriented towards the south? The right collector area with an **orientation** to the south and a collector inclination of 45° optimise the result of a solar thermal system.
- Is the roof permanently or temporarily shaded? A **shaded location** should be avoided. Chimneys, satellite dishes, trees or other buildings can also cast a shadow on the solar thermal system temporarily, which affects its performance. This should be considered during planning.
- What **type of mounting** is chosen for a system on the roof? Is it mounted on the roof or integrated into the roof? In the case of flat or monopitch roofs, the orientation and inclination of the solar system can be optimised by elevating it with the help of aluminium racks that are attached to the roof.

- The **weight of a solar system** should not be underestimated and always means an additional load for the roof. How large this is, depends largely on the design and size of the collectors as well as the type of installation. A commercially available flat-plate collector with a size of 2 m^2 usually weighs about 40 kg. In the case of a collector with a wooden frame, as built by the students, the weight increases. Here the weight is approx. **25 kg/m^2**.
- When mounting **free standing** on a flat roof, the collectors, which are screwed to the base frame, are secured by concrete slabs or plastic tubs filled with sand or gravel, which increases the additional weight even more. It is therefore essential to have the roof checked by a structural engineer.
- Is there sufficient **lightning protection**? The usual lightning protection for solar thermal systems by using a lightning arrester box for the collector sensor is not always sufficient, because the copper or stainless-steel pipes in and on the collectors are connected to the solar pump and the storage tank through the supply and return flow of the solar pipe. Both direct lightning strikes and overvoltage due to charging shifts can thus endanger the regulatory electronics. Additional lightning protection should be considered especially for elevated collectors on flat roofs, as they are often the highest points on the roof and thus potential points of impact. When installing the collectors, you should consult a specialist to find out which type of lightning protection is suitable in each case.

For which use is the system intended?

Are the solar collectors used for **hot water production**, to support **heating** or a combination of both? In addition, the produced heat can also be used for **solar cooling** and air-conditioning of buildings.

System components:

For efficient operation of the solar system, the following questions must be answered in particular:

- Will the system be integrated into an **existing system**? Then it should be clarified which materials and requirements are necessary for this.
- Where is the **heat stored**? Is a buffer tank available or does it have to be purchased? And how large must it be dimensioned?

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Solar water heating systems: Here, of course, it is important to be able to estimate the daily demand for hot water, as this is crucial for the dimensioning of the system. The demand depends on the habits of the building users. The following table can be helpful for estimating the daily demand:

Consumption in litres per person using hot water in the building			
	economical	average	wasteful
School	10	20	40
Sports facility	30	45	60
Single-family house	30	45	60
Apartment house	25	35	60
Hospital	50	75	125
Nursing home	30	45	60
Restaurant	10	25	45

Source: G. Wind, 2020

Once you have calculated the daily demand, you can also determine the storage volume. The storage volume for a solar water heating system in single- and two-family houses should be about twice the daily demand. This enables bridging on days with little sunshine and can cover peaks in consumption.

Daily demand for water at 50 °C in **l/day**	Collector surface in m²	Buffer tank volume in litre
bis 100	4	200
bis 200	6	400
bis 300	8 - 12	500 - 750
bis 400	12 - 16	750 – 1.000

Source: Ausbildungsskriptum „Solarwärme“ (AIT and AEE INTEC)

For example, a 4-person household has an average hot water consumption of 200 litres. The buffer tank should therefore be approx. 400 litres. This corresponds to a collector area of 6 m².

- If a solar thermal system is used for providing **heating support**, the buffer tank should be dimensioned with 50 to 70 litres per m² of collector area.
- Which **pumps** are used? High-efficiency pumps are best, the performance of the pumps should be matched to the system. To keep heat losses low, the **pipes should be insulated**.
- Should **monitoring** take place? Especially in school buildings, but also in other public buildings, the installation of a **heat meter** is quite exciting. In this way,

the solar thermal system can serve as an illustration for teaching in other classes and grades even after it has been built.

Dimensioning the solar system:

The dimensioning of the system depends on the type of use and the number of people to be supplied. The ***planning tool*** (https://solartown.eu/processmanual/) can be of help here.

Dimensioning the system for hot water:

- How many people use the hot water or what is the hot water demand per day? The daily hot water demand (at 50°C) can be roughly calculated as 50 litres per day and per person (see also page 8).
- How is the building used in the summer months/holidays?
- Is there a connection for hot water to a washing machine/dishwasher?

Dimensioning the system for additional heating support?

- What is the heating demand of the building? When calculating for solar heating, the main problem is that the solar thermal system primarily provides a lot of heat when the heating demand is at its lowest. Conversely, the solar heating system produces relatively little heat at the time when you need the most energy for heating. A good solar heating calculation must take this into account. A rough estimate is also possible using an empirical formula. For a single-family house, you need about 1 m^2 of flat-plate collectors per 10 m^2 of habitable or usable space to be heated.
- Is there an energy certificate for the building? In well-insulated buildings with low heating requirements, a solar system makes sense; in buildings with poor building fabric, insulating the walls or replacing the windows may be a better investment.
- What temperature is used for heating? A solar thermal system makes particular sense for a low heating flow temperature (up to 35° C). In general, the higher the heating flow temperature, the fewer days the solar thermal system can support or replace the heating system.

What should be considered when installing a solar system?

If you are not a technician yourself, the assembly and installation on the roof as well as the integration of the solar system into the existing heating system or the construction of such a system should definitely be carried out together with a professional technician (installer or solar engineer).

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Maintenance of the plant:

Once the solar system is installed and running, it normally supplies thermal energy immediately. To ensure trouble-free operation over a long period of time, the system should be maintained regularly. It is also possible to have a maintenance contract with an installer company in the area.

Legal aspects depending on the country:

Consider some **legal aspects** before installation depending on the country. The legal aspects are regulated by the countries, please check them for your location. In the countries of the project partners, they are as follows:

In **Slovenia** all we have to acknowledge is the **Law on Construction of Buildings**, and it is not necessary to acquire approvals or permits, unless we interfere with the building construction or the spatial plan. These are only investment maintenance works. It is recommended to obtain location information and a school permit or permit from the municipalities if we do not own the building.

In **Austria**, the regulations of **the respective building code**, the **provisions of monument protection** and, if applicable, **the local building codes** must be observed when installing a solar thermal system. In Austria, these are regulated on a federal state basis.

Up to a size of 100 m^2, you do not need a building permit for the installation. Nevertheless, it is advisable to inform the responsible authorities of the upcoming construction work in the event of uncertainties, regarding monument protection etc. in order to prevent any problems.

In all cases, it should be noted that the appropriate **accident prevention measures** should be taken for all installation work on the roof. An authorized person should carry out the installation and commissioning of a solar system.

In **Greece,** for the construction and operation of a solar thermal system, the rules of the **Building Regulation**, the **provisions for the protection of monuments** and, where appropriate, **local rules on construction** must be observed.
Appropriate **accident prevention measures** should be taken for all mounting operations on the roof.
Assembling and first operation of a solar thermal system should be performed by a professional.
All regulations are included detailed in the following laws:

- Building Energy Performance Regulation [Κανονισμός Ενεργειακής Απόδοσης Κτιρίων (ΚΕΝΑΚ 2017) (ΚΥΑ Α.Π. ΔΕΠΕΑ/οικ. 178581/30.06.17, ΦΕΚ 2367/Β/12–07–17)]
- New Building Regulation Law No.4067/2012 [Νέος Οικοδομικός Κανονισμός ΝΟΚ Ν.4067/2012]

In **Belgium** no other particular measure should be taken into account to install a solar thermal system. As all the other European countries, you need the **permission of the landlord** and you have to respect the **security measures**, the **monument protection measures** (if it is the case) and any other normal measure as you were installing anything else.

Preparation

Where should you build?

In the warmer months, a covered area of a schoolyard, a public building complex or a park would be ideal, providing shelter from the sun and rain. A larger room in a school such as a gymnasium, workroom or assembly hall or even public buildings such as event or youth centres are also suitable. When choosing a room, it is important to ensure that the fully assembled solar collector fits through the door so that the collector can be transported away!

The diagonal of the door should be 5 to 10 cm above the width of the finished collector.

Transport of the finished collector, sometimes precision work!

How many people are needed for the construction?

It is optimal if there is one technician per collector you want to build. In addition, it is good if one or two teachers per class to support the technicians. If the team also gets support from the school caretaker, it is ideal!

In total, however, no more than **10 to max. 15 people** should be working on one collector at the same time. This would otherwise lead to mutual obstruction due to lack of space. Especially at the beginning, it is possible to carry out several construction steps at the same time and side by side, such as building the frame and cleaning the copper pipes or riveting the absorber strips and painting the frame, etc. But as soon as the individual parts have been installed in the collector, the work can be continued by only 5 to 8 people per collector.

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Materials and tools needed

Materials:

Regarding the materials, we would recommend buying a **construction kit** as it is a cheap and easy way to get the materials you need. As all materials are already pre-cut to the right size, construction is much easier. Possible sources of supply for kits in Austria are:

- Large-area collectors from the company ökoTech Solarkollektoren GmbH (http://www.oekotech.biz)
- The Schwarz Selbstbaukollektor: http://schwarz-solar.at/solaranlagen/

Of course, you can also assemble the material by yourself. For the construction of a solar collector, you need:

Material	Number per collector
Squared timber for the frame	7 (2 x length, 5 x width)
Wooden plate for the back (if the collector is integrated into the roof)	preferably 4 separate wooden boards
Sheet metal for the back (if the collector is placed on a stand)	preferably 4 separate sheet metal components
Black varnish	approx. 1 l
Insulation material	4 plates
Absorber strips	Depending on the size of the collector (14 are in the kit)
Copper manifolds	2
Glass plate	preferably 4 separate glass plates
Rubber seal	2 x length, 5 x width plus safeguard
Bars for external frames	2 x length, 2 x width
Bars for glass fixation in the centre	3 x width
Nails, screws, solder, rivets	various
Trestles	6
Window cleaner	1
Cleaning paper	1 role
Cleaning cloth	2 - 3

If you do not want to use a kit, remember that the collector must be moved and installed. Do not build too large!

Tools

Several tools are needed to build a solar system (see table below). The number of tools is intended for **a group of ten pupils**. For a larger group, the number is correspondingly larger. In general, it is better to have a few more tools ready and in reserve.

Tools	**Number for a group of 10 students**
Brushes	5
Handsaw	2
Jigsaw	1
Drilling machine	1
Folding ruler	3
Cordless screwdriver	1
Steel wool, attachments for cordless screwdrivers	1-3
Hammer	5
Pliers	1
Screwdrivers, various sizes	1 of each size
Riveting pliers	1
Soldering iron	1
Blowtorch	1
Soldering paste with brush	1
Rubber hammer	1
Stanley knife	1
(Hand) vacuum cleaner	1
Pencils	3
Glass lifter	2

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The construction steps

We have divided the construction of a collector into 14 work steps, which are briefly discussed with the pupils in advance. The times given are only guidelines. Of course, the time required also depends on the skill of the pupils and the experience of the technicians in working with pupils.

No.	Construction steps	Time required in minutes
1	Construction of the wooden frame	45
2	Mounting the rear panel	30
3	Insulating the collector	15
4	Painting the frame	60
5	Placing the absorber strips	15
6	Cleaning the copper manifolds and the absorber tube connections	60
7	Attaching and soldering the copper manifolds to the absorber strips	30
8	Fixing of the absorber strips with rivets	45
9	Absorbers are placed in the wooden frame	15
10	Metal frame for attaching the safety glass	60
11	Cleaning and placing the glass on top	30
12	Mounting of the glass	30
13	Stress test	5
14	Transport of the finished collector	depending on where to :-)

1. Construction of the wooden frame

2. Mounting the rear panel (Aluminium)

3. Insulating the collector

4. Painting the frame

5. Placing the absorber strips

6. Cleaning the copper manifolds and the absorber tube connections

7. Attaching and soldering the copper manifolds to the absorber strips

8. Fixing of the absorber strips with rivets

9. Absorbers are placed in the wooden frame

10. Metal frame for attaching the safety glass

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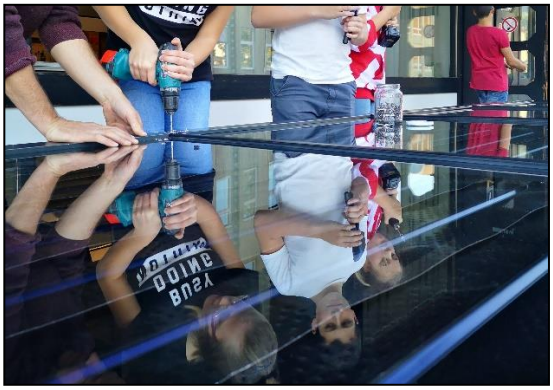
11. Cleaning and placing the glass on top

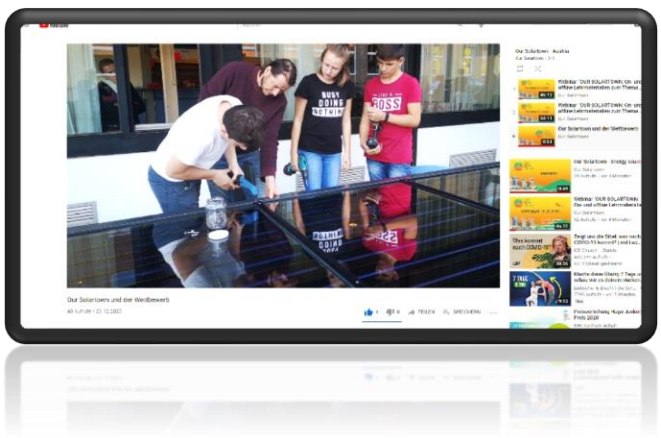


12. Mounting of the glass

13. Stress test

14. Transport of the finished collector

On the ***YouTube channel*** of ***Our Solartown*** you can find tutorial videos that show the individual construction steps and present the project.



https://www.youtube.com/channel/UCagi9EYkafhEO0zNMTjaw0A

Working with pupils

Experiences, tips and tricks from previous solar thermal projects in schools

The experience from the 14 solar thermal projects that have already been carried out has shown that **good planning**, motivation of all participants and **safety-conscious work** are the keys to success.
When building a solar collector with pupils, the following points should be taken into account:

1. Good Planning:

- ✓ The materials should be ordered and delivered well in advance. They should be stored under a roof, as the insulation wool must not get wet.
- ✓ The work steps should be planned in such a way that all students are involved as much as possible.
- ✓ If two collectors are built, it is possible to start with both collectors at the same time.
- ✓ If students cannot be actively involved in the construction of the collector at some point, they should be kept busy with activities such as tidying up the workspace or preparing for other steps. The teaching materials of ***Our Solartown***, such as role plays, quizzes or the creation of a solar newspaper, are also suitable as an activity programme. All materials can be found on the project website.

Possible activity during a break

2. Group size should not exceed 10 to max. 15 pupils:

The size of the group should be chosen so that all pupils can be actively involved in the work process. Otherwise, those pupils with nothing to do start to get bored and can even disturb the further progress of the work.

3. The individual work steps should be guided by adults (teachers, technicians):

It is important that the upcoming work steps are always discussed in advance and demonstrated by adults (see also page 14) and that the pupils are guided.

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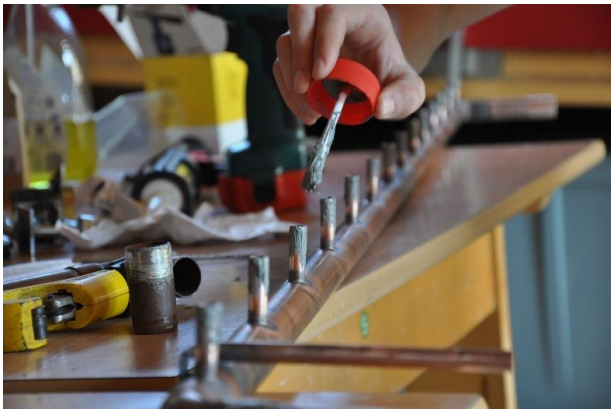
4. Follow the safety rules for working with children and teenagers:

When working with young people, the safety regulations of the respective country must be respected. In each school, the respective handicraft teachers are very familiar with these safety regulations and should therefore be consulted. Below are just a few of them:

Applying the solder paste to the absorber tubes

The first didactic principle is: Machines, equipment and materials are to be used or set up in such a way that any risk or damage to the health of the pupils is excluded according to human judgement!

Individual prerequisites and the level of development of the pupils are to be taken into account: It is the responsibility of the supervisor or the teacher to assess the students correctly and to entrust them with the work they can reasonably be expected to do (for more details, see point 5).



Applying the solder paste to the manifold

The dangers of working with electric current and measures for accident prevention should be strongly pointed out.

Do not let the pupils handle the tools unsupervised!

A "first aid kit" should be available for emergencies.

Be sure to wear appropriate work clothing:
Normal, not too loose everyday clothes should be worn. It should be clear that these can also be damaged, e.g., by splashes of paint, etc. Longer hair should be tied up, especially when working with a cordless screwdriver or drill. There is a risk of tangling! Jewellery such as rings, chains and watches should also be taken off.

5. Work that should be done by pupils, adults and by intallers/technicians:

Students can do most of the work themselves, but need close guidance and adult support.

Work steps	**Can be done by students**	**Should be guided carefully by an adult**	**Should be carried out by an installer or technician**
Construction of the wooden frame	X		
Mounting the rear panel	X		
Insulating the collector	X		
Painting the frame	X		
Placing der absorber strips	X	X	
Cleaning the copper manifolds	X		
Attaching and soldering the manifolds to the absorber strips	X	X	Pressure and leak test!
Fixing of the absorber strips by riveting	X	X	
Inserting the absorber into the wooden frame	X		
Attaching the metal frames for fixing the glass plates	X	X	
Cleaning and inserting of the glass panes	X	X	
Fixing the glass	X	X	
Stress test	X		
Transport of the finished collector	X	X	
Mounting on the roof / installation of the plant			x

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6. Motivating the students:

We consider the following to be particularly important:

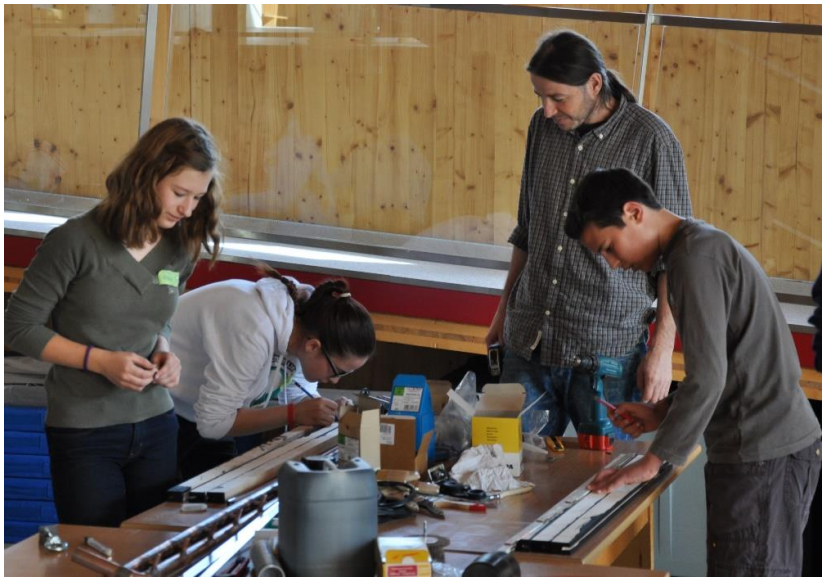
- ✓ When building the plant, it is important to get everyone excited about it right from the start and to focus on "doing" by the means of "learning by doing".
- ✓ True to the motto of Confucius, ***"Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand."***
- ✓ Building trust with the students
- ✓ Trusting them to do something and praising them not only builds their confidence, but also increases motivation, encourages perseverance and builds anticipation for the final product.
- ✓ In order to promote girls' interest in technical professions, it is particularly important to be able to inspire them to work on the collector.

7. Attention must be paid to the pupils' attentiveness and perseverance:

When working with pupils, it is important to remember that their attention, concentration and stamina when working is limited. Therefore, breaks should be scheduled regularly to avoid possibly overstraining them.

8. Working with pupils requires patience above all:

It should be remembered that working with pupils is not like working with adults. Therefore, it is especially important to be understanding and patient with them. Clumsiness and small mistakes should under no circumstances be denounced. Successful and well-done work should be emphasised all the more. It is also normal that the work cannot be done at the usual speed. Therefore, one is also challenged in this regard not to lend a hand oneself right away.



Watch, let them work and only intervene in urgent cases.

9. Valuable tips for building:

- ✓ The safety and health of the students is paramount, so it is advisable to discuss the most important safety rules with the students at the beginning. Do not assume that they are already familiar with them.
- ✓ Individual tools and especially the electrical devices used must be explained and their dangers pointed out before they are used independently.
- ✓ It is important to assess which pupil can be trusted with what.
- ✓ The collector respectively the "construction site" should always be well secured during a break or after the work has been done.
- ✓ If possible, all pupils should be involved in the work process.
- ✓ Unwilling pupils can often be encouraged or motivated by giving them particularly "tricky" work to do and, of course, not withholding compliments.
- ✓ Trust is good, but it is also important that all the work and steps carried out by the students are checked again and again so that the collector ultimately works properly.

Well-deserved break

Good luck in your work with the students!

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Solar Heat Europe/ESTIF

Website: http://www.solarheateurope.eu/

KPE Pertouliou Trikkeon, Greece

Website: https://blogs.sch.gr/kpepertoul/

VseUK Institute, Slovenia

Website: http://www.vseuk.si

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