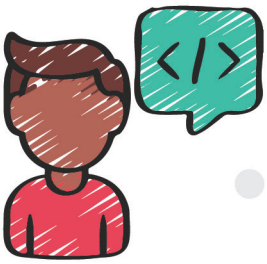
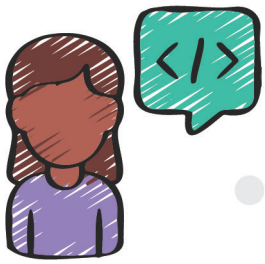
Crystal Clear Electronics

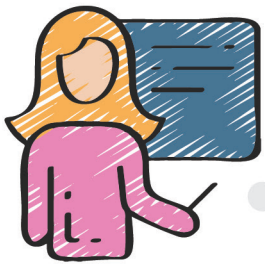
User's Guide



I am a high school student interested in electronics, but I am not sure I will be able to learn it. How do I get started?



I've studied programming before, but I want to build a gadget for my biology course that maintains a controlled environment for a bacterial culture. What do I need to buy for it?



I have taught Arduino in the past, how is this different? How much effort would it cost me?

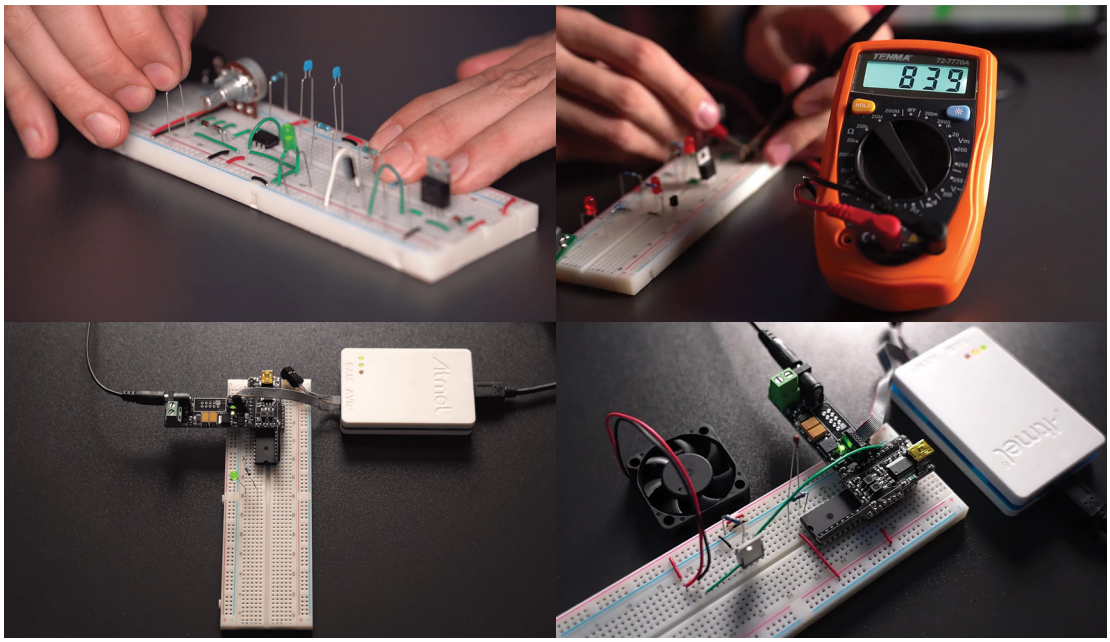
To choose an MSC in electrical or mechatronics engineering, it would be good to get some experience in the world of electronics. Does the curriculum help with this?

I used a multimeter when repairing my scooter, but I am still unsure about using transistors. How should I calculate the required cooling?

What is Crystal Clear Electronics?

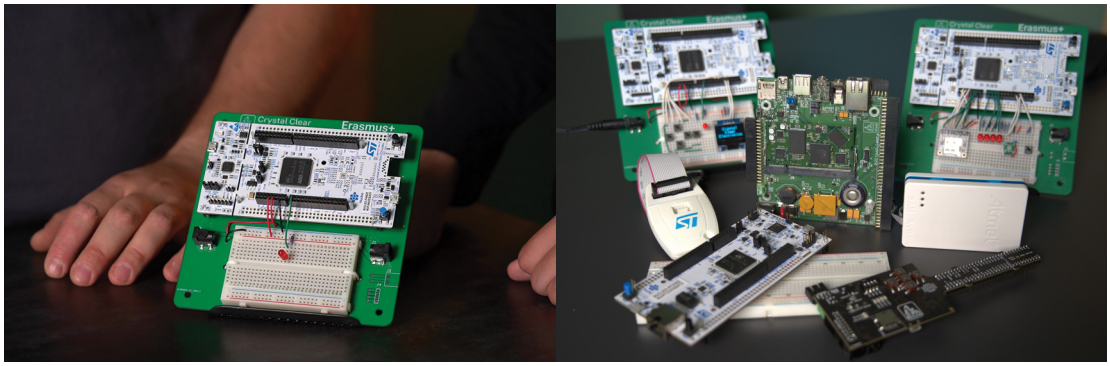
Crystal Clear Electronics is a written and video material on electronics that provides all the theoretical and practical knowledge you need to learn the basics of the field, available in English and Hungarian language.

Crystal Clear Electronics 1: schematics, laboratory tools, common components, simple analogue electronic circuits, 8-bit microcontrollers, use of microcontroller peripherals



Snapshots from the videos of CCE1

Crystal Clear Electronics 2: Theoretical basics of ARM processors, programming STM32 microcontrollers, integrating peripherals, using an embedded operating system



The Nucleo F446ZE panel that we use in the CCE2 videos and other tools

Crystal Clear Electronics Videos

24

CCE1 chapters

24

CCE2 chapters

A complete video version of all the written materials, with additional practical examples.

Crystal Clear Electronics Universe

Over the years, we have produced over 1000+ pages of written material and 70+ hours of video material through Erasmus+ projects. All of our intellectual outputs are available on our website, links to YouTube videos are available attached to the chapters, and the list of tools and components for the curricula are available at the bottom of the website.

The Crystal Clear Electronics Universe includes: the CCE1 curriculum, the CCE2 curriculum, the list of tools and components to the curriculums, a mobile app, the YouTube channel and websites related to the curriculums.

We use the term **universe** because the elements of the curriculums complement each other, and their combined use makes the learning process effective

Our links:

"CCE1" YouTube:

English: https://www.youtube.com/playlist?list=PL_gl70kzyAgPZMe7y9qgkhyPt8ShXw68g

Hungarian: https://www.youtube.com/playlist?list=PL_gl70kzyAgMLycA1QniYdXGhE9mX9lcv

"CCE1" website:

English: https://crystalclearelectronics.eu/en

Hungarian: https://crystalclearelectronics.eu/hu

"CCE2" YouTube:

English: https://www.youtube.com/playlist?list=PL_gl70kzyAgPNwvmhpu182JOO1-ccMIDb

Hungarian: https://www.youtube.com/playlist?list=PL_gl70kzyAgP77PPqcfKAOFwUVSTjTVip

"CCE2" website:

English: https://crystalclearelectronics2.eu/en

Hungarian: https://crystalclearelectronics2.eu/hu

Facebook:

English: https://www.facebook.com/profile.php?id=100057143092479

Hungarian: https://www.facebook.com/kristalytisztaelektronika/

You can download the programming environment for the CCE1 curriculum here:

https://www.microchip.com/mplab/avr-support/avr-and-sam-downloads-archive

You can download the programming environment for the CCE2 curriculum here:

STM32CubeIDE - Integrated Development Environment for STM32 - STMicroelectronics

Crystal Clear Electronics Universe

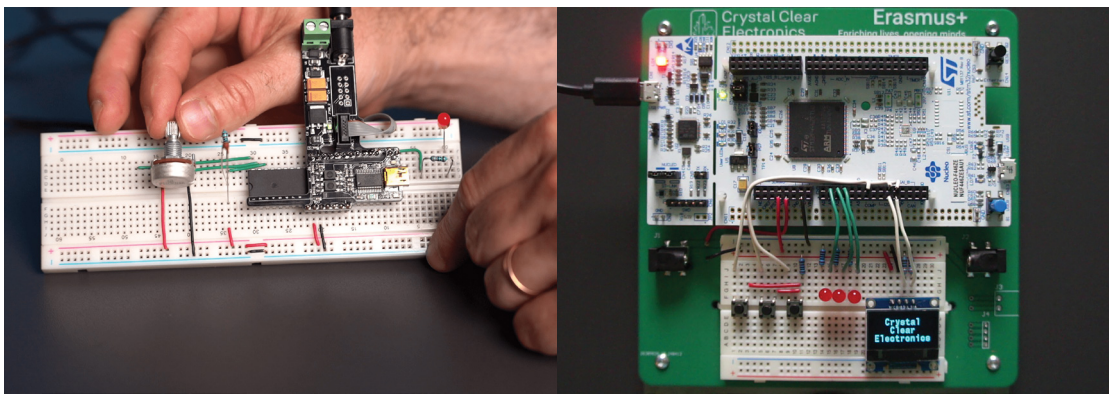
The structure of the CCE Universe

Written materials:

- curriculums
- list of tools and components
- example codes

Our written materials are designed for those who prefer to read and learn through this activity. The written documents of CCE1 and CCE2 can be found on the relevant websites and downloaded free of charge in PDF format. By clicking on the “Curriculum” tab on the website, you can access the chapters for each topic and download them by clicking on the “Download curriculum” button.

Our curriculums include tools that are essential to purchase and use when practicing at home. It is important to emphasise that although our curriculums provide the theoretical and practical basics of the field, it is not possible to fully master this area without trying them out and experimenting with those tools on your own (or with the help of a teacher).



Scenes from Chapter 22 of CCE1 and Chapter 9 of CCE2

To facilitate the purchase of tools, we have created a list of tools and components with the parameters and part numbers (as examples) of all the components used in the curriculums. These parts can be obtained from most electronic component distributors (e.g. Mouser, Farnell, TME, RS), mostly at low prices.

Mobil app

Crystal Clear Electronics has another format in the mobile app, which also has all the building blocks in one place, making it more convenient for people to access while practicing.

Videos

Our video materials are structured on the basis of the written curriculums mentioned above, but have several advantages. The combination of visual and auditory elements helps different learning styles, making it easier to understand and retain information. The presentation of various examples and demonstrations helps to understand the topics and bring the audience closer to this often intangible profession.

Scenes from the video of CCE1, Chapter 13 and CCE2, Chapter 17

As students, how do we use the CCE materials?

If you're interested in electronics, or if you'd like to pursue higher education in this field in the future, you've come to the right place! With our curriculums, you can learn the basics of electronics starting from the beginning, which we show you through practical examples. If you like watching videos about electronics, you can visit our YouTube channel, where you'll find the 48 chapters of the two curriculums. The chapters are broken down into shorter video parts to make them easier to understand. If you are interested in learning the curriculums in Spanish, Italian, French, Japanese or German, there is a chance to do so. With the help of AI, we have translated our videos to these languages also, but be aware of the fact that these translations were not supervised, therefore we suggest you use the English versions.

To make the topics easier to comprehend, we've included lots of practical examples. We highly recommend you to try these examples out, because learning by doing is the most effective way to truly understand and retain new knowledge. To do this, you'll need a variety of tools and components, which you might even find in your school. The quickest way to find out is to ask your maths, IT or physics teacher at your school. If you don't succeed there, we suggest you check the list of tools and components on our website and get the accessories you need!

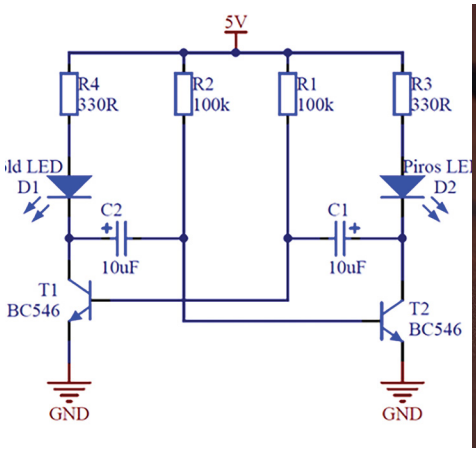
Are you just getting to know the subject?

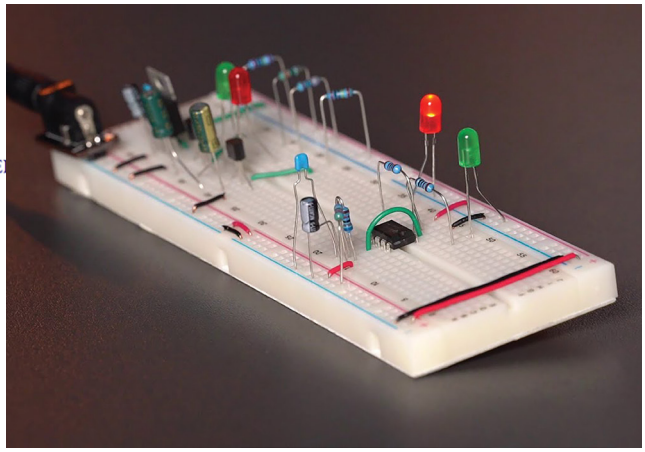
Ask your friends, it's better to learn together, it's always good to have someone to count on!

Ask your teacher at school if they would be willing to organize such a study group. It's already a partial success, if you can get them interested!

Crystal Clear Electronics study group at our partner institution in Szombathely

Don't be discouraged if you end up facing it alone at home! With the help of our videos, our engineers are almost sitting right next to you! For you, the key to success will be to try out each practical example yourself, and even try to get creative with them after your first successes! We recommend that you start with Crystal Clear Electronics 1, scroll through the written material while watching the video, and to save money, buy only as many parts as you surely need to start with, neglecting the more expensive tools. (The lab power supply is very useful, but we recommend that you only get it once you are really committed to the subject and have reached part 157/271 of the curricula.)





Circuit diagram of the astable circuit and the assembled circuit on the breadboard from CCE1, Chapter 8

As teachers, how do we use the CCE materials?

How to use the CCE curriculums as a teacher working in public education?

Have you thought about starting an electronics study group? Have you met a student in your school who would be interested in such an extracurricular activity about electronics and programming? The Crystal Clear Electronics materials will help you to set up a thematic, weekly extracurricular activity in your school!

Our professional experience shows that it takes 4-8 hours of work per chapter to master the curriculums fully. In secondary education it takes two 2-hour lessons weekly for a whole school year to be able to get through the CCE1 and another school year for the CCE2.

Crystal Clear Electronics study group in Szombathely (HU),
ELTE Bolyai János Practice Primary and Secondary Grammar School

To achieve this, you first need to familiarize yourself with our study materials, which are available in both written and video formats. To do so, visit our websites! Both curriculums consist of 24 chapters, starting from the basics and progressing all the way to more complex 32-bit microcontroller programming. Once you are familiar with the structure of the materials, it will depend on you, the students' interests, and the school's equipment on how in-depth you will cover each topic during the extracurricular activity. We recommend focusing a lot of attention on the basics, as they provide the necessary knowledge for the later chapters! We have gathered the components used in the curriculums in our list of tools and components, which can be found on our websites, to make preparation for each activity easier. (See more in: "Obtaining the components needed for learning and how to use them.") If students need help after the study groups, our videos available on YouTube will assist them while studying at home. For the chapters containing programming, you will find example codes on our website that can easily be used to try out the examples mentioned in the chapters.
You can read more about how a Crystal Clear Electronics study group looks like at each partner school in the "Role of Partner Institutions in the Project, study groups" section.

How to use the CCE curriculums as a vocational teacher?

Is there already an electronics extracurricular activity at your school, but you're looking for something new to try out with the students? From the Crystal Clear Electronics materials, you can choose specific topics thematically to discuss with the students during the activities. We recommend the CCE1 chapters for a beginner group, and the CCE2 chapters for an advanced group.

It is likely that during study groups, other extracurricular activities, or tasks involving different development boards (Arduino, Raspberry Pi), you are using the C or C++ programming language. In our curriculums, we also teach students to program in C, as this language demonstrates the close collaboration between hardware and software, which makes it also popular for embedded systems programming.

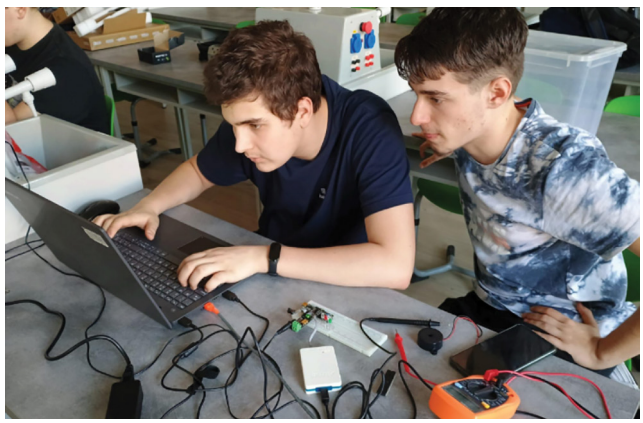
So why is it worth working with our curriculums? Since the chapters and topics are already developed, you only need to minimally prepare for the study groups.
We save you the time of developing new curriculums/methods, gathering the necessary components, and creating example programs. Additionally, we provide video materials that your students can watch before or after the extracurricular activity at home, helping them master the topics.

How to use the CCE curriculums as a university professor?

The chapters of CCE2 contain a lot of information that is essential for university courses involving electronics (such as electrical engineering, computer engineering, mechatronics engineering, mechanical engineering, automotive engineering).

Our professional experience shows that it takes 4-8 hours of work per chapter to master the curriculums fully. This time invested would be enough to organize 5-5 credit worth undergraduate subjects on the CCE1 and CCE2 curriculums.

If you have the opportunity to create a weekly, undergraduate subject for credits, you can do a lot for the future of your students. You will support their practicable training by incorporating a creative project assignment that they will develop during the semester based on the curriculum (a "light" version of a stand-alone laboratory project assignment), and finally evaluate it together in the last meeting of the term.



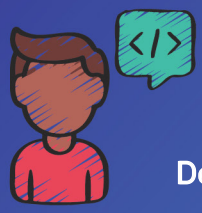
Students at the Crystal Clear Electronics study group at the Bolyai Farkas Secondary School in Târgu Mureș

How to use the CCE curriculums as a curious individual?

You are interested in electronics but don't know where to start? Regardless of your educational institution, you can download our free curriculums from our websites and even learn from the comfort of your own home. CCE1 focuses on the basics, while CCE2 is for those who have fully mastered the information and professional knowledge heard/read in CCE1. We encourage you to try out the examples seen in the videos and written materials, as this will help you to learn the topics properly! Of course, it's essential that you get some components for your journey - our list of tools and components will help get the components you need.

We encourage you to learn the basics in English, regardless of your native language, since the profession's worldwide language is English. The knowledge you gain will help you find your future job, higher education courses, no matter where you are in the world!

Source of the picture: ElectroBOOM



Are you new to electronics?

Do you want to build and program your own electronics gadget?

Do you attend a vocational school or high school?

Are you currently an undergraduate student?

Do you want to put your knowledge in practice?

Some help would be needed with your assignments?

Find the icons related to your interests in the user's guide, so you can find the topics you are most curious about!

Are you a teacher at a highschool or a professor at a university?

Do you want to improve your lab for future practises?

Are you interested in how extracurricular activities are held in other institutions?

Do you like DIY activities?

Do you want to extend your arsenal of tools with instruments used in electronics?

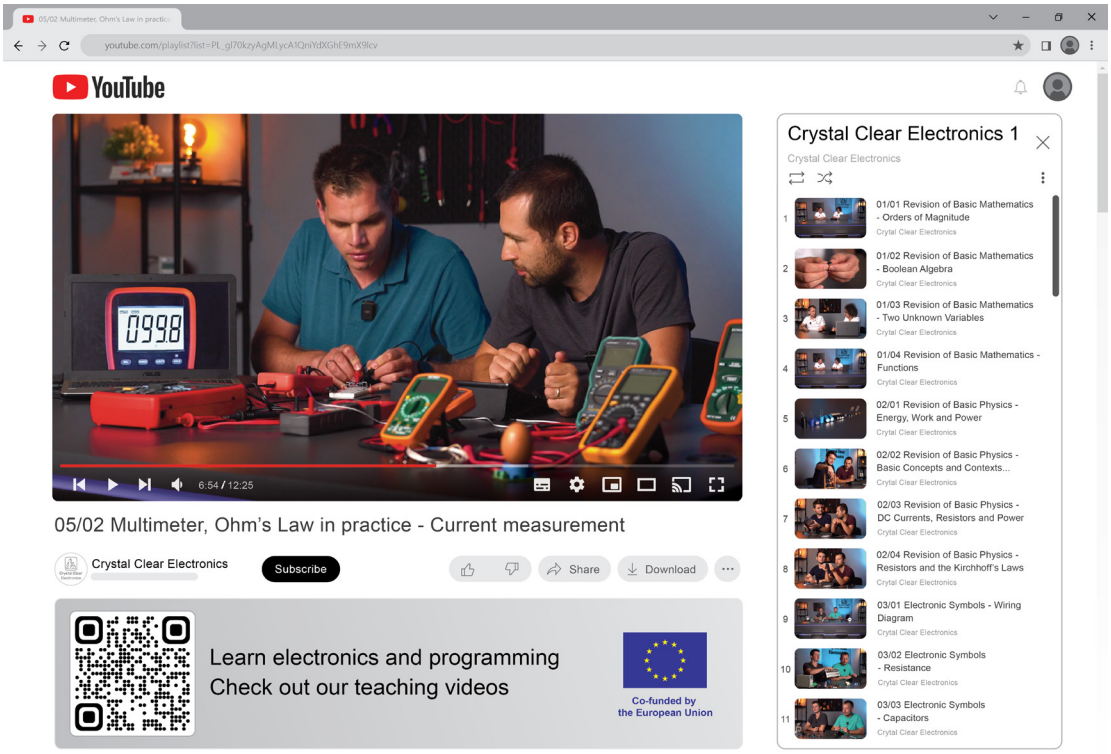
Is the thermostat not working properly?

What knowledge is covered in the curriculums?

Crystal Clear Electronics 1

Crystal Clear Electronics

In the CCE1 curriculum, we can acquire essential knowledge that we apply daily in the profession. This includes the use of laboratory power supplies and multimeters, knowledge of schematic symbols, and use of electronic components (such as transistors, resistors, capacitors, various switches, diodes, etc.). After Chapter 8, we focus on programming the 8-bit Atmel microcontroller. This microcontroller is one of the simplest embedded electronic devices on which the basics of programming can be learned. The programming is done in C language to make the processes clearer and more understandable. The curriculum also covers DC motors, various simple sensors, the USB protocol, the use of EEPROM non-volatile memory, and Pulse Width Modulation (PWM), which can be found in many forms in the electronic devices around us. Each topic is introduced through simple examples. One of the most important stages of learning is trying out the examples in practice, for which our videos available on YouTube are a great help. In our videos, we go through the theoretical background and practical implementation of each process step by step. We have also created a list of tools and components used in the curriculum, which can be found on the website, scrolling down to the bottom of the “Curriculum” tab.



Crystal Clear Electronics 2





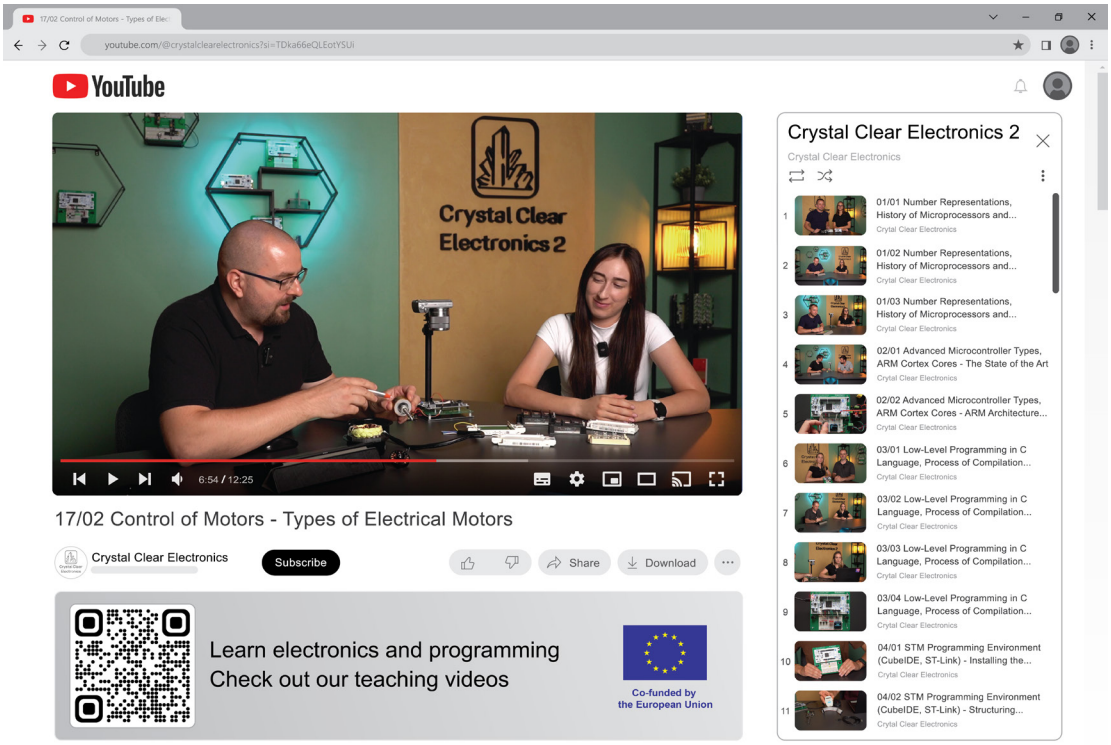
CCE2 was created for intermediate beginners, who are interested in more depth about the modern 32-bit microcontrollers and their programming, also containing both theoretical background and practical examples to master the topics. In contrast to the written curriculum, most of the videos demonstrate programming tasks on a development board which is accessible for everyone, called the Nucleo board.

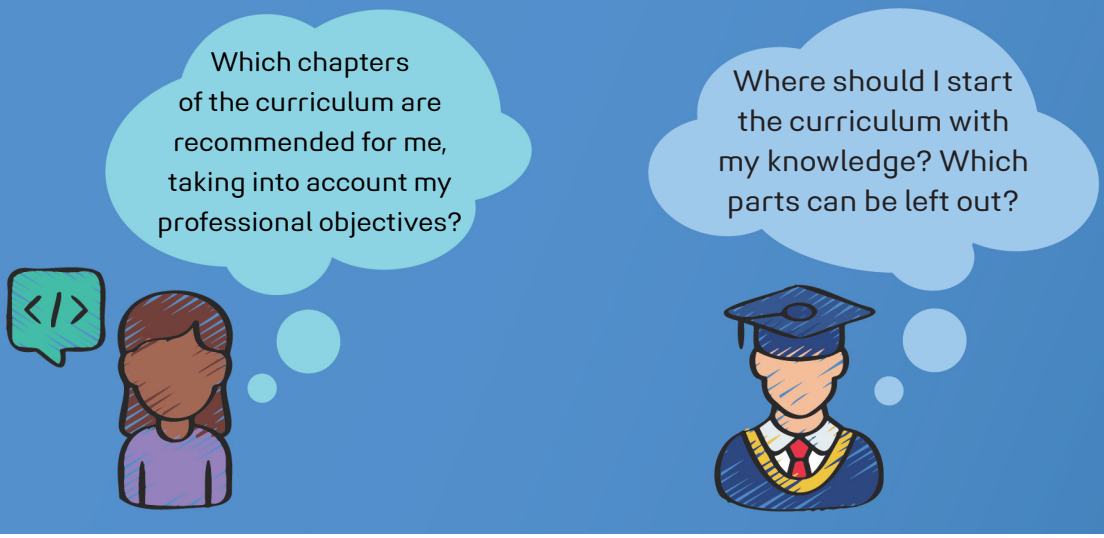
Crystal Clear Electronics 2

The focus of CCE2 is on programming 32-bit ARM microcontrollers. The first three chapters of the CCE2 start by introducing some interesting topics and the necessary components, gradually leading learners into increasingly complex programming tasks. Each chapter of the curriculum includes pre-written example codes that allow students to try out the example tasks presented in the videos.

The 32-bit microcontroller used in the curriculum appears in many aspects of our daily lives, from automation and the automotive industry to smart and medical devices, household appliances, and entertainment electronics. The knowledge gained is not only enjoyable for learners but also lays the foundation for an entire profession. Throughout the chapters, we use the STM32CubeIDE development environment, which helps familiarize learners with the most common methods used in embedded software development, such as debugging. The curriculum provides essential knowledge in the world of embedded programming, covering topics such as hardware abstraction layers, serial communication protocols, A-D and D-A conversions, calibration of sensors, P and PI controllers, simple real-time operating systems, and, not least, the operation of SD cards and their file systems.

Of course, practical experiences of trying out the examples are crucial, for which audiovisual support is provided through our videos available on YouTube. Aiding in the practical implementation is the fact that the Nucleo development board used in the videos is easy to obtain and relatively cheap worldwide.

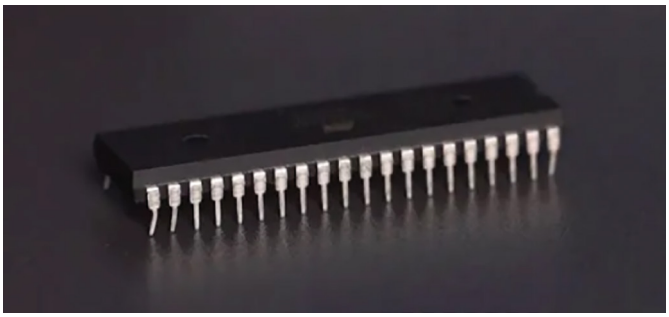




Which chapters of the curriculum are recommended for me?

Interested in electronics (hobbyist)

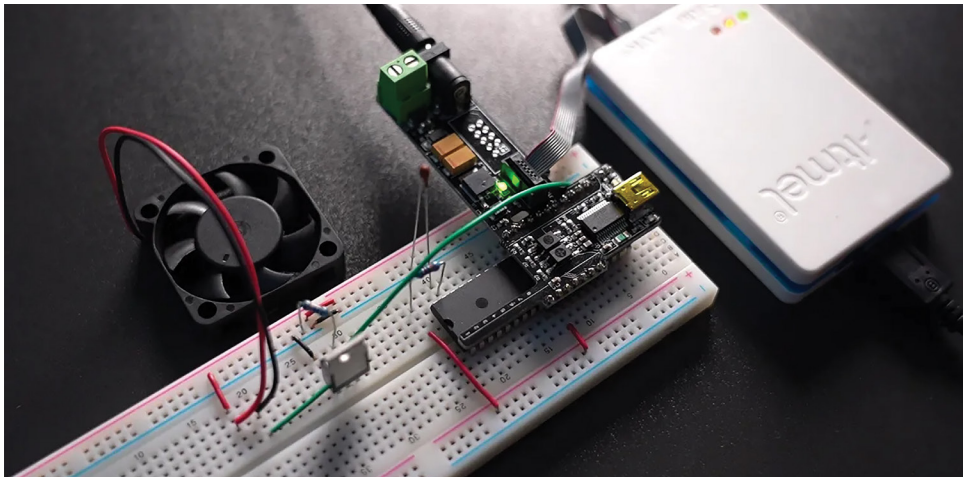
Our curriculums were developed to teach you the basics of the profession step-by-step. The first 8 chapters of Crystal Clear Electronics 1 contain information that is essential to master the basics needed to continue studying the profession further, thus are highly recommended. These chapters provide an insight into fundamental topics in the field of electronics; the revision of basic mathematics and physics, the knowledge and use of symbols, the use of laboratory power supplies, breadboards and multimeters, the world of linear power supplies, diodes and finally the construction of astable circuits.
If you're new to these topics, we highly recommend you dive into the first 8 chapters! Once you feel you have gained sufficient knowledge from these chapters, you can safely move on to the remaining chapters of the curriculum, which will mainly build on the programming of the 8-bit Atmega microcontroller.



An 8-bit Atmega microcontroller from the first video of the 9th chapter of CCE1.

If you have no experience in programming, be sure to study thoroughly the chapters 9, 10, 11 and 12 of CCE1. Later on, we will build on the methods learned in these chapters, so it's important to read through these topics several times or watch the related videos on our YouTube channel. After chapter 12, you will learn about interesting things like
DC motors, PWM (Pulse Width Modulation), USB connection, interrupts, ADC (Analog to Digital Converters), useful sensors in the field and the topic of control and regulation.

PWM signals from the second video of the 15th chapter of CCE1.



The circuit, built for the 24th chapter of CCE1, “Control and Regulation”.

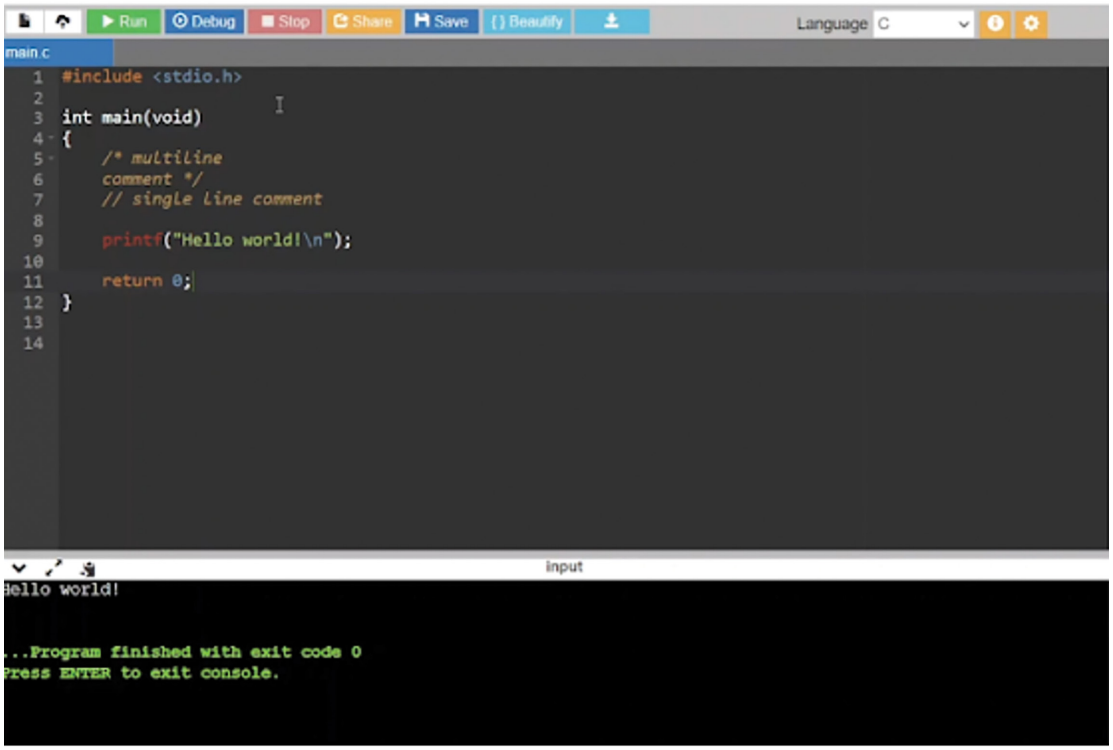
It’s important to remember that you can only gain actual knowledge by practising and trying out as many examples as you can while learning! The list of tools and components has been created to help you get the components as cost-effectively as possible, the videos are also structured for continuous practice, so we can guide you along the way!

Most of the chapters in the Crystal Clear Electronics 2 curriculum contain new information for hobbyists that may seem complicated at first. The first 4 chapters of CCE2 will introduce you to the embedded programming using a 32-bit microcontroller. Once you feel you have learned everything mentioned in these chapters, feel free to move on to the next chapters.
Similarly to the first curriculum, the best way to master what you hear/read is to try it out and build it yourself. To begin your exciting journey, our list of tools and components, moreover the example programs included in the chapters are helping you along the way!

Beginner electronics student (highschool/gymnasium)

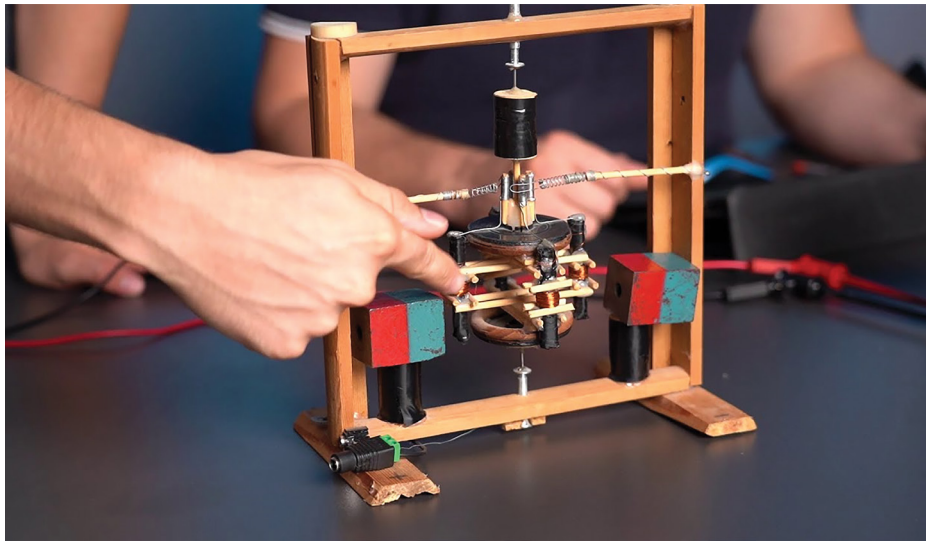
Do you feel like there is not enough material in the school which would satisfy your curiosity, so you are trying to find something that will give you new knowledge and more real life practice? If you are interested in the field and you have already spent some time acquiring a little background on it, then our materials are designed for you!

If you feel like your knowledge is enough to build an astable circuit on the breadboard correctly even when you're by yourself, then it is enough for you to start from Chapter 9, where we will start to get to know the 8 bit microcontroller and its programming. The programming is in C language, this will help you oversee the process of the programming. (There are also higher- and lower-level programming languages but for those aiming to work as an embedded electronics engineer the C language is the golden solution!)



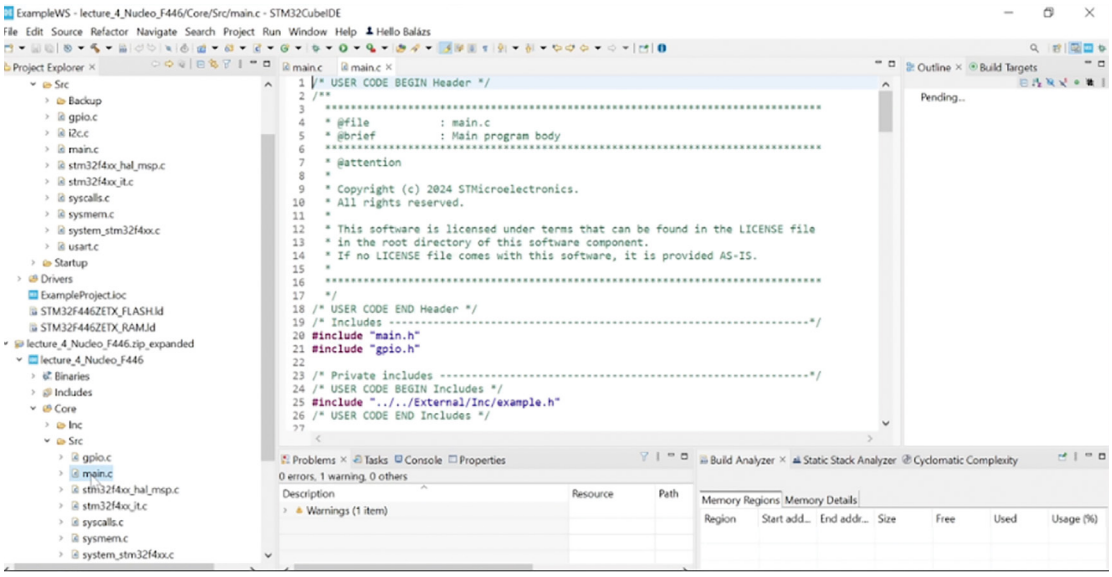
Implementation of "Hello World!" in C language in the fourth video of Chapter 10 of CCE1

If you have the opportunity, discuss with one of your informatics, mathematics or physics teachers in your school, who might be able to share some components with you for your studies. (Needed tools for programming: laptop, programmer, breadboard, 8-bit microcontroller, other small components such as wires, resistors, diodes, transistors.) To try out the various examples from the chapters, we provide you with example codes which are free to download from our websites, above the download-icon of each chapter. In the 13th chapter of CCE1 you can gain inside of the world of DC motors, from which you are able to collect knowledge that can help you build even a small electronic vehicle, but at least it will take you a liking for the world of electric machines!



The presentation of how a DC Motor works from the second video of the 13th Chapter of CCE1.

During your study of the curriculum you will hear the word “PWM” very often, so if you are not familiar with this term, we advise you to take a look at the 15th and 17th chapter of CCE1. It is best not to jump straight into the CCE2 curriculum, since what you have learnt in the CCE1 will be the building pillars of the second curriculum. Instead of the previously used 8-bit microcontroller, in CCE2 we will focus on programming a 32-bit ARM based microcontroller manufactured by STMicroelectronics (STM), and by learning these professional practices you can strongly fund your future studies in university. For example, the curriculum’s 4th chapter will guide you through the STM development environment, where you can learn the building blocks to a program that is currently used e.g. in the automotive industry.



The STM development environment from the first video of the 4th Chapter of CCE2

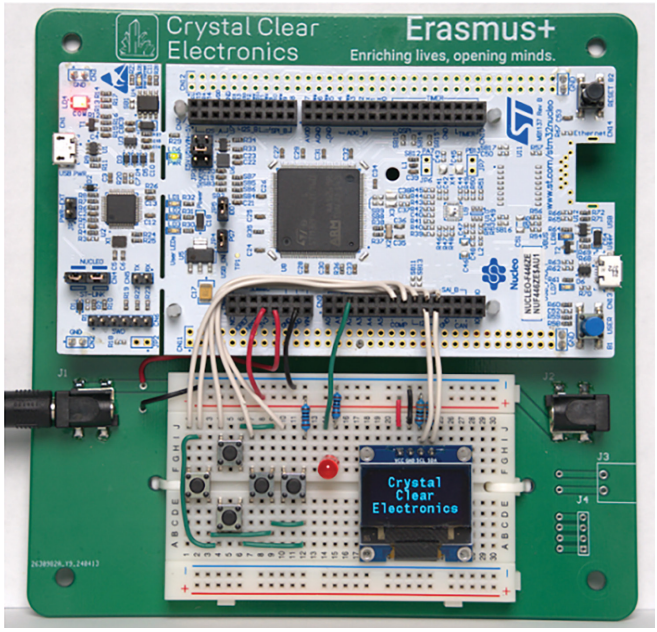
Advanced electronics student (higher education/university)

Are you engaging in electronics for some years? In your free time you have already built unique circuits or you have managed to repair all of your electronics devices at home? Maybe you have already applied for a higher technical education? The CCE curriculums can show you some new stuff too! Based on your studies or experiences, you may already know a lot about certain tools and components, but in our curriculums we highlight interesting facts and demonstrate common problems through specific examples.

You're probably already familiar with the basics of electronics, such as the roles of basic circuit components, and you can read and design a schematic circuit without doubts. If you have already designed a custom circuit, the first eight chapters of CCE1 can be skipped, but if you feel you have incomplete knowledge or have forgotten much about these topics, you can easily catch up by looking at the chapter titles.

Chapters 9, 10 and 11 of CCE1 introduce the basics of C programming using an 8-bit microcontroller. You can skip these chapters if you have previously studied the C language and microcontrollers. Throughout the curriculum you may encounter various peripherals and tools you may not be familiar with. You can easily find out which topics you have already learned about by looking at the chapter titles.

In CCE2, you will learn about the operation of embedded electronics using a Nucleo board with a 32-bit STM microcontroller. If you are already familiar with this development board or have worked with similar boards, the first 7 chapters are just a brief overview. We advise you to only focus on the parts which seem challenging for you.



The assembled circuit used in the videos in CCE2, Chapter 10. The top white component is the development panel (Nucleo F446ZE), and at the bottom is a breadboard with the components built for the chapter.

In the following chapters, we will introduce you to a range of new technologies, tools, and theoretical concepts. To name a few: I2C and UART serial communication protocols, A-D and D-A conversions or motor control and regulation.

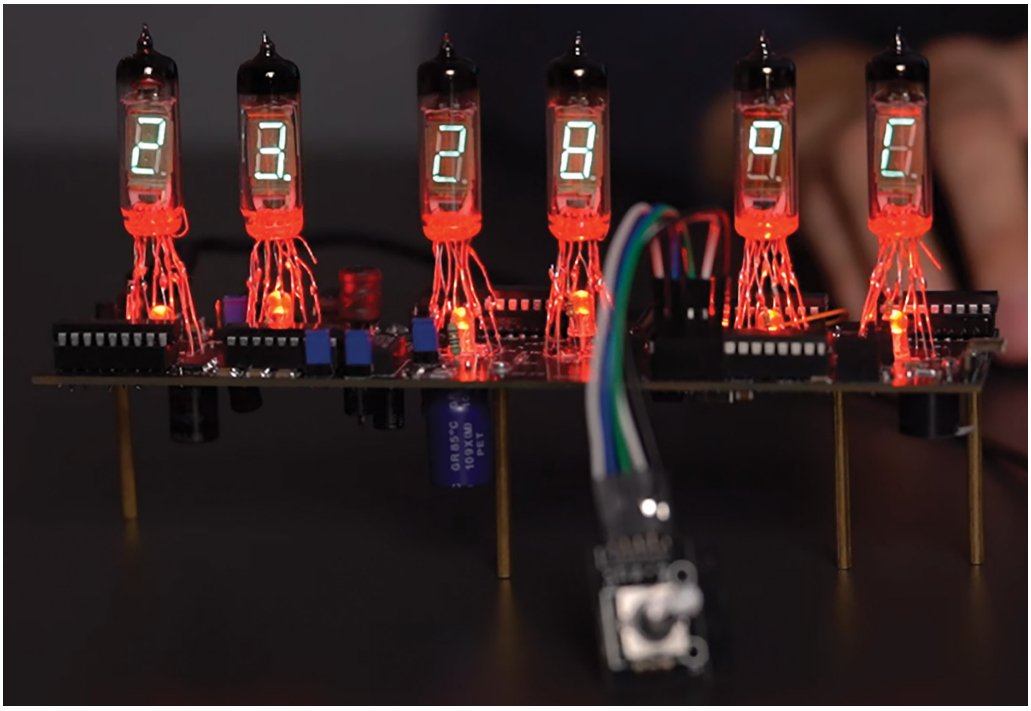
Electronics professional

If your profession involves working with electronic equipment on a daily basis, your knowledge will of course extend beyond CCE1 and CCE2. However, the chapters cover many areas of electronics, so everyone will find a topic of interest. The CCE curriculums provide you with an excellent opportunity for further training or reskilling within the industry, or even preparing for a complete career change.

Technicians or engineers may be new to programming. C programming is introduced in chapters 9, 10 and 11 of CCE1 and in chapter 3 of CCE2.

IT experts, on the other hand, may be new to the more physical, hardware-oriented solutions discussed in the CCE1 chapters.

With the CCE2 curriculum, you can build up a knowledge of microcontrollers and more specifically of embedded systems development, which will give you an insight into a new profession, and further expand your skills to a new field. Even if you don't want to change your career, the skills you gain can help to create useful everyday electronic devices such as a home security system, an alarm clock or a smart shower.



The custom-built VFD clock shown in the second video of the 22nd Chapter of CCE1.

Purchase of the required components and how to use them





We have included a list of tools and components with the parameters and manufacturer part numbers (as examples) of all the components used in the curriculum, to facilitate easy procurement. The components lists can be accessed from the curriculums webpage by clicking on the “Curriculum” tab, and scrolling to the bottom of the page.

One of our most important tools is the breadboard, as it is the basis for the practical examples and which will be used to implement future connections. Most of the components are available from any European supplier (e.g. Mouser, Farnell, TME, RS) usually only for a few euros, but there may be some components that are subject to manufacturer’s restrictions (one example of this is the Nucleo board used in the CCE2 curriculum, which is available in several types, but these slightly differ from each other, so what is written/said in the curriculum will not always be equally applicable to the different development boards. Don’t worry, in the 5th chapter of CCE2 we will show you how to rewrite your program for different types of development panels with different microcontrollers!)

It is important to note that it is not mandatory to use exactly the same components for the example projects presented in the curriculums, but you should be aware of the differences, as this is not specifically mentioned in the curriculums.

CCE1 curriculum and the required components

For beginners in electronics, we recommend the purchase of the basic CCE1 supplements, which will help you to put your acquired knowledge from the curriculums into practice and learn the basics. These are the: multimeter, breadboard, DC power adapter and different value resistors, capacitors, diodes, transistors. In addition to these, a very useful but slightly more expensive tool is the laboratory power supply. You can start without it, but the more you get into it, the more likely you will need it.

For the chapters involving programming, you will need several tools in addition to the components already mentioned. These are: a laptop, a programmer (e.g. ATATMEL-ICE-Basic, ATATMEL-ICE-Basic-PCBA), a development environment.

CCE2 curriculum and the required components

The CCE2 curriculum works mostly with the CCE1 components, but unlike the first, the second curriculum focuses on programming 32-bit STM microcontrollers. To try out the practical examples in the CCE2 chapters, you will need a Nucleo development panel, of which you can find several versions available. A list of “Currently recommended development tools and components” can be found on the CCE2 website under the “Curriculum” tab, scrolling to the bottom of the page. The CCE2 curriculum may also require additional components, varying from chapter to chapter, such as OLED display, external SD card slot, DC motor and associated motor control unit or sensors for measuring temperature, light and humidity.

How can I use the curriculums in my studies/ career?

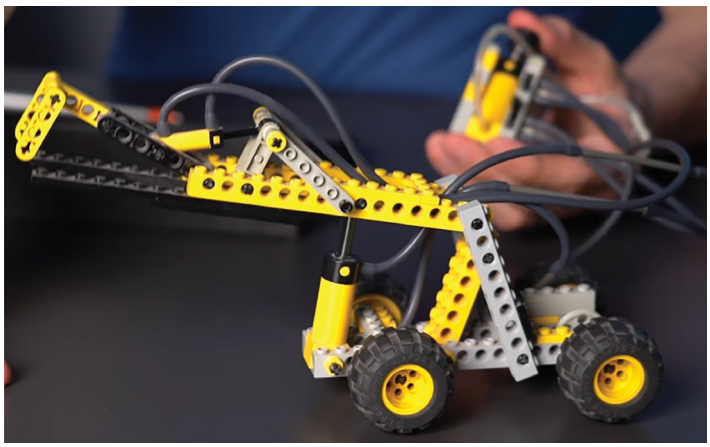




With Crystal Clear Electronics, you can even be able on your own to learn the basics of electronics. The curriculums are available free of charge in written (downloadable PDF) and video (YouTube) formats using the links at the beginning of the user's guide. Of course, we all have different backgrounds, but our materials teach you the necessary knowledge from the basics, so you can decide which chapters to skip according to your level of expertise. For information on the levels appropriate to your expertise, see the chapter **"Which chapters of the curriculum are recommended for me?"** for more information.

The CCE chapters are not based on the public education system's maths, IT and physics classes and their materials, so you can get an insight into a profession you rarely hear about in school.

What are the areas of expertise in electronics? In today's modern world, almost every device has some kind of electronics in it, so you'll find it in most industries. Mostly in telecommunications (mobile phones, radios, cell towers), IT (computers, servers, routers), automation and robotics (assembly lines, robotic arms, drones), automotive industry (air, land, water), space industry (rockets, satellites, space probes, rovers), medical devices, entertainment devices (TV, speakers, telephones), power electronics (power supplies, control equipment), and various measurement equipment are containing electronics.



Example shown in the first video of the 24th Chapter of CCE1, to help you understand the topic of control and regulation.

Fresh university students often encounter problems in their first semester that they suddenly cannot answer because they rarely met these topics in high school. Crystal Clear Electronics will give you the basic knowledge you need to start your university education, so you will not start your life with empty hands.

To master the topics, as with any other profession, you need to take the time to understand the various interactions and tasks involved. In our materials, we present a number of example tasks and example programmes, which you will hopefully find useful in your future studies. We recommend that you take the time to try out the examples in practice!

Why would we recommend starting with the Crystal Clear Electronics curriculums?

The outstanding feature of Crystal Clear Electronics is that you don't need to use any other external source for the materials; all the necessary documents for the topics used in the written and video format materials are available on our websites. The Crystal Clear Universe includes all of our available materials, with interoperability between them; all of our platforms are connected, so you can access our Facebook page or YouTube channel either from our website or mobile app.

The chapters of the curriculum have been designed for secondary school knowledge, so the focus is on teaching the basics and the knowledge needed for practical applications, rather than deep theoretical knowledge. By reading, watching and studying the materials, we teach you all the basic knowledge useful in electronics, laying the foundations for starting your higher education or repeating, expanding your existing knowledge.

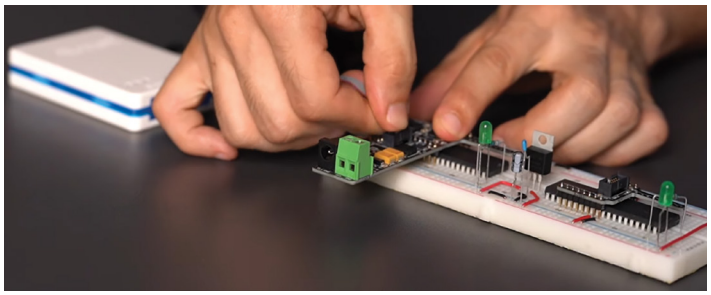
Understanding the link between the previously mentioned specialties can be one of the most difficult tasks, but it also provides essential and unavoidable information. Crystal Clear Electronics provides teaching materials that are not only aimed at teaching a single subject, but also at building bridges between the worlds of electronics and programming, hardware and software, providing particularly valuable knowledge for anyone wishing to become more confident in these areas.

The history of the development of the Crystal Clear Electronics materials



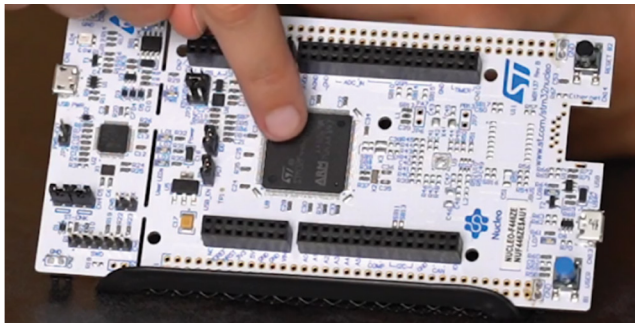


The development of Crystal Clear Electronics started in 2018. Our goal was to create a curriculum that would introduce the reader step-by-step to the world of electronics, describing topics that teach the essential basics of the field. Crystal Clear Electronics 1 (referred to as CCE1) contains 24 chapters, the first 8 of which teach the basics, including symbols, the use of a laboratory power supply and multimeter, and the operation of various components (such as resistors, transistors, diodes, push buttons, etc.). The other 16 chapters focus on simpler circuits and microcontroller programming, which is demonstrated by programming the 8-bit ATmega16A microcontroller using various example codes and various example programs. These example codes are available on the websites, enabling interested students to try each example in practice.



In the fourth video of the 9th Chapter of CCE1, we upload the Firmware to our microcontroller

In 2020, we created the Crystal Clear Electronics 2 (referred to as CCE2) curriculum, also in the framework of the Erasmus+ Programme, with the aim of reaching out to a group of people who are already more immersed in the world of electronics, who are planning to continue their studies in this field or who have found the CCE1 curriculum not challenging enough. This curriculum also contains 24 chapters that teach the programming processes of modern embedded electronics. The curriculum uses a 32-bit ARM-based STMicroelectronics microcontroller, a device that is found almost everywhere in our world, including cars, smart watches and even machines used in healthcare.



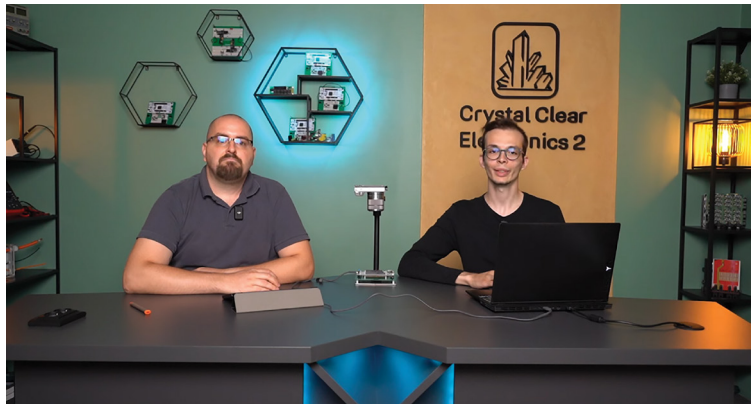
The STM32F446 microcontroller on the Nucleo development board

As a student standing before a career choice, the Crystal Clear Electronics materials will help you get a greater insight into the profession, thus contributing to the choice of programming or electronics courses in higher education. With our curricula, we aimed to maintain diversity and innovation, enhanced by the app “Crystal Clear Electronics” for Android and iOS devices, created in the CCE2 project. The app provides direct access to the written materials for a total of 48 chapters related to the two curricula, the related example codes, schematic circuits, data sheets and video contents. The app provides easy access to all the materials.

Our projects have also been very successful in the partner institutions’ countries (Hungary, Slovakia and Romania). In 2022, we had the opportunity of funding a new project called Crystal Clear Electronics Videos (referred to as CCE Videos). In our project, we started recording and producing videos that cover the topics presented in the written curricula, as well as presenting new insights/interesting facts. In total, 48 chapters of the curriculums were divided into several shorter video parts, which are available on the Crystal Clear Electronics YouTube channel.

Since the start of the CCE Videos project, we have conducted more extensive dissemination activities than ever before, with social media campaigns across the EU and presentations in schools, in order to achieve a real international impact.

The studio of the CCE1 videos



The studio of the CCE2 videos

Role of partner institutions in the projects, study groups

The aim of our projects was not only to create teaching materials that would provide the right amount of knowledge for secondary school students, but also to make this knowledge understandable and crystal clear for them - hence the name of our project. In total, four partner institutions were directly involved in our projects, one from Szombathely (HU), one from Šamorín (SK), one from Târgu Mures (RO) and one from Komárno (SK). The Selye János Gymnasium from Komárno was involved in the development work during CCE1, while the other institutions were also involved in the CCE2 and CCE Videos projects. The role of the partner institutions was essential in testing the materials, as feedback from students was incorporated into the workflow. The students completed a mixed methods questionnaire after each chapter and gave in-depth interviews to their teachers after 4 chapters, which were used to develop the teaching materials. Teachers from the partner institutions held electronics study groups for interested students, where they could not only help their professional development but also get answers to their questions about further education. The institutions organised weekly, thematic study groups for students at pre-arranged times.

The partner institutions were asked to study the given curriculum and to evaluate each chapter by solving the given tasks. The evaluation criteria were as follows:

1. How well did the students understand the given chapter?
2. Were the chapters interesting and did they meet the students' expectations?
3. To whom and for what age group would they recommend the curriculum?
4. To what extent will they be able to use the knowledge acquired in their further studies?
5. What would you change in the curriculum, were there any professional mistakes?

Târgu Mureș (RO) - Liceul Teoretic Bolyai Farkas

The partner institution in Târgu Mures has also been part of our projects from the beginning. Since 2019, they have been organizing Crystal Clear Electronics study groups at the school, multiple times they have organized 2 groups in one school year (one for advanced and one for beginners), thus contributing to the success of the projects. In the beginning the study groups' participants were using the written materials, and from 2023 the video materials are used on the extracurricular activities. The students are always prepared in advance for the activities, where they will only have to do practical experiments and revise the topics that the teacher considers important.

The partner institution places a strong emphasis on learning the basics, as these skills are essential for acquiring higher level skills. One of the institution's priorities is to improve the competitiveness of their students, and one of the key tools for this can be the use of the electronics curriculum. At the Farkas Bolyai Secondary School, there are two computer science classes running in the school per year: one mathematics-computer science, including intensive English classes and one mathematics-computer science, including intensive computer science. The electronics extracurricular activities are open to anyone interested in the subject, with an average of 10-10 students attending every year.

The good reputation of the Crystal Clear Electronics materials is further enhanced by the fact that the Dean of the Electrical Engineering Department of Sapientia University of Transylvania, Târgu Mureș, also finds them useful and uses them to teach secondary school students.

The extracurricular activities in the partner institution in Târgu Mureș were held by József Domokos and Sándor Papp.

Szombathely (HU) - ELTE Bolyai János Practice Primary and Secondary Grammar School

A The partner institution in Szombathely joined our Erasmus+ project “Developing an innovative electronics curriculum for school education” (CCE1) in 2018, and since then they have been partners in all our Erasmus projects. Since 2019, the institution has been running electronics study groups, first using the CCE1 and then the CCE2 written curriculum. In 2023, a renewed activity was organized at the school, with a strong emphasis on the students’ home education. In these extracurricular activities, students are asked to watch the videos of a chapter before the activity, so that they do not start the chapters from the beginning, but sit in the classroom with already gained, basic background knowledge. In this way, the activity is more practical than theoretical. An average of 8 students from different classes participate in a study group. Students’ backgrounds often vary, so in the activities they are encouraged to ask questions; “there are no wrong questions, only questions that have not yet been asked”.

The extracurricular activities in the partner institution in Szombathely were held by Szabolcs Pájer.

Šamorín (SK) - Nadácia PRO RATIO, Imre Madách Gymnasium

The first part of the CCE1 project focused on the properties of electronic circuit elements and their role in the circuit, and then the students learned about the properties of microcontrollers, their programming, sensors and controllers.

In 2020-2022, electronics education was continued at the institution, but due to the situation caused by Covid, the activities were conducted through distance learning. All students who participated in the activities had access to a set of electronics tools that they could take home and actively participate in the sessions.

The CCE2 project was largely focusing on programming the 32-bit microcontroller: (functional) configurations of the legs, communication channels, interrupts, sensors and controllers, OLED display and the use of operating systems. Feedbacks from the students showed that they were very interested in these topics.

After that, the CCE Videos project continued from 2022 onwards, linked to the previous projects. The videos produced for each chapter were tested in the study groups on the basis of the criteria mentioned above. The consortium was also looking to see how well these videos helped students to understand each topic. The activities showed that the materials are very useful and a great help to students. In addition, the use of the written materials was negligible during these activities, and it is advisable to use the written curriculum along with the videos. With the videos, care should also be taken to stop at certain examples and study the corresponding circuit diagrams and calculations in the written material for the related sections.

The extracurricular activities in the partner institution in Šamorín were held by Béla Liszkay.

> “All in all, the CCE projects’ curriculums are very useful and we highly recommend them to anyone interested in this topic. It teaches us a lot, it explains the properties of electronic devices very well, so that everyone can understand the certain roles of the components and how each circuit works.”
>
> - Béla Liszkay

Phiaro Technologies Ltd.

Founded in 2010, the years with Crystal Clear Electronics span a significant period in our company's history. In setting our goals, we have always been guided by the attitude, the will to do something and the dedication of the professionals working with us, so it is no coincidence that we have set our minds on creating teaching materials that are relatively easy to understand and accessible to everyone.

As a custom electronic hardware and software development company, of course, when we're not working on electronics curriculums, we're working on a variety of other technical tasks, just as other similar companies. Electronic design, mechanical design, electronics manufacturing, metal parts production, component integration, embedded programming make up the rest of our work, so in Crystal Clear Electronics we teach something that we also apply ourselves.

The development of the teaching materials is very much carried out by the company's past and current employees, in a multi-stakeholder teamwork, working only with our partners: partner institutions, teachers, their students, dozens of engineers involved, patrons and subcontractors.

Our employees have put their hearts and souls into our teaching materials, which we warmly recommend to everyone, wishing them to provide pleasant moments, useful and timeless knowledge, and contribute to the users' development goals.

Implementation through the Erasmus Plus Programme

Many people are familiar with Erasmus Plus, the programme that enables higher education students to study for part of their degree in a European or other associated country, but less people are familiar with the many other opportunities that the Erasmus Plus Programme provides.

Erasmus+ offers mobility and cooperation opportunities in:

- Higher education
- Vocational education and training
- School education (including early childhood education and care)
- Adult education
- Youth
- Sport

The programme offers both individuals and institutions the opportunity to achieve their educational goals. Crystal Clear Electronics is part of the Erasmus Plus programme's "Key Action 2: Cooperation among organisations and institutions".

The Erasmus Plus Programme website: https://erasmus-plus.ec.europa.eu/en

Letter of recommendation from Gergely Lágler, CEO of Phiaro Technologies Ltd.

Dear Reader!

We communicate with our users in a direct and informal way in our teaching materials, because we want to educate them as if they were sitting next to a fellow student. We immerse ourselves in the world of electronics and electronics programming with readers and viewers of our videos. Please allow me to highlight some of the statements in this guide from my personal perspective!

First of all, I would like to address those of you who are studying with us or are considering using Crystal Clear Electronics! The main purpose of our teaching materials is to help you! If you are still unsure about your future, Crystal Clear Electronics gives you the opportunity to get a taste of the field of electronics, which will come in handy when shaping your decisions about your future.

Our whole lives are surrounded by the rapid development of technology. It is my personal belief that, when used correctly, technology can help us, but it is no substitute for practice, experimentation and knowledge. Excessive consumption of any educational material without anchoring the knowledge is just a waste of time. I believe this to be also true of the Crystal Clear Electronics materials. We've tried to cram a lot of useful information into each chapter, so it will not be enough to read through the curriculums or watch the videos to understand. I recommend that you get the components found from the beginning of the curriculums, but in case of the more expensive laboratory power supply I advise you to wait until you absolutely need it. I wish you to find joy in studying and benefit from the knowledge you acquire!

I would like to encourage teachers, professors in high schools, technical schools and universities to consider incorporating some parts of the curriculum into their work. I am also relying on the fact that the free teaching materials will take a considerable burden off the shoulders of teachers. I see the advantages of using videos primarily to support at-home preparation, that will leave more room for practice, consultation and troubleshooting circuits built during the study groups. I am convinced that if a student is exposed to practical examples at an early stage, there is a significant improvement in the quality of the theoretical knowledge they will acquire later on.

I respectfully call on all decision-makers at national and EU level to support the education of electronics and electronics programming in their own environment! It is in the interest of education and economic policy to strengthen the skilled workforce. No curriculum can meet all needs, but Crystal Clear Electronics is the result of many years of very intensive professional cooperation, and I would recommend it for deepening professional knowledge, preparing for university studies, and as a supplement to early university studies. Great examples have already been realised, for example, a university professor organizing an extracurricular activity for secondary school students, or a large company has donated tools and components used in Crystal Clear Electronics also to secondary schools. You can be the next!

Finally, I would like to thank all those who contributed to the creation of the curriculum. Thank you very much! I feel that we have managed to answer all our initial questions and put a professionally "safe" option in the hands of those who want to learn together. I have seen with my own eyes that we have helped many hard-working students, and I am sure that the materials will help many more in the future!

I've been thinking a lot about how many people have contributed to our work, and I'm afraid I'd miss someone if I tried to list everyone by name. The list of patrons, European and national experts, colleagues, students involved in testing, friends who helped with ideas is very long. Thank you very much on behalf of myself, my colleagues and all users!

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