Go-Lab

Global Online Science Labs for Inquiry Learning at School

Collaborative Project in European Union's Seventh Framework Programme

Grant Agreement no. 317601

Deliverable 1.2

Go-Lab Curriculum Analysis

Editors	Gabriela Collado (EUN) Evita Tasiopoulou (EUN) Tommaso Dalla Vecchia (EUN) Gina Mihai (EUN)
Date	29 October 2013
Dissemination Level	Public
Status	Final

The Go-Lab Consortium

Beneficiary Number	Beneficiary name	Beneficiary short name	Country
1	University Twente	UT	The Netherlands
2	Ellinogermaniki Agogi Scholi Panagea Savva AE	EA	Greece
3	École Polytechnique Fédérale de Lausanne	EPFL	Switzerland
4	EUN Partnership AISBL	EUN	Belgium
5	IMC AG	IMC	Germany
6	Reseau Menon E.E.I.G.	MENON	Belgium
7	Universidad Nacional de Educación a Distancia	UNED	Spain
8	University of Leicester	ULEIC	United Kingdom
9	University of Cyprus	UCY	Cyprus
10	Universität Duisburg-Essen	UDE	Germany
11	Centre for Research and Technology Hellas	CERTH	Greece
12	Universidad de la Iglesia de Deusto	UDEUSTO	Spain
13	Fachhochschule Kärnten – Gemeinnützige Privatstiftung	CUAS	Austria
14	Tartu Ulikool	UTE	Estonia
15	European Organization for Nuclear Research	CERN	Switzerland
16	European Space Agency	ESA	France
17	University of Glamorgan	UoG	United Kingdom
18	Institute of Accelerating Systems and Applications	IASA	Greece
19	Núcleo Interactivo de Astronomia	NUCLIO	Portugal

Contributors

Name	Institution
Gabriela Collado, Evita Tasiopoulou, Tommaso Dalla Vecchia, Gina Mihai	EUN
Nikos Zygouritsas	MENON
Eleftheria Tsourlidaki	EA
Constantinos Manoli	UCY
Effie Law	ULEIC
Henny Leemkuil	UT
Urmas Heinaste	UTE
Sven Manske	UDE
Sofoklis Sotiriou (peer review)	EA
Adrian Holzer (peer review)	EPFL
Ton de Jong (peer review)	UT

Legal Notices

Executive Summary

This report has as its primary aim to ensure that from a content and pedagogical point of view, the Go-Lab portal represented by the various laboratory experiments promoted in this portal can be seamlessly integrated into the curricula of European countries. Additionally, this report intends to examine curricula to further determine arising requirements for Go-Lab labs, i.e., to identify potential new online labs to be proposed for better fitting the curricula of European countries.

The presentation of a consistent methodology, as well as conclusions and suggestions on the integration possibilities of the Go-Lab portal's labs in the national curricula of the various countries, are the outputs of this study. Moreover, this analysis presents a collection of recommendations on factors that should be taken into account when choosing laboratories to include in the Go-Lab portal and a lab-checklist that would support this process.

For this study, an analysis of science subjects within the curricula of eight countries including Belgium, Cyprus, Estonia, Germany, Greece, Poland, The Netherlands and UK-England, has been performed. Also, eight (8) online labs in total were selected: Hypatia, CosmoQuest, VISIR Lab, Faulkes Telescope, SimQuest Elektro, ELVIS / OP– AMP Labs, Aquarium WebLab, and Galaxy Crash.

The main analysis has shown that in general, the selected labs appear to have integration possibilities into the national/local curricula. However, some factors obstruct the integration process of the labs into the curricula. Some of these factors are directly connected to the *curriculum* (including the teacher competences aspect and suggested activities not always matching curriculum topics), *time constraints* (getting familiar to a new tool, long work preparation for the teacher and long lasting activities, registration, set up the technical logistics) and *missing translations* in the native language of the selected countries (problematic for young students, and increasing the needed teacher preparation time).

In case labs do not seem to match with any part of the curriculum, integration possibilities include the creation of a new lesson or topic or the introduction to a new topic in an existing subject, or even relating the lab to a topic of another existing subject. The lab could also be introduced as a practical research experience or as an end of the year project. Furthermore, in the cases where no binding curriculum exists, it could be introduced in curricula of private schools.

The analysis has provided a set of recommendations which aim to smooth the integration process of the Go-Lab portal's labs in the curricula. These recommendations encourage the practice of extracurricular activities and end of the year projects in STEM as well as the development of flexible activities, i.e., activities that can fit to various topics and thus link up to different labs. Moreover, the minimisation of the time constraints plus the translation of labs' materials and the promotion of interdisciplinary activities combining the teaching of English language with the selected scientific topic, could support the integration of labs in European curricula.

Regarding arising requirements for Go-Lab labs, some umbrella STEM subjects such as biology, chemistry and geosciences have been identified as lacking lab subjects. It is

recommended that new lab candidacies should focus on them as well as on activities that cannot be (at all or easily) carried out in the classroom.
Finally, to maximize the Go-Lab benefits, a checklist focusing on the easiness of laboratories' integration to Go-Lab Portal is presented in order to help addressing more precisely the process of compiling lab activities and resources. This checklist can be used separately or become an integral part of the Go-Lab portal.

Regarding its structure, this study consists of six parts:

- The **first part** describes the followed methodology regarding the collection of and analysis of information.
- The **second part** gives a view on each of the national education systems as long as an insight to the status of science education within each country. The combination of the two provides us already with a first set of suggestions regarding the integration possibilities of Go-Lab portal to the sample countries.
- The **third part** links the curriculum to the use of online labs. A summary presents the overall observations of the situation per laboratory in the sample of selected countries revealed by the raw data collected from curricula. Besides, this part gives some highlights of the analysis related to specific laboratories.
- The **fourth part** intends to provide preliminary conclusions and suggestions per country. Additionally, the requirements that arise from existing curricula for Go-Lab experiments are discussed.
- The **fifth part** presents the overall conclusions on the integration possibilities of the Go-Lab portal's laboratories in the national curricula of the various countries discussing possible enables and barriers to a successful integration.
- Finally, the **last part** puts together a collection of recommendations on factors and features that the portal's laboratories would have to address in order to achieve maximum integration on the various countries. As a final point, this report presents a checklist for the selection of online labs.

Table of Contents

1 Introduction

This report presents the output of a curriculum analysis of STEM subjects within the curricula of eight selected European countries and the possible integration of eight selected Go-Lab laboratories in them.

The sample selected countries is composed by: Belgium, Cyprus, Estonia, Germany, Greece, Poland, The Netherlands and UK-England. For Germany, the North Rhine-Westphalia state which is the biggest and most populated state, was chosen to represent the country. All countries together represent 43, 4%of the total EU27 population in 2012 (Eurostat, 2013).

The labs selected for this study were: Hypatia, CosmoQuest, VISIR Lab, Faulkes Telescope, SimQuest Elektro, ELVIS / OP– AMP Labs, Aquarium WebLab and Galaxy Crash.

The selection criteria of both countries and laboratories can be found in the section dedicated to the methodology which can be found under “

Methodology". The presentation of a consistent methodology, as well as conclusions and suggestions on the integration possibilities of the Go-Lab portal in the national curricula of the various countries are the output of this study. Moreover, this analysis presents a collection of recommendations on factors that should be taken into account when choosing laboratories to include in the portal and a lab-checklist that would support this process.

Aims

The aim of performing a curriculum analysis in a sample of different countries is to ensure that from a content and pedagogical approach point of view, the Go-Lab portal can be seamlessly integrated into the curricula of European countries (DoW – WP1, Task 1.4).

Moreover, efforts were made to take a step back and look into the specific countries' needs in order to be able to take them into consideration when formulating global recommendations on the integration of the Go-Lab portal into the national curricula.

Definitions

In the framework of Go-Lab project and as a first step in this study, it is fundamental to define what the terms Go-Lab portal and laboratory, or lab, consists of.

The *Go-Lab portal* offers a federation of online labs, as well as facilities to embed these online labs in pedagogically structured learning spaces by teachers. Go-Lab leverages on existing online lab repositories and increases their accessibility by offering lightweight end-user interfaces allowing teachers to use existing learning spaces or create their own.

An *online laboratory* consists of remote laboratories, virtual experiments, and/or data sets. More specifically, a *remote laboratory* uses telecommunications (usually computers, laptops or even smart phones) to remotely conduct real experiments, at the physical location of the operating technology. *Virtual experiments* are usually web-based interactive activities, replicating real laboratory experiments, but without having any interaction or access to real laboratory equipment. *Data sets* usually correspond to organised collections of data that are made available from the data owners and are intended for scientific use. In the Go-lab context these data sets can be measurements, results, images etc. Data sets are often presented together with dedicated tools to inspect and analyse the data.

2 Methodology

This study was carried out by screening national and local curricula of a group of selected countries to identify places where a sample of labs, to be included in the Go-Lab portal, could be integrated.
In reverse, curricula have been examined to further determine arising requirements for Go-Lab labs.

The curricula analysed corresponded to those for compulsory secondary education level, that is to say, in most cases for ages between 10 to 18 years old, since this matches the target audience of the concerned Go-Lab labs.

National and local, as in the case of Germany, curricula were screened with the goal of finding appropriate places where the Go-Lab laboratories can be integrated. Special efforts were made to identify all the potential problems and issues that may arise during that process, as long as suggesting ways of overcoming them.

Moreover, in reverse, existing curricula were examined to further determine arising requirements, bottlenecks, challenges and opportunities that can affect the integration of Go-Lab laboratories within the various curricula.

2.1 Selection of sample countries

A comprehensive curriculum analysis was performed from a representative sample of eight countries that included Belgium, Cyprus, Estonia, Germany, Greece, Poland, The Netherlands and UK-England. For Germany, the North Rhine-Westphalia state, its most populated state (länder), was chosen to represent the country.

The sample of countries was chosen based on three main facts that can be found below:

- The **countries of provenance of WP1 partners** were the main analysis was carried out. Preference was given to the Go-Lab members of the consortium participating into the work of WP1. There partners were responsible for carrying out part of the analysis related to their own country.
- The case of **Germany:** With the highest population among the EU member states (16, 25 % of the EU27 population, Eurostat 2013) the integration possibilities of Go-Lap portal to the national curriculum, is of great importance. However, as Germany is composed by 16 states (länder) each one deciding its own educational policies, diverse curricula can be found across the country. This is why the North Rhine-Westphalia state, the most populated state, has been selected to represent the whole country.
- The case of **Poland:** This country has been traditionally quite active and supportive when it comes to science and technology matters so the inclusion of its curriculum will enrich the diversity of the analysis and provide us with insight on the integration possibilities of Go-lab portal to Eastern Europe.

2.2 Selection of sample laboratories

Based on the online lab definition we have seen earlier, eight (8) laboratories were selected for this analysis, namely: Hypatia, CosmoQuest, VISIR Lab, Faulkes Telescope, SimQuest Elektro, ELVIS / OP – AMP Labs, Aquarium WebLab and Galaxy Crash.

The criteria led to the selection of the specific labs can be found below:

- **Subject diversity:** An effort was made to select laboratories that cover a wide range of subjects. Analysing the possibilities to include these laboratories to the various curricula will provide us with a wide overview on the integration possibilities of the Go-Lab portal, throughout the European curricula. Physics, astronomy, electrical engineering and chemistry are the main subjects covered by the selected laboratories.
- **Labs' importance and position in the implementation phase:** Priority was given to core laboratories that have been used during the initial phase of Go-Lab portal design (anchor labs: Hypatia, Faulkes Telescope, and Aquarium) while the remaining labs are to be implemented and integrated to Go-Lab portal, at the end of the current implementation phase.

2.3 Data collection and data analysis

1. Trial phase

As a first step, a trial data collection has been carried out by European Schoolnet (EUN). Thus, a first curricula analysis was done for four countries - Belgium, Poland, The Netherlands and UK-England - regarding the possibilities of integration for four online laboratories: Hypatia, CosmoQuest, Visir lab, and Faulkes Telescopes.

Based on this, dedicated templates (to be found in ANNEX I) were created in order to gather the rest of the raw data and to obtain specific feedback from WP1 partners who contributed to complete this study.

2. Collection phase

The task of data collection was equally distributed among the participating to the analysis partners.
Following the trial phase, each Go-Lab WP1 partner was responsible for the collection and for part of the analysis of the selected laboratories in relation to their national curriculum. EUN carried out the data collection and data analysis for Germany and Poland as well as the synthesis of the entire study.

3 Education systems, current status of Science education and integration possibilities for Go-Lab

In this section, the different education systems in the selected countries are described and visually presented. Descriptions focus on secondary education only as this corresponds to the target audience the Go-Lab portal is addressing.

Moreover, insights in the current status of science education in the specific countries are also provided leading to a set of integration opportunities for Go-Lab portal in the respective countries.
The information in this section comes mainly from Eurypedia[1], ex Eurydice, and the Observatory for new technologies in education (Insight[2]) website. The visual representations used are products of the Eurydice publication “The Structure of the European Education Systems” (European Commission, 2013)[3] following the index shown below:

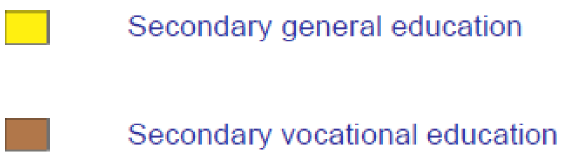

Figure 1. Index applying to education system diagrams

3.1 Belgium

Education levels structure

At around the age of 12, when graduating from primary school, students can enter the secondary education. For all three Communities (Flemish, Wallonia and German), compulsory schooling goes from the age of 6 to 15/16 on a full-time basis or to 18 on a part-time basis.

The secondary education consists of three cycles:

- First cycle (year 1 and 2, ages 12 and 13/14)
- Second cycle (year 3 and 4, ages 14/15 and 15/16)
- Third cycle (year 5 and 6, ages 16 and 17/18)

The first cycle provides a broad general basis. Students are able to choose a few optional courses such as additional mathematics, technology and Latin. The second and third cycles are much more specific in each of the possible directions. Although, core lessons are compulsory like the first language and sport, students have the possibility to choose between different sets of courses according to their interests.
From the third year of secondary education onwards, a distinction is made between four general types of education each of which contains options: general education, technical schooling, vocational education and art secondary education. Each type gives access to a set of different directions that may vary from school to school.

[1] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Main_Page
[2] http://insight.eun.org/
[3] http://eacea.ec.europa.eu/education/eurydice/documents/facts_and_figures/education_structures_EN.pdf

The *Secondary General Education, is* a very broad general education, preparing for higher education. Once students have completed their six-year study, they can access university or college. Possible directions include sciences and mathematics, apart from languages, economy and human sciences.

The *Technical Secondary Education* is divided into two sub-streams, one focusing more on technical aspects and the other one focusing more on practical matters. Among others, both offer a general education in mathematics and sciences. After the completion of all six years, students are either ready for the job market or to continue their studies in order to achieve a bachelor or master degree. Possible directions include practical ICT, Practical Engineering, Teaching, Health, and others.

For students looking for a very practical and job orientated education, the *Vocational Secondary Education* is the most suitable. Afterwards, that is to say, after six years of study, several directions offer one or two more optional specialisation years. Examples of possible directions are Carpentry, Car mechanics, Jewellery, Masonry and others. This is the only type of secondary education that does not qualify students to pursue higher education unless the student chooses to follow the optional 7th, and sometimes 8th, year.

In the *Art Secondary Education* schools link general secondary education with art practice. Directions include graphical and musical arts, ballet and acting. Graduate students often continue their studies at music conservatories, higher ballet, acting schools or art colleges. Depending on the direction closed, students can qualify to pursue higher education.

A visual representation of the education system in all three Belgian communities can be found below:

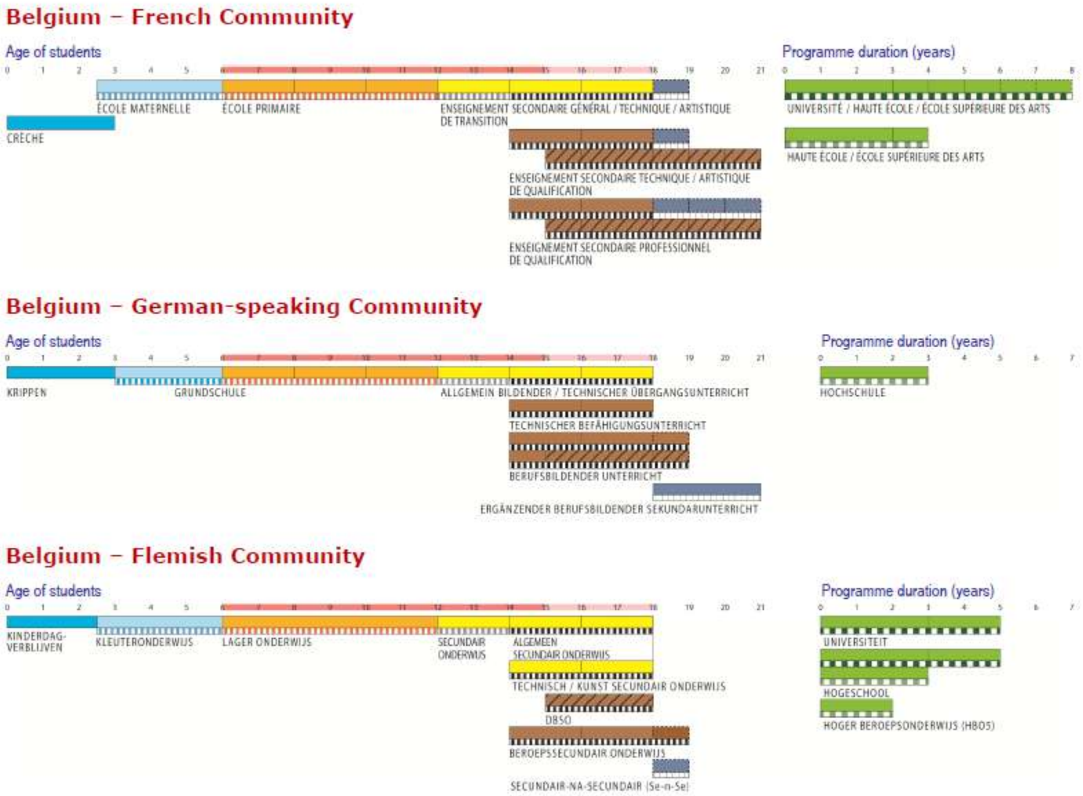

Figure 2. Education system - Belgium

Education governance

Competence for education in Belgium has been transferred to its communities, thus it is regulated and at a larger part financed by one of the three communities: Flemish, French and German-speaking.
Only the determination of ages for compulsory education and the minimum requirements for diploma conferrals are decided by the national government.

In the Flemish-speaking Community, the “Vlaams Ministerie van Onderwijs en Vorming”, or Flemish Ministry of Education and Training, is the one responsible for the policy preparation and implementation. In the French-speaking Community the “Fédération Wallonie-Bruxelles” (the French Community of Belgium) has all competences in education. The equivalent for the German-speaking Community is the “Ministerium der Deutschsprachigen Gemeinschaft”, the Ministry of the German-speaking Community.

Go-Lab integration possibilities

In Belgium, secondary schools are quite autonomous in the way they teach science. Science teachers in particular, receive detailed information on the topics they need to cover until the end of the academic year but the timing, teaching and actual content of these lessons is up to their own judgement and decision.

In the German community in particular and in an attempt to support what is being taught in the classroom, extracurricular activities are greatly supported while providing an opportunity to promote inquiry-based learning approaches within classrooms.

In Belgium, the first steps of inquiry based learning focusing on *observation*, *investigation* and finally the *evaluation* and *justification* of observations, are clear stated aims within the secondary education curriculum. Consequently, Go-Lab portal with its solid IBSE[4] basis has the opportunity to become a very useful and widely used tool in the hands of Belgian science teachers. What is really important in this case is to ensure the following:

- Provide short in duration activities that can be easily integrated within a lesson
- Activities should ideally cover small topics that can be easily integrated or adjusted to fit longer lessons. For example a teacher teaching Motion will need to cover the following topics:
    - Forces in nature
    - Newton laws
    - Speed & acceleration
    - Gravity
    - Vectors

Each of these topics can be supported and demonstrated using simulations. For example the Motion simulation provided by SimQuest[5] can be part of the lesson related to speed, acceleration and distance. This simulation can, for example, assist students to understand the relation among the various variables during the observation phase and form their hypothesis.

Reforms

In Belgium (Flemish Community), the Department of Education organised a survey in 2005 to find out to what extent pupils in primary education obtain the final objectives in the learning area 'world orientation'. In 2006, a similar survey was organised for biology at lower secondary level. The results of both surveys triggered a quality debate between all stakeholders on these final objectives. Consequently, changes have been made in the first stage of secondary education. The final objectives for biology have been expanded with a number of objectives for physics and some approaches to chemistry. These objectives were brought into force on the 1st September 2010. Improved science literacy was the basic underlying principle. Starting September 2013 an update of the final objectives for natural sciences in the second and third stages of secondary education is planned as a sequel to the changes that have already taken place in the first stage.

3.2 Cyprus

Education levels structure

In Cyprus, public education is free from the age of 4 years and 8 months to the age of 18.
The Secondary education in particular is organised in two different types:

1. *Secondary General Education*: offers a six-year educational programme for students aged between 12 and 18 and consists of two cycles of studies of three years duration each cycle, the first one being the Gymnasium and the second one the Lyceum.

[4] Inquiry Based Science Education
[5] http://www.simquest.nl/SQsims.jsp

At the Gymnasium (lower secondary school), the main orientation is the general humanistic education. Education at Gymnasium is compulsory for the first three years, up to the age of 15.

At the Lykeio (upper secondary school), the educational system is more flexible and offers various specialisations depending on the inclination, skills and interests of the students. The Upper Secondary cycle of the Public Secondary General Education offers a three-year duration programme for students aged between 15and 18.

2. *Secondary Technical and Vocational Education*: comprises the second cycle of secondary education only and it is open to pupils who have successfully graduated from the 3rd grade at the Gymnasium. This type of secondary education is offered in two streams, a theoretical and a practical one.

A visual representation of the education system in Cyprus can be found below:

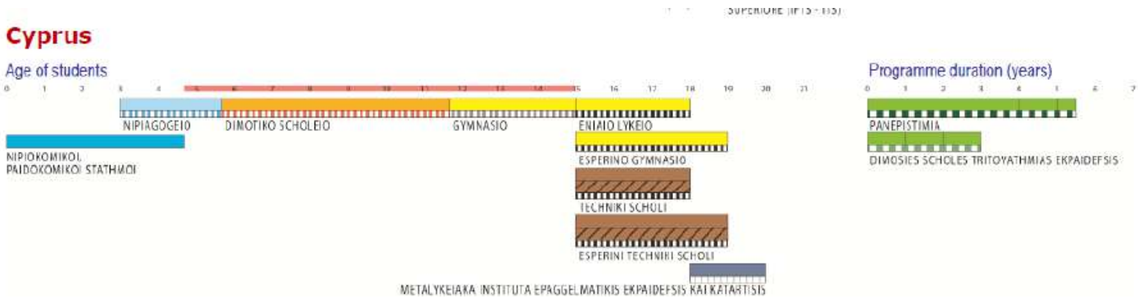

Figure 3. Education system - Cyprus

Education governance

The educational system of Cyprus is mainly centralized, but with elements of decentralization regarding the distribution of responsibilities. The main authorities or bodies responsible for education are the Council of Ministers, the Ministry of Education and Culture, the Education Service Commission and the Local School Boards. The Council of Ministers is the highest authority for educational policy. Overall responsibility for education rests with the Ministry of Education and Culture, except for a small number of higher education institutions which come under the Ministries of Labour and Social Insurance, Agriculture and Health.

The Ministry of Education and Culture is responsible for the administration of education, the enforcement of educational laws and the implementation of educational policy, the preparation of the education budget and educational bills and the construction of school buildings. Educational administration is centralized. Therefore, curricula, syllabuses and textbooks are set by the Ministry. The inspectorate of the Ministry of Education and culture has the overall responsibility for supervising the proper functioning of the schools (EUN website, 2013).

Go-Lab integration possibilities

As we have seen above, the teaching of science subjects in Cyprus is compulsory for every student only during the first three years of upper secondary education. For the remaining three years students have the flexibility to choose subjects based on their preferences and inclinations.

As a result the Go-Lab portal has an important role to play not only as an access provider to remote laboratories but also in increasing young students' interest in STEM careers. The use of online laboratories can support teaching, strengthen the use of IBSE and assist students into exploring a range of scientific directions.

A good example is the use of Galaxy Crash laboratory into teaching the motion of planets to upper secondary education students. In this example students should:

- Argue about the role of the sun in the planet motion.
- Present theories about the nature of the sun, the stars and their life cycle.
- Understand the light-year as an astronomical unit of length.
- Search and present information about scientific theories concerning the interpretation framework for the motion of planets.

Using Galaxy Crash, students can investigate and try their different theories, arriving to a set of conclusions that they can later use while presenting their arguments.

Moreover, schools have the possibility to offer activities outside of curriculum time and often decide to devote them to science subjects. Go-Lab portal has, through these activities, the opportunity to take on an inspirational role by providing access to a range of particularly challenging activities and labs that can provide scientific and inquiry based stimuli to students.

Reforms

In Cyprus, within the framework of a broader educational reform introducing the concept of key competences, the main changes in the new science curriculum relate to the modernisation of content. This includes the use of real everyday life situations as a tool and object of study, relating scientific skills to the development of pupils' key-competences and to the requirements for democratic citizenship, promoting problem solving and the use of ICT. Increased attention has also been paid to incorporate everyday life scenarios into assessment. The changes involve ISCED levels 1 and 2. Staff training and the piloting of material is currently in progress, with the gradual implementation of the new curricula scheduled to commence at the end of 2011.

3.3 Estonia

Education levels structure

In Estonia, Primary and Lower Secondary Education is organised as a single system (Estonian põhikool or basic school) of nine years of comprehensive and compulsory schooling starting at the age of 7.

- First grade (age 7/8)
- Second grade (age 8/9)
- Third grade (age 9/10)
- Fourth grade (age 10/11)
- Fifth grade (age 11/12)
- Sixth grade (age 12/13)
- Seventh grade (age 13/14)
- Eights grade (age 14/15)
- Ninth grade (age 15/16)

The Secondary education is divided into two streams:

1. *Secondary General Education*, which is a set of requirements established with the national curriculum and acquired in upper secondary schools. Upper secondary education is not compulsory, but a majority of the population participates. Graduated students of general secondary education qualify to pursue their studies for acquisition of higher education.

2. *Vocational secondary education*, acquired in vocational schools, involves a set of requirements established by the vocational education standard and by national curricula for professions or vocations. After graduation, secondary students are qualified to start working in the acquired profession or vocation as well as for continuation of higher education studies

Both in upper secondary and vocational schools, daily study activities are carried out according to the requirements of the national curricula.
The standard of Basic Education is determined by the national curriculum for basic schools (2010).
The Basic Schools and Upper Secondary Schools Act (2010) establishes the requirements for general secondary education, that is to say, the basis of organisation of study, the rights and responsibilities of students, parents and school staff as well as the basis of operating and financing a school and of state supervision. The requirements for Vocational Secondary Education are established by the Vocational Educational Institutions Act (1998).

A visual representation of the education system in Estonia can be found below:

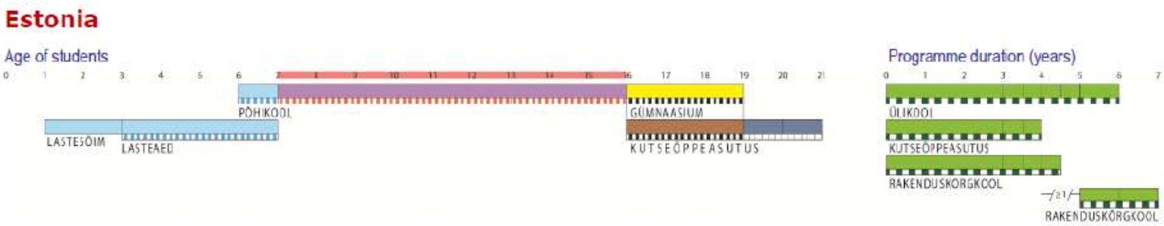

Figure 4. Education system - Estonia

Education governance

As well as in Cyprus, the education system is centrally managed, in this case, by the Ministry of Education and Research.

Go-Lab integration possibilities

In Estonia, the science curriculum is concentrating on the *observation* and *investigation* phases of inquiry learning. Special attention is also given to the *justification of explanations* and *explanation of scientific results*. Go-Lab portal, with its strong inquiry based background, scaffolding and activities can become a valuable, complementary tool in the hands of Estonian science teachers. Moreover, the organisation of extra curriculum activities aims mainly to supplement the science curriculum and help pupils to achieve the defined targets. The majority of these activities though are specifically designed for gifted and talented students. Consequently the need for the Go-Lab portal to provide activities ranging from simple to more challenging and from instantly available to more inspiring ones needs to also be taken into account.

Reforms

In Estonia, the new national curriculum for ISCED 1, 2 and 3 was approved by the government in January 2010. It emphasises inquiry-based science education and recommends that special attention is paid to foster positive attitudes towards mathematics, science and technology. Topics for all science subjects (general science, biology, chemistry, and physics) incorporate a list of practical activities, laboratory work, and guidelines for their implementation. The main goals in renewing the curriculum were to promote students’ scientific and technological literacy, to modernise curriculum content, to reduce students’ study load, and to include student-directed approaches and active learning methods.

Additional opportunities for using ICT are also indicated. The learning outcomes are formulated more specifically, which provides a good basis for the development of materials for teachers and students. More emphasis has been put on the development of students' personal motivation and the implementation of active learning methods. A very important change has also been the opportunity to divide classes into smaller groups in science lessons. The new national curriculum for upper secondary schools states that schools have to develop their fields of study (altogether 3 fields of study should be developed by each school); one of the fields must be focused on science and technology and provide compulsory and optional courses. The new curricula will be implemented from the start of the 2011/12 academic year.

3.4 Germany

Education levels structure

Compulsory schooling in Germany starts at 6 years old and last 9 years or 10. The German education system varies according to the states (Länder), which decides its own educational policies. Most children attend primary school (Grundschule) from the age of 6 to 10 years old covering grades 1 to 4. After the 4th grade, students follow a secondary education, which covers grades 5 to 12 or 13, depending on state.

Once students have completed the compulsory schooling period they can follow the upper secondary education. The range of courses on offer includes full-time general education and vocational schools, as well as vocational training within the dual system (*duales System)*. Students who have completed the upper secondary level can access institutions of higher education and other establishments that offer study courses that qualifies for entry into a profession.

In general, secondary education in the Länder is characterised by division into the various educational paths involving different qualifications for which different school types are responsible. There are five main types of school: *Hauptschule, Realschule, Gymnasium, Gesamtschule* and *Berufsschule.*

Lower secondary education:

1. The *Hauptschule*, involves grades 5 to 9. This type of school teaches the same subjects as the Realschule and Gymnasium, but at a slower pace and with some vocational-oriented courses. It prepares students for vocational education and finishes (after grade 9 or 10) with the final examination and diploma awarded called *Hauptschulabschluss*. This type of school lasts between 5 to 6 years in most Länder and students following it are aged between 10 to 15 years old. The *Hauptschule* leads to part-time enrolment in a vocational school combined with apprenticeship training until the age of 18.

2. The *Realschule* involves grades 5 to 10 in most Länder (ages 10 to 16 years old). This type of school has a broader range of emphasis for intermediate students and finishes with the final examination *Mittlere Reife* (after grade 10). It leads to part-time vocational schools and higher vocational schools. It is now possible for students with high academic achievement at the *Realschule* to switch to a *Gymnasium* on graduation.

3. The *Gymnasium* prepares students for university education or for a dual academic and vocational qualification, and finishes with the final examination *Abitur* (after grade 12 or 13). This type of school lasts between 8 to 9 years in most Länder and students following it are aged between 10 to 19 years old. The most common education tracks offered by the standard *Gymnasium* are classical language, modern language, and mathematics and natural science. In recent years many States have changed the curriculum so students can get the "*Abi*" at the end of the 12th grade. Other States are making the transition but may still require a 13th grade.

4. The *Gesamtschule*, or comprehensive school, is only found in some of the Länder. It takes the place of both the *Hauptschule* and *Realschule*. It enrolls students of all ability levels in

the 5th through the 10th grades. Students who satisfactorily complete the *Gesamtschule* through the 9th grade receive the *Hauptschule* certificate, while those who satisfactorily complete schooling through the 10th grade receive the *Realschule* certificate.

Upper secondary level:

5. The *Berufsschule* (15 to 17 years old, grades 10 to 12) combines part-time academic study and apprenticeship. The successful completion of an apprenticeship program leads to certification in a particular trade or field of work. These schools differ from the *Hauptschule* and the *Realschule* ones in that control rests not with the local and regional school authorities, but with the federal government, industry and the trade unions.

No matter what kind of school students attend, they must complete at least nine years of education.

In order to enter university, students are, as a rule, required to have passed the Abitur examination or have a Meisterbrief (master craftsman's diploma). Students wishing to attend a "university of applied sciences" must, as a rule, have Abitur, Fachhochschulreife, or a Meisterbrief.
The Fachhochschulreife or technical college in Germany, entitled to study at a technical college, and in some states to receive a bachelor's degree program at a university. The Meisterbrief (master craftsman) is a certificate and diploma in addition to the title, obtained after passing the master examination. It is considered equivalent a bachelor degree.

Lacking those qualifications, pupils are eligible to enter a university or university of applied sciences if they can present additional proof that they will be able to keep up with their fellow students through a Begabtenprüfung or Hochbegabtenstudium. The Begabtenprüfung is a college admission examination which provides an alternative to the Abitur or qualifies the student for a "field-specific Abitur" (Fachgebundene Hochschulreife).
The Hochbegabtenstudium is a programme that allows students of prerequisite intellectual ability (as shown on IQ-tests) to attend college even if they do not hold the Abitur. A person wishing to do the Hochbegabtenstudium must be of above average intellectual ability and must as a rule have completed at least 10th grade.

A visual representation of the education system in Germany, can be found below:

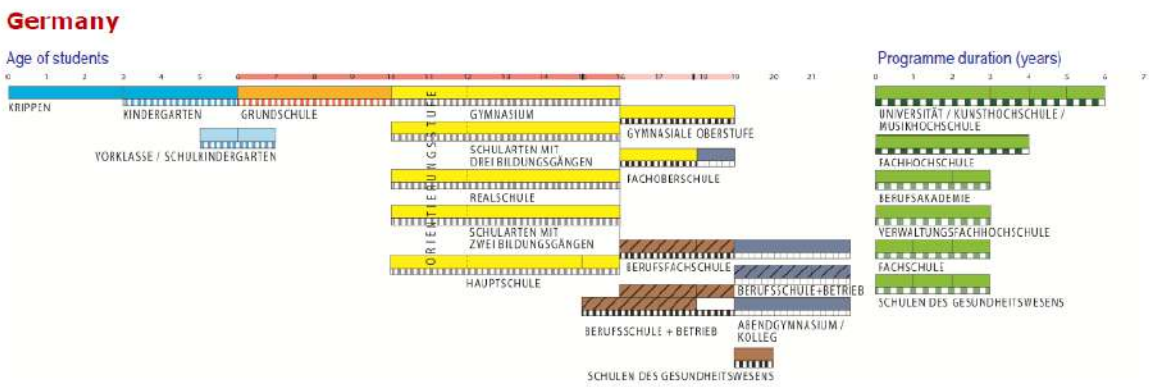

Figure 5. Education system - Germany

Education governance

The responsibility for the education system is divided between the Länder and the Federal Government, which plays a minor role. Responsibilities in the field of education for the second one are defined in the Basic Law (*Grundgesetz*). Unless the Basic Law awards legislative powers to the Federation, the Länder have the right to legislate. Within the education system, this applies to the school sector, the higher education sector, adult education and continuing education. Administration of the education system in these areas is almost exclusively a matter for the Länder.

The Basic Law also provides for particular forms of cooperation between the Federal Government and the Länder within the scope of the so-called joint tasks (*Gemeinschaftsaufgaben*).

On the federal level, within the framework of public welfare responsibility lies with the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (*Bundesministerium für Familie, Senioren, Frauen und Jugend* – BMFSFJ), on the level of the Länder, the Ministries of Youth and Social Affairs and, in part, also the Ministries of Education and Cultural Affairs, are the competent authorities.

Go-Lab integration possibilities

In Germany, under a Resolution of the Standing Conference of 2005 of the Ministers of Education and Cultural Affairs on activities of the *Länder* for the development of mathematics and science education, several programmes focused on partnerships have been carried out. The City of Science, Technology, and Media in Adlershof – Berlin organises activities targeted at secondary students. One of these activities 'School labs: learning by doing'[6] involves laboratory experiments on different science-related topics (32). Under the ELAN project – *Experimentierlabor Adlershof für naturwissenschaftliche Grundbildung*[7] (experimental laboratory for scientific literacy), chemistry experiments have been run since 2008 with sponsorship from the Department of Chemistry, Humboldt University of Berlin. The project is aimed at teachers and students from the 5th grade.

'School labs: learning by doing' provides access to companies' laboratories to more than 20000 secondary students per year. The main subjects it covers are: Chemistry, Physics, Mathematics, Informatics and Geology. With a target to double the number of students it gets involved per year, collaboration between *'School labs: learning by doing'* and Go-Lab can be quite beneficial for both sides.

"School labs" will get the opportunity to use Physics and Chemistry based Go-Lab activities in order to reach students that are not able to join the live sessions. Go-Lab activities can also be used as follow up activities that students who have followed a laboratory session can do in their own time and place in order to maintain their skills, practice or confirm their findings.

Go-Lab on the other hand can expand its outreach within Germany while receiving information and inspiration on the types of activities that students carry out in relation to other subjects. In

[6] http://genau-bb.de/
[7] http://www.tiemann-education.de/service/elan/

this way, Go-Lab can target better its search for appropriate laboratories and look into the design of activities that can be either remote versions or complementary to the existing ones.

ELAN offers experiments on the following topics of chemistry: dyes, detergents and fuel cells. The modules are based on themes of the Berlin curriculum framework and are designed for different grade levels of low and upper secondary education. Go-Lab has the opportunity to act as a provider of complementary chemistry activities that are present in all curricula and can act as preparatory and complementary activities. For example, online chemistry laboratories like virtlab[8] cover additional subjects like:

- Stoichiometry.
- Gases.
- Liquids, Solutions, and Phase Equilibrium.
- Chemical Equilibrium.
- Acids, Bases, and Ions.
- Kinetics.
- Thermodynamics.

Go-Lab portal, after the inclusion of this chemistry activities, will be an ideal addition to these initiatives, providing students and teachers with access to online laboratories and related to them activities based on the inquiry based model.

[8] http://www.virtlab.com

3.5 Greece

Education levels structure

Compulsory education in Greece starts from the age of 5 with pre-primary schools. After six years of primary school, students can attend the "Γυμνάσιο" or *Gymnasium* (Lower Secondary school) during 3 more years as follows:

- First grade (age 12/13)
- Second grade (age 13/14)
- Third grade (age 14/15)

These three years of lower secondary education are the last period of compulsory education.

There are 6 types of Gymnasiums in Greece:

1. General Gymnasium (entering there from the primary school is automatic)
2. Experimental Gymnasium
3. Art Gymnasium
4. Athletic Gymnasium
5. Ecclesiastical Gymnasium
6. Musical Gymnasium

Graduating from the Gymnasium is a prerequisite for enrolling to Upper Secondary schools, which are not mandatory. Upper Secondary Education last 3 years:

- First grade (age 15/16)
- Second grade (age 16/17)
- Third grade (age 17/18)

and it can be distinguished between:

1. *Secondary General Education* including Geniko Lykeio (General Lyceum)

2. *Vocational Secondary Education* including Epaggelmatiko Lykeio/Vocational Lykeio and Epaggelmatiki Scholi (Vocational high school, Vocational lyceum and Vocational school).

Lyceums also have different types Lykeia:

- Musical
- Ecclesiastical (self-sufficient and autonomous)
- Physical Education Schools B' grade
- Special A' grade

A visual representation of the education system in Greece can be found below:

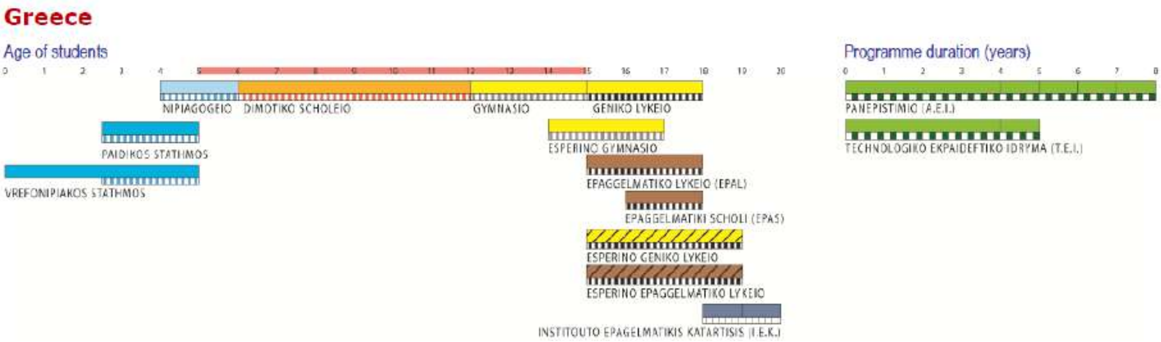

Figure 6. Education system - Greece

Education governance

The Greek administration of secondary education is under the responsibility of the Ministry of Education and Religious affairs and later of the Regional Education Directorates, the Directorates of Education and the School.

Go-Lab integration possibilities

In Greece, science subjects are compulsory for every student only during the first years of upper secondary education. After that period, students have the possibility to choose subjects based more on their preference and inclination.

Same as Cyprus, Go-Lab portal has an important role to play not only as an access provider to remote laboratories but also in increasing young students' interest in STEM careers. The use of online laboratories can support teaching, strengthen the use of inquiry learning and assist students into discovering a range of scientific subjects and careers.

Project work forms also part of the curriculum and is taking place on annual basis. Go-Lab portal has again the possibility to contribute to the diversity of project topics by providing a set of challenging activities that can for the basis to these projects.

Reforms

In Greece, in 2009/10 the Ministry of Education, Lifelong Learning and Religious Affairs set up committees which limited the material to be taught and prepared new teaching materials for various subjects including sciences. The intention has been to avoid repetition and ensure improved coordination between the different grades. The Ministry of Education also announced radical changes to curricula and systematic in-service training for teachers with a view to optimising the quality of the education offered as well as providing better continuity between ISCED levels 1 and 2.

3.6 Poland

Education levels structure

Compulsory education in Poland includes the final year of pre-primary education, 6-year primary education (stages I and II) and 3-year Lower Secondary education – Gymnasium – (stage III), that is to say from the age of 6 to 16.

Lower Secondary education comprises the following grades:

- Seventh grade (age 13/14)
- Eights grade (age 14/15)
- Ninth grade (age 15/16)

Students have to take two compulsory exams, one at the end of 6th grade when the students are 12/3, that will determine to which Lower Secondary school they will be accepted, and a second one to determine the Upper Secondary level school they will attend.

There are several alternatives from then on, the most common being 3-years study in a *Lyceum* or 4-years in a *Technikum* (stage IV). Upper secondary schools are not compulsory but are attended by the vast majority of the population in the age group 16-19/20 years. Lyceum and Technikum, both end with a maturity examination ("matura", similar to French baccalauréat), and may be followed by several forms of upper education, leading to Bachelor, Master and eventually PhD.

A visual representation of the education system in Poland can be found below:

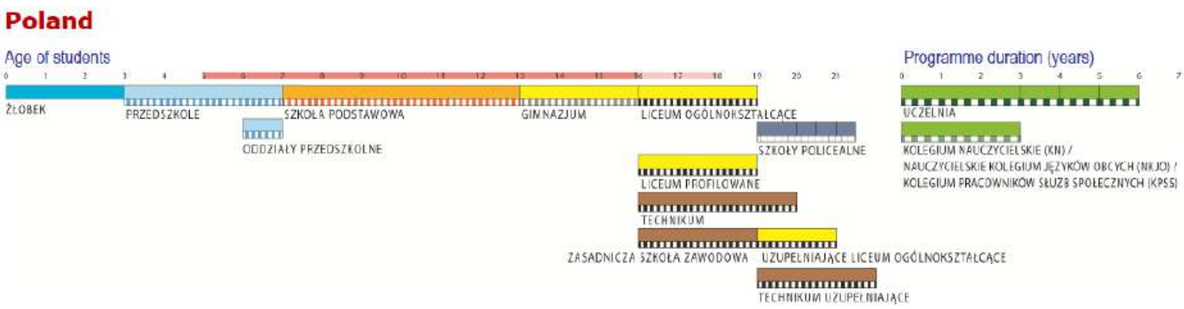

Figure 7. Education system - Poland

Education governance

Lower secondary schools are administered by commune (gmina) authorities as well as nursery and primary schools while upper secondary schools are administered by district (powiat) authorities.
The education system in Poland is centrally managed by the Ministry of National Education and the Ministry of Science and Higher Education.

Go-Lab integration possibilities

In Poland, science education at basic level ends after the second grade of the three-year general upper secondary education programme. When science is taught at the extended level, it lasts throughout the entire period of upper secondary education.

In upper secondary education students have compulsory courses in biology, geography, physics and chemistry, but they can also choose optional specialisation courses as well. In this light, the expansion of Go-Lab portal subjects to include *biology* and *geography* is very important.

Moreover, science classes are provided outside curriculum time within the programme 'Pupil Academy – Mathematicalscientific. Projects in Lower Secondary Schools' *(Akademia uczniowska. Projekty matematyczno-przyrodnicze wgimnazjach)* are also implemented by the Centre for Citizenship Education (CEO). The main aim of the programme is to promote laboratory methods in science subjects. Over 300 lower secondary schools in Poland will provide these extracurricular science classes within school science clubs. The programme has involved ca. 35 000 students in the 2011/12 school year. The use of Go-Lab portal in this framework can on one hand, assist the program into expanding its practices to Polish schools that do not have real laboratories and at the same time enrich Go-Lab portal with a series of activities focusing on laboratories practices, working methods and safety.

Reforms

In Poland, the curricular reform in science subjects focused on teaching both practical skills (carrying out laboratory experiments and field work) and intellectual skills (cause and effect reasoning, deduction, processing and creation of information, etc.); restoring the significance of the laboratory method; providing greater differentiation between knowledge levels within the basic programmes at the third and fourth stages of education while maintaining their coherence; ensuring continuity in science teaching from ISCED 1 to ISCED 3 while retaining proper levels of knowledge and skills and using suitable teaching methods at each stage. The core curriculum includes European recommendations for science teaching at ISCED level 2 and is intended to motivate, evoke interest and provide students with skills for further study of these subjects and everyday life. In 2010, the Central Examination Board announced a reformulation of the lower secondary school leaving exam for 2011/12, in which the science part (geography, biology, chemistry, and physics) has been separated from the previously combined mathematics and science part.

3.7 The Netherlands

Education levels structure

After attending primary education, usually by the age of 12 years old, students in the Netherlands go directly to secondary school (voortgezet onderwijs or continued education). Education is compulsory in the Netherlands until the age of 18.

Based on the results of the “Cito” test and on the advice of their primary school, students can choose to follow the VMBO, HAVO or VWO, the main three sorts of secondary education according to their abilities:

1. *Pre-vocational secondary education (VMBO)*: It lasts four years, that is to say, it is for students between the ages of 12 and 16. VMBO provides a basis for further vocational training and combines it with sciences, languages, mathematics, history and arts. Students may choose from four different levels of VMBO that differ in the ratio of practical vocational training and theoretical education

2. *Senior general secondary education (HAVO):* It lasts five years and it is addressed to students aged 12 to 17 years. HAVO consist of a basic general education and prepares students for higher professional education. The HAVO diploma is the minimum requirement for admission to HBO (universities of applied sciences) and provides access to the HBO level (polytechnic) of tertiary education.

3. *Pre-university education (VWO):* It lasts six years and it is for students aged 12 to 18 years. The VWO is divided into Atheneum and Gymnasium. The VWO curriculum prepares pupils for university and only the VWO diploma grants access to WO (research universities).

Students can transfer to other type of secondary education. That is to say, it is possible for students who have attained the VMBO diploma to attend the final two years of HAVO level education and take the HAVO exam, and for students with a HAVO diploma to attend the final two years of VWO level education and take the VWO exam. This flexibility grants students the right to access to a more advanced level of higher education.

HAVO and VWO are composed of two phases:

1. *The first phase*, the first three years of both HAVO and VWO, are called the basisvorming ("basic forming"). All students follow the same subjects: sciences, mathematics, languages, history and arts.

2. *The second phase*, the last two years of HAVO and the last three years of VWO corresponds to the Upper Secondary Education. This part of the educational programme allows choosing for "profiles” which emphasizes a specific area of study in which the student specializes. Among the profiles that can be chosen are "nature and technology" and "nature and health".

A visual representation of the education system in Netherlands can be found below:

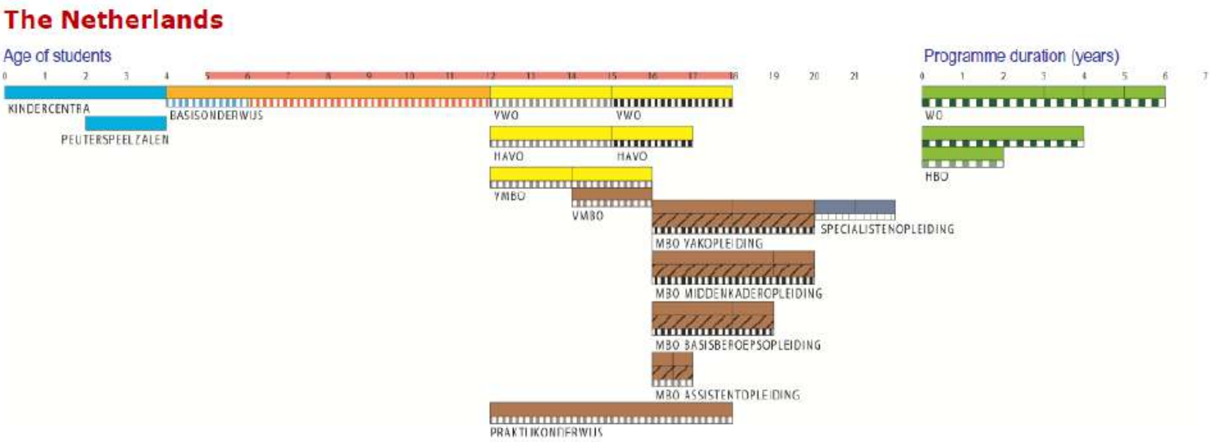

Figure 8. Education system – The Netherlands

Education governance

Regarding the education system management, the provinces have a limited role to play when it comes to managing education and its content. Provinces can perform supervisory and jurisdictional duties only. Overall responsibility for the public-private education system lies with the Ministry of Education, Culture and Science. The administration and management of schools of primary, secondary general and vocational education is locally organized.

Go-lab integration possibilities

In the Netherlands, Science education and the promotion of science careers is high on government's agenda. *Platform Bèta Techniek* and *Jet-Net* for example have been commissioned by the government, in order to ensure sufficient availability of people who have a background in scientific or technical education. Both *Jet-Net* and *Platform Bèta Techniek* provide schools within their networks with a variety of practices (activities) on various Science subjects that they carry out with their students. The aims of these practices are mainly to increase students' interest in STEM and the collaboration between schools and industry. Companies like AKZO, Basf and Shell chemicals can make use of chemistry laboratories like the one we have seen earlier, in order to strengthen their activities and better demonstrate the topics they wish to demonstrate.

The curricula flexibility provided to secondary education teachers offers also a number of opportunities to introduce Go-Lab to schools.

3.8 UK-England

Education levels structure

In England, full-time education is compulsory for all children aged between 5 and 17 (from 2013, and up to 18 from 2015) but the great majority of students continue with full-time education after the age of 16.

Compulsory education years are divided in Key stages. Key stages 1 and 2 belong to primary education. For secondary education the key stages are the following:

- Key stage 3: age 11 to 14 (years 7 to 9)
- Key stage 4: age 14 to 16 (years 10-11)

After secondary school (key stage 4), students are able to follow a post-compulsory secondary school until the age of 18/19 (years 12-13). That is to say, the upper-secondary level (age 16-18/19) doesn't fall within the compulsory education in the UK, thus no binding curriculum exists for this level.

All maintained schools in England are required to follow the National Curriculum, which is made up of core subjects: English, Mathematics and Science. These subjects are compulsory for all students aged 5 to 16. A range of other subjects, known as foundation subjects, are compulsory at one or more Key Stages. In addition, other subjects with a non-statutory programme of study in the National Curriculum are also taught, including Religious education in all Key Stages and Career education and Work-related learning in Key Stages 3 and 4.

A visual representation of the education system in UK can be found below:

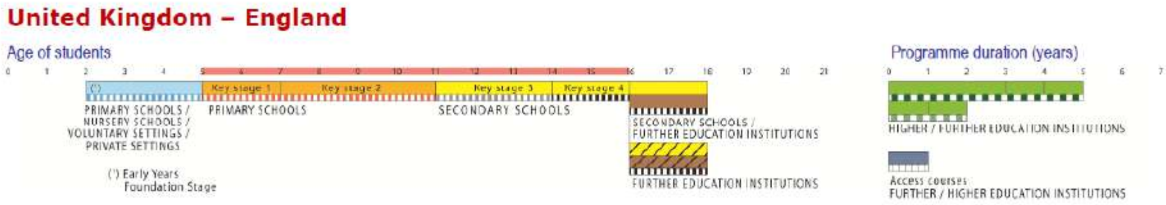

Figure 9. Education system - UK

Education governance

Regarding responsibilities, the central government has overall responsibility for the education system in England. However, the responsibility for the provision of education is decentralised, lying with local authorities, voluntary providers including churches, the governing bodies of educational institutions and the teaching profession. Overall responsibility for the education service lies with the Department for Education (DfE) and with the Department for Business, Innovation and Skills (BIS).

Go-Lab integration possibilities

In England, science education follows an integrated approach. Science subjects are compulsory for every student only during the first years of upper secondary education and then selection is possible based on students' inclination.

Moreover, schools are free to run their own school science activities in ISCED 1 and 2. In addition, and in the framework of STEMNET, a programme called "After School Science and Engineering Clubs (ASSEC)" aims to inspire key stage 3 students aged 11 to 14 (ISCED 2) to learn and enjoy science and engineering.

With the large majority of schools equipped with computer labs and average internet connections, English schools can greatly benefit from Go-Lab portal.

One important issue that needs to be taken into account though is that upper secondary education is greatly influenced by the CSCE exams where teachers and students are under pressure to cover specific subjects and topics in a strict time frame. The role of Go-lab portal on this matter can be quite catalytic when it comes to topics related to laboratory processes, use of telescopes and nano materials where the use of online laboratories can facilitate and complement teaching. Moreover activities related to the safe use of laboratories and operational procedures will also have the potential to be used by teachers.

Reforms

In the United Kingdom, since 2007/08, the curriculum and the examinations system have been revised including increasing young people's entitlement to separate science GCSE courses and reducing the factual content of the curriculum to allow for more engaging and innovative teaching during ISCED 2 and 3. For example, in England, there is now a new non-statutory entitlement to triple science (biology, physics and chemistry) teaching at GCSE for those who reach at least level 6 in science at Key Stage 3 (the expected level of performance at age 14). The Learning and Skills
Network (LSN) Triple Science Community has developed a generic programme to help all schools plan, develop and implement triple science; it will provide more intensive support to a small number of schools in need of additional assistance.

It is to be taken into account that the UK currently undertakes a curriculum change. Existing curriculum is valid until 2014. The final version of the new National Curriculum will be available in autumn 2013 for first teaching in schools from September 2014. For the latest the follow UK website can be followed at:
http://www.education.gov.uk/schools/teachingandlearning/curriculum

Conclusive summary

- In the European countries that have been selected for this study, the secondary education is generally organized in lower level and upper level. In most countries, the teaching of science education subjects is compulsory at the lower level but is based on preference/students' inclination during the upper level. As a result, Go-Lab portal activities need to cover both levels, taking into account their different educational and motivational needs.

- In continuation of the previous point, the Go-Lab portal has a role to play in students' preferences when it comes to the selection of STEM careers. Go-Lab portal has the capacity to provide students with an insight of laboratory work, widen their views and even positively influence their future choices in relation to STEM careers.

- In order to increase the integration possibilities of the Go-Lab portal, the subjects of *biology* and *geography* need to be covered either through dedicated laboratories or interdisciplinary activities (i.e., combining biology with chemistry).

- The use of *"Project"* appears in a variety of curricula either as official part of them like i.e., Greece or as part of extra curriculum activities i.e., Poland. In this light, the Go-Lab portal needs to incorporate a set of inspiring and longer activities that can form the basis to these kind of projects.

- Laboratories' activities need to fulfil different requirements. To sum them up and from analysing the current situation of science education in our sample countries, it became obvious that the Go-Lab portal needs to provide:

    - Short activities, to fit lesson hour, targeting specific topics
    - Inspiring activities going beyond the standard curricula requirements that can be used in Projects and extra curricula activities for more talented students
    - Activities related to the use of microscopes & telescopes matching the GCSE requirements in England

- Education systems are most of the times governed at national level (e.g., Cyprus, Estonia, Greece, Poland, Netherlands, and UK) though in some countries management is transferred to the communities (e.g., Belgium). As a consequence, several curricula have to be taken into account.

- For most countries, compulsory schooling goes from 5, 6 or even 7 years old to 16 or 17 years old on full-time basis or, to 18 years old on full-time (e.g., Cyprus, Netherlands) or on part-time basis (e.g., Belgium). Compulsory schooling implies the existence of available binding curricula.

- In some countries however, the Upper Secondary level (16 to 18/19 years old) does not fall within the compulsory education. As a consequence, no official binding curriculum exist and thus no curriculum analysis can be performed (e.g., UK, Estonia, Greece, Poland).

- In Estonia for instance, primary and lower secondary education are organised as a single system. This reveals that what is called secondary education in most countries means only the upper secondary education or vocational secondary education in this country.

- In Germany education is practically managed by the different states (Länder). At the same time five (5) different types of schools provide secondary education students with a variety of educational paths.

- Reforms are announced in Belgium (starting 2013), Cyprus (started in 2005 and currently under way), and the UK (phase 1 already completed and phase 2 starting from 2015). Reforms in most cases will lead to stronger presence of Science education within the curricula so attention needs to be given to all these future developments since they will have an impact on the way Go-Lab portal will be received in the next few years.

4 Linking the curriculum to the use of the Go-Lab laboratories

As we have discussed in the Methodology section, the raw data collected via the various partners provided us with loads of information on the various countries and led us to many useful conclusions regarding the role of the selected workshops in the selected countries curricula. The collected data can be found in ANNEX I.

Following each laboratory description and key features, data was collected through the means of tables indicating country, age-group, subject, topic, lesson (if applicable), and goals in relation to the laboratory described. Activities have been suggested concerning how the laboratory might be used to meet the goals of the topic to be taught. Moreover, comments are included where necessary, concerning the enablers or obstacles to using the laboratory in the specific country concerned in relation to the subject mentioned.

Some highlights of this analysis related to specific laboratories can be found below:

- With the Hypatia lab, students using the virtual lab are able to determine the total momentum from all particles tracked after a particle collision and calculate the missing momentum. They also learn to identify the tracks of different particles and seek to find events that could indicate the existences of the Higgs boson. Hypatia addresses mainly upper secondary education students and requires high level knowledge of Physics. At the same time, it offers integration possibilities to a variety of subjects namely Physics, Mathematics, Energy, Chemistry and related topics. With the exception of Energy, the remaining subjects are taught in all analysed countries which reveals not only the integration possibilities of the lab but also the interdisciplinary opportunities arising from its use.

- Galaxy Crash is a great example of a how a phenomenally “simple” yet nicely made laboratory, can attract students and motivate them to investigate a series of small topics bridging different subjects. In Galaxy Crash students are asked to make predictions on how galaxies form and evolve in the Universe. What looks like an astronomy based activity quickly expands to more Physics oriented matters. Students use the ‘Galaxy Crash’ tool to simulate the evolution of 2 disc galaxies over time, and see if the results match their predictions. They look into their properties and the way galaxies move (i.e., distance, velocity etc.) They then try and use the ‘Galaxy Crash’ software to reproduce the images which they have found and draw conclusions on the initial conditions from which the interacting galaxies came from, and what they might expect to happen to the galaxies in the future. This lab aims to demonstrate how scientists work, how, through the use of simulations astronomers can draw conclusions on what they observe in the Universe and to help explain how galaxies evolve in the Universe.

- Faulkes Telescopes Project motivates students by giving them the possibility to manipulate remote telescopes, thus allowing them to become actors in real research-based science. Even if this lab focus on Astronomy and Physics, the integration possibilities that have been identified also include Earth Sciences and Mathematics (Geometry and Trigonometry). Any of the mentioned subjects could integrate it as part of curricular or extra-curricular activities. In order to make the most of it, particularly in Astronomy, Faulkes can also be used in combination with SalsaJ analysis tool that allows students to display, analyse, and explore real astronomical images and other data. A precious advantage of Faulkes is the fact that teachers are supported by a range of educational materials and a team of educators and astronomers. They can also benefit from personalised training and support that is tailored to the age range of students they teach. The most important disadvantage though is that currently only schools in the UK and in Ireland are allowed to book time on the telescopes. Fortunately, it is envisaged to be expanded.

- Using the Aquarium lab, students can perform different experimentations and actions. The buoyancy force and the Archimedes' Principle can be put into practice and investigate the relation between volume, mass and density. Students can throw balls filled with different liquids (water, oil and alcohol) into the water and take them out using a web interface. How much of the ball is over or below the water can be seen by students through a web cam. The access to a real aquarium also allows users to perform other actions such as feed the fish, turn on and off the lights, and control the submarine. It is a simple, yet a well-made and easy to use laboratory targeting students at the end of their primary education mainly for the simplest activities and lower secondary students mainly for the Archimedes' Principle related experimentation. Simple activities allow teachers to introduce this lab in the context of other subjects different to Physics (biology, natural sciences) in the case of primary school students. As buoyancy and Archimedes' Principle within the subject of physics is widespread in European curricula, it has been seen that this lab doesn't present any obstacle concerning its integration possibilities. Offering translations to 9 official EU languages and 1 ES dialect is one of its interesting advantages.

- One case to mention due to the difficulties found when searching for integration possibilities to the curricula is Elvis / OP – AMP Labs. Elvis is a well-made and an easy to use lab. It covers an interesting subject since it focuses on the operational amplifiers, specifically on how they work. Users are able to experiment using predefine electric circuits with operational amplifiers and test their behaviour in different possible configurations. In relation to European curricula, this lab offers integration possibilities within two main subjects namely Engineering and Physics (in subjects such as electricity and current). However, in three of the eight analysed countries no subject has been identified that matched the use of this lab. This is mainly due to the fact that its focus on a very specific aspect of electronics not covered by all curricula. In order to promote its integration, this lab could be proposed as a good candidate to be included in extracurricular activities or end of the year projects as a minor or no guidance is required from teachers. As a nice advantage, this lab is made accessible through a variety of platforms (Windows, Linux etc.).

Conclusive summary

The points below summarize the overall observations concerning classroom requirements for lab use:

- For most laboratories, subject-background preparation is required in order to prepare students to carry out the selected lab activities.

- Matching with curricula exists for most laboratories since subjects such as astronomy, physics, mathematics and electronics are part of school curriculum in all analysed countries

- The only laboratory that integration to the curricula is hard to materialise is the ELVIS/OP-AMP (amplifiers). The main reason for this is the fact that lab is focusing on a very specific aspect of electronic engineering which is not included in the curricula. Integration possibilities to the curricula still exist since the lab in question can be used as part of wider activities and in combination with other laboratories

- The basic technical/logistical issues that contributors have reported as first level blockages are:
    - Lack of translations into respective languages
    - Need of registration to access labs (combination of technical difficulties and time limitations)

5 Curriculum analysis: conclusions and suggestions

This section presents the overall findings, i.e., the preliminary conclusions and suggestions per country as well as the arising requirements for Go-Lab experiments.

5.1 Preliminary conclusions and suggestions per country

5.1.1 Belgium

The overall results from the analysis of the selected labs in relation to the Belgian national curriculum for both Wallonia and Flemish part, can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
FRENCH			
1. Hypatia	Physics and Mathematics (14-18 years old). Physics topics: Structure and properties of matter, elementary particles: the structure of atom and nucleus; Links between macro- and microscopic phenomena; Special theory of relativity and Energy: nuclear fusion and fission. Maths topics: Data processing and analysis.	NA	• Issues related to teachers' competencies: Mathematics teachers might face difficulties when trying to get familiar with the quantum physics topic in general and with the ATLAS research in particular. • Timing issues: a good understanding of the topic background is time-consuming particularly for mathematics teachers (in comparison with physics teachers) as some preliminary tasks must be carried out before starting to use the lab: becoming familiar with the background information and the detector, understandings the aims of the analysis tools and the physics quantities that will be measured, learning how to use HYPATIA and having an overall view of the

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
			educational project. Also, some of the projects to be carried out by the students/class can be accomplished in few hours but others could take more time, depending on the number of events and detail they are/the teacher is willing to reach.
2. Cosmoquest	Physics (14-18 years old). Physics topics: The space and the Earth: the nature of the main celestial objects; Evolution of the Universe.	NA	NA
3. Visir Lab	Physics topics: Physics (14-18). Electricity: Ohm's law, Kirchhoff's law, electrical circuits.	NA	NA
4. Faulkes Telescope	Physics and Mathematics (14-18 years old). Physics topics: The space and the Earth: the nature of the main celestial objects. Evolution of the Universe. Maths topics: Geometry and Trigonometry.	NA	NA
5. SimQuest Elektro	Scientific Training and Physics (12-14 and 14-16 years old). Scientific Training and Physics topic:	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Electricity.		
6. Elvis/OP-AMP Labs	Physics (14-16 years old). Physics topic: Electricity.	NA	NA
7. Aquarium WebLab	Scientific Initiation (8-12 years old). Scientific Initiation topic: Nature.	NA	NA
8. Galaxy Crash	Physics (14-16 years old). Physics topics: The universe and earth.	NA	NA
DUTCH			
1. Hypatia	Physics and Mathematics (16-18 years old). Physics topics: Matter and radiation - Cosmology and elementary particles. Maths topics: Real functions and Statistics.	NA	Issues related to teachers' competencies (Refer to Hypatia for Belgium-French) Timing issues: (Refer to Hypatia for Belgium-French)
2. Cosmoquest	Physics (16-18 years old). Physics topics: Movement and force: motion of the moon; Gravitational force between bodies; Movement in space.	NA	NA
3. Visir Lab	Physics (16-18 years old). Physics topics: Electricity and Magnetism: the	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	relationship between voltage, change in electric potential energy and electric charge; Electrical circuits.		
4. Faulkes Telescope	Physics (16-18 years old) and Mathematics (14-18 years old). Physics topics: Physics and the Cosmos; Cosmology and elementary particles. Maths topics: Geometry.	NA	NA
5. SimQuest Elektro	Nature (15-18 years old). Nature topic: Electricity and Magnetism.	NA	NA
6. Elvis/OP-AMP Labs	Nature (15-18 years old). Nature topics: Electricity and Magnetism.	NA	NA
7. Aquarium WebLab	Environmental Studies (8-12 years old). Environmental Studies topic: Environment.	NA	NA
8. Galaxy Crash	Natural science (12-14 and 14-16 years old). Natural science topic: Scientific skills (12-14 years old) and Physics	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	(14-16 years old).		

Go-Lab inclusion to Belgian curriculum

The majority of analysed laboratories can easily be integrated to the Flemish and Wallonia curricula. The only lab which seems to need extra attention is Hypatia where teachers using it, will need to put extra effort into preparing themselves and their students before carrying out the actual activities. Time consuming preparation will also have an impact on the overall duration of the activities.

5.1.2 Cyprus

The overall results from the analysis of the selected labs in relation to the Cyprus national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Physics common core and major courses (16-17 years old); Physics elective course (17-18 years old). Physics common core course topics: Solar System and Atomic Physics. Physics major course topic: Atomic Physics. Physics elective course topics: Nuclear Physics and Electron transfer in electric and magnetic field.	NA	NA
2. Cosmoquest	Physics (15-16 years old); Physics common core (16-17 years old) and major courses (16-17 years old).	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Physics topic: Circular motion. Physics common core course topics: The Solar system and the Universe. Physics major courses topic: Gravitation		
3. Visir Lab	Physics (14-15 and 15-16 years old), Physics common core and major courses (16-17 years old) and Physics elective course (17-18 years old). Physics topics: Electric circuit (14-15 years old) and Electromagnetism (15-16 years old). Physics common core course: Electricity. Physics major course: Direct electric current. Physics elective course: Alternating Current (AC).	NA	NA
4. Faulkes Telescope	Physics common core course (16-17 years old). Physics common core course topic: The Solar system and the Universe.	NA	NA
5. SimQuest Elektro	Physics (13-14 years old) and Physics major course (16-17 years old).	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Physics topic: Electricity. Physics major course topic: Static Electricity. Physics common core course: Electricity.		
6. Elvis/OP-AMP Labs	NA	Science educators in Cyprus tend to use on-line simulations in their classrooms when the right equipment is at place (e.g., computers for all students are available), the simulations are compatible with the national curriculum (e.g., the emphasis is on concepts/variables examined in the curriculum) and the teachers have received relevant training. All these factors need to coexist, otherwise the number of teachers using them becomes limited. The main sources of simulation are from ready-made software, such as of 'Crocodile Physics' and 'Interactive Physics', customary made multimedia environments that also include simulations (these were made from the ministry of education for the last three grades of high-school to match the national curriculum), and online simulations, such as 'PhET'. All these simulations operate outside the context of a learning management platform, such as the one we are planning to make	This lab could be introduced as an extracurricular activity

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
		for GoLab.	
7. Aquarium WebLab	Physics (14-15 years old). Physics topics: Buoyancy	NA	NA
8. Galaxy Crash	Physics (15-16 years old); Physics common core and major courses (16-17 years old); Physics topics: Circular motion. Physics common core course topics: The Solar system and the Universe. Physics major course topic: Gravitation.	NA	NA

Go-Lab inclusion to Cypriot curriculum

The majority of analysed labs can also be easily integrated to the Cypriot curriculum target the upper secondary education with students' ages varying between 14-18 years of age. In the case of Elvis OP/AMP labs were no direct link with the curriculum is available, the creation of simulations that can fit with the curriculum is suggested. Moreover, use of the lab in the frame of "project" creation targeting more advanced students, can also be any option.

5.1.3 Estonia

The overall results from the analysis of the selected labs in relation to the Estonian national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Science (13-16 years old); Mathematics, Physics and ICT (16-19 years old); Physics (17-18 years old, 12th grade). Science topics: Structure of matter, Elementary particles, weak and strong interactions. Maths topics: Statistics. Physics topics: Structure and properties of matter, elementary particles: the structure of atom and nucleus (16-19 years old); Nuclear Phenomena (17-18 years old). ICT topics: Data processing, data analysis, databases.	NA	Possible issues would be related to teacher's competences and to lesson preparation, which can be time consuming if the teacher has little knowledge on particle physics. Moreover, HYPATIA lab is not available in Estonian.
2. Cosmoquest	The environment, Earth and universe (10-13 years old); ICT and Physics (16-19 years old). The environment, Earth and universe topics: Astronomy and space science: the nature and observed motions of the sun, moon,	NA	COSMOQUEST lab is not available in Estonian. Apart from this language issue, the lesson preparation can be time consuming. Other possible issues identified are related to teacher's competences (ICT teachers).

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	stars, planets and other celestial bodies. ICT topics: NA Physics topics: Gravitation and astronomy: Solar system, galaxies, evolution of the universe; Movement in space; Movement and force: motion of the moon; Gravitational force between bodies; Movement in space.		
3. **Visir Lab**	Mechatronics and robotics (16-19 years old) and Physics (16-18 years old). Mechatronics and robotics topics: Electronics, Electric current, electronic circuits. The use of electricity: electrical current, ohmic resistance, series and parallel circuits. Physics topics: Electricity and Magnetism: the relationship between voltage, change in electric potential energy and electric charge Electrical circuits. Electrical power: its transfers and control, the use of electrical power.	NA	VISIR lab is not available in Estonian, which has been highlighted as a factor that could discourage teachers and students to use it.
4. **Faulkes Telescope**	The environment, Earth and universe (10-13 years old); Science (13-16		Registration to FT is not available for Estonia. Another possible issue could

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	years old); Mathematics, Astronomy and Physics (16-19 years old). The environment, Earth and universe topics: Astronomy and space science: the nature and observed motions of the sun, moon, stars, planets and other celestial bodies. Science topics: Solar System and Universe; Earth and universe. Maths topics: Geometry; Trigonometry. Astronomy, Physics topics: Solar System and Universe; Earth and universe.		be related to lesson preparation, which can be time consuming.
5. SimQuest Elektro	Physics (13-16 and 16-19 years old); ICT and Mechatronics & Robotics (16-19 years old). Physics topics: Electricity (13-16 years old); and Energy: Electric current. ICT topics: Applications: Practical work and use of ICT. Mechatronics &	NA	This lab is not available in Estonian This lab requires ICT basic tools, including applications software, a web browser, and presentation software. Apart from access to computers with broadband as students do not need any electricity expertise there are no issues to mention. Timing issues: a good understanding of the topic background is time-consuming.

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Robotics topics: Applications of alternating current.		
6. Elvis/OP-AMP Labs	Engineering (15-18 years old). Engineering topics: NA	Electricity and electronic circuits are topics that are part of school curriculum in High School (Year 10-12; age 16-19). Thus, the integration of the ELVIS / OP – AMP LABS should be a possible extra topic for advanced students.	Language issue (Refer to SImQuest Elektro previous point) ICT requirements (Refer to SImQuest Elektro previous point) Timing issues (Refer to SImQuest Elektro previous point)
7. Aquarium WebLab	Science, Physics (13-16 years old). Science, Physics topics: Quantitative Description of Bodies.	NA	Apart from access to computers with broadband as students do not need any expertise there are no issues to mention.
8. Galaxy Crash	Astronomy and Another Kinds of Physics (optional course) (15-18 years old). Astronomy topics: Physics of the mega world. Another Kinds of Physics topic: Galaxies.	NA	ICT requirements (Refer to SImQuest Elektro for Estonia).

Go-Lab inclusion to Estonian curriculum

Similarly to the other countries, in Estonia the majority of selected laboratories fits seemingly to the national curriculum. Since in Estonia the lower level secondary education has the possibility to teacher subjects in different levels addressing students' specific capacities and needs, the Elvis OP/AMP labs can be used for the more advanced students

5.1.4 Germany-North Rhine-Westphalia state

The overall results from the analysis of the selected labs in relation to the German regional curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Physics (15-18) Atom and quantum physics Nuclear physics and atomic structure Quantum effect	NA	•Only simplified version might be useful when it comes to school education and complexity of the subject and the lab itself. It might be too time consuming even for the teachers to get to learn the program. •Only available in English – too time consuming and difficult to understand when it comes to formula and technical terms, even for teachers. In addition teachers and students need to learn how to handle the program. •The JAVA plugin and/or the downloadable program might cause a problem due to administrational restrictions. It might take weeks until the program or the plugin are installed.
2. Cosmoquest	Physics Geography English	NA	•The lab could be used when there is time for a school project or there are project days. The topic of this project should be astronomy and subjects as Biology, Geography, Physics and even English could be combined. It's an opportunity to show that English is necessary for a great deal of subjects and professions. But it might be too difficult to get all information of this topic in English – even with the tutorials in lower classes. Teachers would need to have a look on the lab and the whole subject itself before starting such a project. The hangouts in the learning space could be a great start to get into astronomy and arouse interest in the students. The language is easy to understand and everything is explained in an appropriate way – again teachers would need to look through the hangouts (every single one around ~1 hour length!) and see which one would fit the topic chosen for the project.

			•If explained by teachers even lower classes could be able to mark craters with the lab. Though this task is not challenging for a longer time this might just be an exercise for one lesson imbedded in the topic of astronomy.
3. Visir Lab	13-15 Optic instruments Optic Instruments, colour dispersion of light 15-18 Physics About times and spaces - view of the world (school projects matches)	NA	Only peripheral matches to Physics could be found.
4. Faulkes Telescope	13-15 Physics Optic Instruments, colour dispersion of light 15-18 Physics About times and spaces - view of the world	NA	Only peripheral matches to Physics could be found.
5. SimQuest Elektro	15-18 Physics	NA	NA
6. Elvis/OP-AMP Labs	Physics (16-18 years old). Physics topics: Electronic.	NA	• Due to administrational restrictions it might take weeks to get these plugins (Java runtime engine and flash) installed on all needed devices.

7. Aquarium WebLab	Physics (13-16 years old). Physics topics: Force, compression, mechanic and inner energy.	NA	
8. Galaxy Crash	16-18 Physics Gravity	NA	The lab could be used as an additional example for gravity.

Go-Lab inclusion to German-NRW curriculum

Integration of the selected laboratories to the German regional curriculum was proved to be quite feasible in upper secondary education. The use of Project as part of the curriculum has facilitated the integration of certain laboratories where the covered topics could not find a direct match to the curriculum. Some technical difficulties concerning the installation of plugins and software have also been noted but the allowance of adequate time and in advance planning should be able to overcome them.

5.1.5 Greece

The overall results from the analysis of the selected labs in relation to the Greek national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Mathematics (14-15 years old); Physics (15-16 years old -12th grade- and 16-19 years old); Projects (15-16 years old -10th grade-). Maths topics: Vectors. Physics topics: Quantities that are conserved (15-16 years old); Nuclear physics: structure of atom and nucleus and relations between mass and energy (16-19 years old).	NA	Teachers need to be acquainted with the lab beforehand. Best if students work in teams.

2.	**Cosmoquest**	Geography (11-12 years old). Geography topic: Means of recording and picturing geographical elements.	NA	NA
3.	**Visir Lab**	Projects (15-16 years old) and Physics (16-17 years old). Physics topics: Electric current.	NA	Teachers need to be acquainted with the lab beforehand.
4.	**Faulkes Telescope**	Natural Sciences in our everyday life (10-11 and 11-12 years old); Projects (15-16 years old); Astronomy (16-17 years old). Natural Sciences in our everyday life topic: Research in Astronomy. Astronomy topics: Stars, Galaxies, Space.	NA	Teachers need to be acquainted with the lab beforehand.
5.	**SimQuest Elektro**	Physics (14-15 and 15-16 years old) and Projects (15-16 years old). Physics topics: Electricity – Simple Circuits (14-15 years old); Electricity – Direct Current (15-16 years old).	NA	In Greece many schools don't have a real lab for such experiments or a very much under-supplied. Plus, as making real experiments with electricity could be proved a source of hazard for students, this lab could be very useful. Best if students worked in teams.
6.	**Elvis/OP-AMP Labs**	Projects (15-16 years old); Department of Engineering (16-17 years old) and Department of Electronics (17-18 years old). Department of	NA	NA

		Engineering and of Electronics topic: Electrical elements.		
7.	**Aquarium WebLab**	Physics (10-11 and 13-14 years old). Physics topics: Materials and the structure of matter (10-11 years old) and Pressure (13-14 years old).	NA	NA
8.	**Galaxy Crash**	Natural Sciences in our everyday life (10-11 and 11-12 years old); Physics (14-15 years old); Projects (15-16 years old); Astronomy (optional course) (16-17 years old). Natural Sciences in our everyday life topic: Research in Astronomy. Physics topics: Matter and Energy – Forces. Astronomy topics: Galaxies.	NA	NA

Go-Lab inclusion to Greek curriculum

Integration of the selected laboratories to the Greek curriculum proved to be quite straightforward. The only issues that teachers need to take into account is the preparation time needed for both themselves and their students before being in a position to actually use and benefit from the labs. Moreover, the majority of labs promote teamwork which makes the selected laboratories good candidate for the Project part of the curriculum.

5.1.6 Poland

The overall results from the analysis of the selected labs in relation to the Polish national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Physics (15-18 years old); Mathematics and ICT (16-19 years old) Physics topics: Matter: Development of models for the building blocks of matter in the course of time; Quantum world: quantum model of matter; Nuclear and particle processes. Maths topics: Functions; Statistics. ICT topics: Data processing, data analysis, databases.	NA	• Issues related to teachers' competencies: Mathematics and ICT teachers might face difficulties when trying to get familiar with the quantum physics topic in general and with the ATLAS research in particular. • Timing issues: a good understanding of the topic background is time-consuming particularly for mathematics and ICT teachers (in comparison with physics teachers) as some preliminary tasks must be carried out before starting to use the lab: becoming familiar with the background information and the detector, understandings the aims of the analysis tools and the physics quantities that will be measured, learning how to use HYPATIA and having an overall view of the educational project. Also, some of the projects to be carried out by the students/class can be accomplished in few hours but others could take

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
			more time, depending on the number of events and detail they are/the teacher is willing to reach.
2. Cosmoquest	Physics (16-19 years old). Physics topics: Gravitation and astronomy: Solar system, galaxies, evolution of the universe; Movement in space; Movement and force: motion of the moon; Gravitational force between bodies; Movement in space.	NA	NA
3. Visir Lab	Physics (13-16 years old). Physics topics: Electricity: Electrical circuits, Ohm's law, measurement units of electricity and electrical current.	NA	VISIR lab is not available in Polish, which has been highlighted as a factor that could discourage teachers and students to use it.
4. Faulkes Telescope	Physics and Mathematics (16-19 years old). Physics topics: Gravity and elements of astronomy. Maths topics: Geometry; Trigonometry.	NA	NA
5. SimQuest Elektro	Physics (15-16 and 16-19 years old).	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Physics topic: Electricity (15-16 years old) and Current (16-19 years old).		
6. **Elvis/OP-AMP Labs**	Physics (15-16 and 16-19 years old). Physics topic: Electricity (15-16 years old) and Current (16-19 years old).	NA	NA
7. **Aquarium WebLab**	Physics (15-16 and 16-19 years old)	NA	NA
8. **Galaxy Crash**	Physics (16-19 years old). Physics topics: Gravity and elements of astronomy.	NA	NA
9. **Microcontroller platform in robotic lab.eu**	Informatics - Computer programming (15-16 and 16-19 years old). Informatics - Computer programming topics: NA	NA	NA

Go-Lab inclusion to Polish curriculum

Integration of the selected laboratories to the Polish curriculum was also proved to be quite straightforward. The only issues that teachers need to take into account is the effort and preparation time needed for both themselves and their students before being in a position to actually use and benefit from the labs.

5.1.7 The Netherlands

The overall results from the analysis of the selected labs in relation to the Greek national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. **Hypatia**	Chemical and material behaviour; Energy, electricity and forces & Mathematics (15-18 years old). Chemical and material behaviour; Energy, electricity and forces topics: Structure of matter, Elementary particles; weak and strong interactions or other. Maths topics: Information processing; Algebraic relations: graphs and formulas on the relationship between quantities and variables, mathematical models.	NA	• Issues related to teachers' competencies (Refer to Hypatia for Belgium-French) • Timing issues: (Refer to Hypatia for Belgium-French)
2. **Cosmoquest**	Physics (15-18). Physics topics: Solar system and universe: the origins, development and characteristics of the universe, motion in the solar system.	NA	NA
3. **Visir Lab**	Physics (15-16 years old). Physics topics: The use of electricity: electrical current, ohmic resistance, series and parallel circuits.	NA	NA
4. **Faulkes Telescope**	General sciences; Physics and Mathematics (VWO, 12-17 and HAVO, 12-18 years old) and Mathematics (VMBOb, 12-16 years old). General sciences; Physics topics: Solar System and Universe;	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Earth and universe. Maths topics: Measurement and Geometry (VWO, HAVO and VMBOb).		
5. SimQuest Elektro	Nask-1 (Physics and chemistry), Human & Nature, Technology (VMBO, 12-14 and 14-16 years old); Physics (HAVO, 15-17 and VWO, 15-18 years old); Electrical engineering (MBO, 16-20 years old). Nask-1, Human & Nature, Technology topic: Energy. Physics topics: Energy, Domain G: Measurement and Control (HAVO) and Energy, Domain D Charge and field (VWO). Electrical engineering topic: Electricity.	NA	NA
6. Elvis/OP-AMP Labs	Physics (VWO, 15-18 years old). Physics topics: Energy, Domain D: Charge and field.	NA	NA
7. Aquarium WebLab	Orientation on yourself and the world (PO, 10-12 years old). Orientation on yourself and the world topic: Nature and technology.	NA	NA
8. Galaxy Crash	Nature, life and technology and General science (ANW) (VWO, 15-18 years old); Physics (HAVO, 15-17 years old);	NA	NA

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
	Nature, life and technology topic: Domain C: Earth, nature and universe. General science topic: Domain F: Solar system and universe. Physics topic: Domain E: Earth and universe.		

Go-Lab inclusion to Dutch curriculum

Integration of the selected laboratories to the Netherlands curriculum proved to be quite straightforward. The only issues that teachers need to take into account is the preparation time needed for both themselves and their students before being in a position to actually use and benefit from the labs, Hypatia in particular.

5.1.8 UK-England

The overall results from the analysis of the selected labs in relation to the Greek national curriculum can be found below:

Laboratory	Matching possibilities	Suggestions if no matching is available	Technical & logistical issues
1. Hypatia	Mathematics (11-14 and 14-16 years old); Energy, electricity and radiations (14-16 years old). Maths topics: Statistics. Energy, electricity and radiations topics: Weak and strong interactions or other	NA	Issues related to teachers' competencies (Refer to Hypatia for Belgium-French) Timing issues (Refer to Hypatia for Belgium-French)
2. Cosmoquest	The environment, Earth and universe (11-14 years old); Environment, Earth and universe (14-16 years old). The environment, Earth and universe topics: Astronomy and space	NA	NA

	science: the nature and observed motions of the sun, moon, stars, planets and other celestial bodies. Environment, Earth and universe topics: The solar system as part of the universe, which has changed since its origin and continues to show long-term changes.		
3. Visir Lab	Energy, electricity and forces (11-14 and 14-16 years old). Energy, electricity and forces topics: Electric current, electronic circuits. Electrical power: its transfers and control, the use of electrical power.	NA	NA
4. Faulkes Telescope	Environment, Earth and universe (11-14 and 14-16 years old). Environment, Earth and universe topics: Astronomy and space science; motions of the sun, moon, stars, planets and other celestial bodies (11-14 years old) and The solar system (14-16 years old).	NA	Registration to this lab is not currently available for the studied countries apart from the UK.
5. SimQuest Elektro	Science (8-11 years old and 12-14 years old); Design and technology (8-11 years old). Science topics: • Sc4 Physical processes topic: Electricity (8-11 years old). • Science - Sc1 Scientific enquiry topics: Knowledge,	NA	Teachers are required to have basic ICT skills to be able to install the SimQuest Learner Environment and SimQuest Elektro simulations. Science teacher should be able to use the lab without the need for help.

	skills and understanding (8-11 years old). • Energy, electricity and forces (12-14 years old). Design and technology topic: Knowledge and understanding of materials and components.		
6. Elvis/OP-AMP Labs	NA	The suggestion for use of this lab would include two age groups. The first is the 15-16 year-old students at GCSE level who study the subject of Design & Technology and the topic of Integrated circuits. This suggestion is based on BBC [GCSE Bitesize website](#) introducing the topic of integrated circuits. The second age group are 17-18 year-old students of BTEC, Sixth Form or A-level. The related subject would be Electronics at Sixth Form or BTEC [http://www.farnborough.ac.uk/Courses_Electronics] and Physics (topic: Electronics) at A-level.	This lab could be introduced as an extracurricular activity
7. Aquarium WebLab	Science: Sc1 Scientific enquiry, Sc3 Materials and their properties	NA	The teacher should ask WebLab owner for

	and Sc4 Physical processes (8-11 years old); Science (12-14 years old) Science topics: • Sc1 Scientific enquiry topics: Investigative skills (8-11 years old). • Sc3 Materials and their properties topic: Grouping and classifying materials (8-11 years old). • Sc4 Physical processes: Forces and motion (8-11 years old). • Science: Energy, electricity and forces (12-14 years old).		registration. Registered participants can access the lab using a web browser.
8. Galaxy Crash	Science (12-14 and 15-16 years old). Science topics: Environment, Earth and universe.	In addition to the official school curriculum in the UK Galaxy Crash can be used for teaching Physics & Astronomy courses at GSCE level (age 15-16) and Sixth Form, A-level and Key Stage 5 (age 17-18).	Galaxy Crash' tool requires a web browser with JavaScript enabled, which is usually installed on the computer.

Go-Lab inclusion to English curriculum

Integration of the selected laboratories to the UK curriculum proved to be quite straightforward. The main issues that teachers need to take into account is the preparation time needed for both themselves and their students before being in a position to actually use and benefit from the labs, Hypatia in particular. Moreover some technical issues concerning the installation of plugin and software need to also be taken into account. Certain labs provide also good matches to the GCSE content so effort should be put into making them part of the GCSE preparatory trainings.

5.2 Arising requirements for Go-Lab labs

The output of the curriculum analysis above, revealed the lack of some umbrella STEM subjects in the current Go-Lab catalogue of labs, such as biology, chemistry, and geosciences including geology, oceanography and climatology. Apart from taking into consideration these particular subjects, lab candidates to be included in the Go-Lab portal should also focus on activities that cannot be (at all or easily) carried out in the classroom, such radioactivity or zero gravity. In this sense, the integration of Go-Lab experimentations into the curricula could cover the absence of lab infrastructure in schools across Europe, e.g., rural schools that do not have labs or specific lab equipment.

For instance, the identified websites or individual laboratories below could be further analysed as possible candidates to be included in the Go-Lab portal:

1. EDUWEB LABS (http://eduweblabs.com/), provides more than two hundred laboratories allowing users to manipulate laboratory equipment, gather data and process that data. Subjects of proposed labs are chemistry, biology, physics and earth sciences.

2. BENCH AP BIOLOGY LABS (http://www.phschool.com/science/biology_place/labbench/lab8/intro.html), on biology offers 12 labs covering several subjects such as population growth, genetics and animal behaviour and others**.**

3. Geology labs online – Virtual Earthquake (http://www.sciencecourseware.org/VirtualEarthquake/), introduce the concepts of how an earthquake epicentre is located and how the Richter magnitude of an earthquake is determined.

4. Virtual Microscope: http://www.udel.edu/biology/ketcham/microscope/scope.html Allows to manipulate a microscope and to visualise microscopic material.

Finally, some countries started to plan and implement reforms of their education systems. Reform efforts in relation to the STEM education such as introduction of inquiry approaches, could be clearly supported by the Go-Lab project.

Conclusive summary

Suggestions to include labs if no matching with curriculum exist

- Relate the lab to a part of an existing lesson
- Create a new lesson on an existing topic
- Create a new topic in an existing subject to introduce the lab
- Relate the lab to a topic of another existing subject
- Introduce the lab as a practical research experience
- Combine a final year project with a lab activity
- Where no binding curriculum exists: introduce as extracurricular activity, as end of the year project or in curricula of private schools

Technical and logistical issues when using this labs

- Translation into the respective languages
- Correct timing and good preparation are extremely important for both teacher and students' experience. Enough time needs to be allowed for lab familiarisation, testing the platform/interface, preparation, activities.
- Teachers need to have adequate knowledge background related to the subject in question. In most situations scientific background can be obtained through preparation which takes us back the previous point.
- Software needed (Adobe Flash Player, Java VM/ script)
- Software installation might take a while due to administrative procedures within schools
- Registration is also in many case, essential

Suggestions on the use of labs

- Teachers and students should get familiar with info needed beforehand! (the lab features, needed inputs, possible outputs, read user manuals, read "how to start section", …)
- Good lesson planning (timing, content, students' working way)
- If precise background needed, lab use should be complemented with study of subject-related basic concepts
- Translations vs. Support from language teacher/s
- Possibility to combine different courses: e.g., physics and English language; physics and maths; science and ICT teachers

6 Overall conclusions on the integration of the Go-Lab portal

6.1 Enablers to the successful integration of the Go-Lab portal into the curriculum

The observation on the potential introduction of the Go-Lab portal into national curricula showed that the considered resources are in general appropriate for the intended purpose. The basic enablers to the successful integration of the selected labs to the chosen curricula are:

Curriculum match

Successful integration is highly depending on whether a laboratory corresponds to a specific theme, subject or topic within the curriculum. When this is the case, it is easier for teachers to take the first step and include the use of online laboratories in the classrooms.

Promoting integrated science teaching (versus separate-subject science teaching)

At the moment there is an ongoing debate as to whether science teaching should be organised in distinct subject areas or as a single, integrated programme during later school years.

“There are several clusters of arguments in support of the integrated approach to science teaching.
Firstly, integration seems to make 'common sense' or have 'face validity' (Czerniak, C.M., 2007) since in real life knowledge and experience are not separated into distinct subjects. This line of argument usually stresses that traditional discipline boundaries do not reflect contemporary needs, and that scientific research itself is becoming increasingly integrated and interlinked (James E. et al., 1997) and (Atkin, J.M., 1998). The second line of arguments stresses the process of knowledge construction. Teaching science in a holistic approach and making connections between different disciplines is seen as a process leading to new ways of thinking and knowledge (Riquarts, K., Hansen, H.K., 1998) that links various abilities (Ballstaedt, S., 1995) develops critical thinking, and forms the 'big picture’ and deeper understanding (Czerniak, C.M., 2007). Finally, there is an underlying belief that integrated teaching motivates both teachers and students (St. Clair, B., Hough, D.L., 1992).”[9]

Even though there are many theoretical arguments that support either integrated or separated science teaching, little empirical evidence of their influence on student achievement is available.

In any case though, certain laboratories can promote interdisciplinary teaching and be combined with other subjects providing students and teachers with unique learning opportunities. Since the majority of labs are available in English, collaboration between a science and language teacher can also prove quite beneficial. An Astronomy laboratory can also be combined with Physics and Chemistry aspects, providing students with a holistic learning experience.

Team work facilitator

The majority of laboratories are structured and developed in a way that promotes team work within the classroom. Tasks and observations can be split among different groups, allowing them to work in parallel, perform their observations or measurements and then continue their work with their colleagues.

Easy to combine with other labs/tools

The cases were laboratories and tools can be combined, work together and complement each other are also particularly appealing. For example SalsaJ can work smoothly with Faulkes telescope providing teachers and their students with a plethora or activities.

6.2 Barriers to the successful integration of the Go-Lab portal into the curriculum

In contrast to the enablers, a number of factors/barriers can sometimes block, delay or even make the integration process impossible.

The major concerns on the use of the Labs in the classroom are related to: mismatching between different curricula and labs target age ranges, time constraints, additional competences to be mastered by leading teachers, lack of translation of resources in the native language of the recipients and environmental barriers. The listed obstacles have been also integrated taking into account the results presented in D3.2.

Translations

Among the most evident direct factors that might discourage the undertaking of lab activities by teachers and pupils, is the missing translation of some of the resources in the native language of the recipients. Particularly, for the labs' activities aimed at younger students, the linguistic barrier can represent a relevant hurdle to the tool integration.

Content issues - Matching the curriculum

The proposed activities are in general properly designed for the age range they are addressing, however, due to discrepancies among different countries' curricula, some of them are not always matching the topics taught in the related grades. In addition, it has been noted that the terminology used in some of the labs was not always perceived as appropriate for the target audience, especially by students.
The teachers themselves are sometimes not prepared to master at a satisfactory level some of the topics involved in the activities since, according to their national curriculum, they are not supposed to teach them to their pupils or, the teaching of such a subject is foreseen less extensively.
In general terms, some labs propose activities too difficult for the age range addressed or provide guidelines and specifications which use too specific terminology or scientific jargon. This makes difficult the understanding of the activities, can discourage the adoption of the remote labs and consequently that of Go-Lab portal.

Time constraints

In some of the observations and comments, time constraints have been highlighted as strongly influencing the process of integration of the labs in the curriculum. Teachers may consider the extra time to be allocated for the implementation of the activity as excessive and decide not to undertake it. Some of the labs in fact propose activities which are long lasting or foresee a long work of preparation for the teacher. The preparation of the lesson plan, including the adaptation to the new tool, as well as the study of those topics involved not directly foreseen in the curriculum, are indeed the most time consuming phases of the process. Furthermore, direct procedures as registration to platforms, set up of the necessary technical tools and understanding of the lab functioning have also to be taken into account.
Time constraints issues are closely related to the curricula, which at the moment do not provide optimal conditions to accommodate the use of labs. Furthermore mismatches between labs activities and curricula, require even more investment in terms of time and commitment from the teachers side which should be mitigate as much as possible.

Teachers' training

It should be taken into consideration that the use of ICT in education is perceived and undertaken differently in the different European countries. Not only the use of remote labs is newly undertaken by some pioneer teachers, but in some cases, teachers are simply not using extensively IT tools in their classrooms and they lack the basic knowledge to integrate online labs in their lessons. Many teachers would benefit from training and detailed guidelines or information on the use of the labs and ICT in general, gaining more familiarity with the tools and developing a better attitude towards them.
Appropriate training or guiding instruments would allow teachers and students to overcome also usability problems linked to the complex user interface or structure of some of the labs.

Context barriers

The adoption of the Go-Lab portal can be limited also by environmental barriers, affecting directly or indirectly the capacity of schools of making use of online or ICT tools in general.
On one hand, not all schools have access to a sufficient number of pcs. On the other hand one of the technical problems more often recurring is the limited access to internet, namely unreliable connections or low bandwidth. The low performance of the available devices, can also limit the number of students that can simultaneously access an online lab activity.

According to the "Survey of schools: ICT in education"[10] which was published at the beginning on 2013, there are now between three and seven students per computer on average in the EU; laptops, tablets and netbooks are becoming pervasive, but only in some countries. More than nine out of ten students are in schools with broadband, at most commonly between 2 and 30mbps on average in the EU. The Survey findings estimate that at EU level on average, between 25 and 35% of students at grades 4 and 8, and around 50% of students at grade 11, are in highly equipped schools, i.e., with high equipment level, fast broadband (10 mbps or more) and high connectedness. The percentages of such schools differ enormously between

[10] https://ec.europa.eu/digital-agenda/node/51275

countries. Even so, school heads and teachers consider that insufficient ICT equipment (especially interactive whiteboards and laptops) is the major obstacle to ICT use.

Furthermore, many schools are not supportive in encouraging the integration of online labs into the classroom, and the teachers who adopt these tools are often not recognised or encouraged enough for their efforts.

Conclusive summary

The integration of Go-Lab portal into the national curricula can be facilitated when the right school equipment (computer labs, computers etc.) is in place, technical infrastructure in available at good standards (i.e., bandwidth connection), when labs are compatible with parts of the curriculum and when teachers are not only aware of labs existence but have also received relevant training.
In general, the selected labs have shown the capacity to be integrated into the national/regional curricula. However, some factors may sometimes make the integration process of the Go-Lab portal into the curricula difficult:

- **ICT infrastructure and use:**
    - A large number of schools and students from all around Europe still have limited access to pcs, laptops etc.
    - In many cases, the presence of ICT equipment is not accompanied by stable and fast broadband connection which directly limits schools' ability to access and use the Go-Lab portal.
- **Matching the curriculum issues:**
    - Activities properly designed for the age range they address do not always match curriculum based topics. In this case, teachers need to have this information in advance and also be provided with suggested alternatives i.e., creating a new lesson, using the activity as an extra curriculum activity etc.
    - Teacher competences: In many occasions teachers do not have the adequate background allowing them to fully understand and carry out the specific activity. In this case, support material needs to be available beforehand while the value of training also needs to be noted.
- **Time constraints:**
    - Familiarisation with the Go-Lab portal can take a while
    - Teacher registration to the respective lab can be long lasting and technically challenging
    - When an appropriate lesson plan is not provided, the creation of a new one by the teacher can be quite time consuming
    - Certain activities may need to run for more than one teaching hour. Teacher needs to have this information in advance in order to properly plan his work and

his students.
  - Set up of necessary technical logistics might also require a certain amount of time (booking a projector or computer room, installation of specific software etc.)

- **Translations:**

  - For lower secondary education students, the lack of translations can be quite discouraging
  - Cooperation with an English (for example) language teacher can raise this block for students but at the same time increases the preparation times for teachers
  - The use of automatic translation with the possibility to tailor translation depending on the age of the use, is also useful[11]

[11] The use of such tool is currently being investigated and will form part of the Go-Lab portal.

7 Recommendations to achieve maximum integration

This section intends to give a set of recommendations on features that Go-Lab portal's laboratories will need to address in order to achieve maximum integration in the various countries.

Since the involvement of a broad percentage of teachers in the use of the Go-Lab portal is a core objective of the project, a set of recommendations on obstacles and incentives to the integration of the tool and its resources in the teachers' curriculum may facilitate the process of adoption.

ICT and infrastructure

On Policy level, policies and actions at infrastructure level are still needed to enable the large majority of students, at all grades, to be in highly digitally equipped schools as defined above. These policies, putting the focus on providing laptops (or tablets, netbooks, etc.) and interactive whiteboards, would help to overcome what is still considered by practitioners as the major obstacle to ICT use. Such policies are a matter of urgency in some countries lagging far behind others. Infrastructure-related policies should be accompanied by complementary measures in other areas – and particularly in teacher professional development - for the use of this infrastructure to happen. Depending on the level of autonomy given to schools, national, regional and local policy makers, or school heads, are in the first line to implement such policies; reaching consistency and cross fertilising efforts between actions implemented at each of these levels are important in bringing about successful change.

Translation

Not having all the proposed activities available in the native languages of the recipients, poses some difficulties in undertaking these activities especially in the case of lower secondary education students. In these case, combining the study of English as a foreign language with the scientific topic can help overcoming the issue. Special attention needs to be given to the preparation phase i.e., provide in advance students and their language teacher with a glossary concerning the activity vocabulary in order to help foreign language teachers to master scientific or technical language.

Contents - Matching the curriculum

For an activity to be broadly adaptable to different national curricula, it is important to always maintain a degree of flexibility plus a layer structure that will allow it to fit in multiple topics/subjects. It has been noted that some of the labs, beside their main focus, could be used to explain collateral concepts which might be suitable for an audience younger than the one targeted. Developing pedagogical guidelines on the use of the tool at different levels of depth, or involving different topics and scopes, may encourage teachers to make an inspirational use of the tool in their classroom.

On a more speculative level, the result of some of the curriculum analysis carried out suggests that the integration of different labs into the same pedagogical path would give further opportunities of integrating successfully the Go-Lab portal into the curriculum. Link up activities available on different labs, developing interconnected lesson plans, would allow teachers to fit the tool into their lessons and curricula in a more consistent and flexible way.

A variety of interconnected activities would enable teachers to undertake a pedagogical path with their classrooms, providing students with an integrated set of experiences linked to different topics of study. This might be realised via the elaboration of thematic paths, focusing for instance on the concept of environment, or other complex themes, that involve different and interconnecting scientific disciplines.
The terminology used should be also considered carefully, and a too specific scientific jargon avoided when possible. With the complexity of the language used appearing as a potential obstacle to the adoption of the lab, appropriate tools, as a glossary for the scientific vocabulary used, should be provided.

Time constraints

To encourage a teacher to use one of the provided lesson plans or make his own within the Go-Lab portal, the time constraints incurring need to be taken into account. For teachers interested in using one of the already available lesson plans, clear information on the prerequisites, duration and any other requirement need to be visible and available. Teachers wishing to develop their own lesson plan within Go-Lab portal, need to be provided with clear guidelines on the whole process plus instructions and example on IBSE based lesson plans that they can use as inspiration.
Since some of the activities require long time to be implemented in the classroom or entail a relevant commitment from the teacher for their preparation, some `ice-breaker` videos or shorter activities may be designed to facilitate the introduction of the tool and labs into the classroom and make teachers and students familiar with the interface before undertaking more complex experiments. Propose readymade lesson plans to teachers would also help them to save time as well as allow them to concentrate on the adaptation of lesson plans according to their particular needs. An open forum dedicated to teachers may also be helpful for making suggestions on the use of the labs, or for sharing adapted lesson plans and teaching material.
Among the best practices already in place to cope with time constraints related to technical issues we can mention: availability of guidelines, tutorials, technical support interfaces, forum for technical enquires. Procedures linked to the registration to the tool should also be designed in an as much user-friendly way as possible.

Teachers' training

In order to train teachers in the use of remote labs and make them familiarize with the ICT devices and instruments, the Go-Lab portal could link to training facilities and resources. Supporting teachers' professional development in this domain, would increase teachers competence in using the tools and improve their attitude towards the use of ICT in education.

Go-Lab can also have a role to play in the initial teacher training organisations, where a type of awareness seminar for future science teachers could be organised. During that seminar, teachers can exploit the opportunities offered by Go-Lab within their way of teaching science when they become active teachers in their various schools.

Teacher training should also comprise quite elaborated learning stories and learning scenarios integrating the use of Go-Lab laboratories. In this way, future teachers will be in a position to see the added value the use of online laboratories and Go-Lab portal can bring to their teaching practices.

Additional extra efforts could be also made by the labs owners on the design of the activities and portals. Teachers could for instance be given access to a common test area in which they can try to perform different tasks and share comments and results with their peers. Regarding the actual use of the labs, owners should finally provide their audience with step by step guidance tools, such as tutorials, or at least with clear guidelines.

Moreover, relationships with large teacher networks like eTwinning and Scientix should also be developed. Combined workshops, webinars and training can contribute greatly to the population and wider acknowledgement of Go-Lab portal as a useful for science teachers' tool.

On the Policy side, policies and actions on national and regional level need to facilitate the provision of regular teacher training where the use of online laboratories can be a part of.

A more and more trendy way to gain access to training is through self-learning via massive online courses. Thus, this could be also an effective way to reach science teachers. An introduction to the Go-Lab project addressing the issue on how to integrate its labs in a curriculum could be put in place in a format of a MOOC. Activities inviting teachers to discover and experiment with the available labs, together with expert support and forum discussions could greatly help to encourage teacher use of labs in the classroom. A MOOC like this is currently under development by European Schoolnet. A draft plan including Go-Lab can be seen in "*Innovative Practices for Engaging STEM Teaching*".

Context barriers

Intervening to environmental barriers which are largely dependent on the financial availability of the single school or its own management, is particularly difficult. Nevertheless some indirect actions could be undertaken as for instance encouraging labs owner to provide activities also in offline modes, overcoming the issues related to unreliable and weak internet connections.
To enhance teachers' involvement in the adoption of remote labs, some efforts could also be done in order to recognise teachers' efforts by linking the Go-Lab portal to initiatives aimed at awarding such achievements (ICT in education teachers and schools competitions).

Selection of new online labs

Some general recommendations can be set out on the next developments of the Go-Lab portal regarding the selection and systematization of new online labs.
It is important to give priority to those labs which are strongly needed for education purposes and are focusing on activities that cannot be carried out in the classroom (e.g., nuclear physics, radioactivity, zero gravity).

7.1 Checklist for the selection of online labs

A concrete output of this study that has the capacity to become part of the Go-Lab portal and a useful guide throughout its continuous expansion and development, is a checklist for the selection of new online labs. The list is related to their integration characteristics and addresses more precisely the process of compiling lab activities and resources, bearing in mind which qualities may or may not facilitate the adoption of specific labs under different curricula.

Content

- Is the content appropriate for the target audience?
- Is the terminology appropriate (understandable) to the target audience?
- Is the activity editable/customizable by the teacher?

Time constraints

- Is the activity quick to be undertaken? Can the activity fit within a lesson (40'-50')?
- Is the registration process to the lab simple and fast?
- Is any additional software needed before teacher will be able to access the lab?
- Does the lab entail different levels or layers of activities?

Teacher training

- Is any kind of guidance/support tool foreseen?
- Are tutorials available?

Translations

- Is the activity available at least in English, in addition to its national language?
- Is the activity available in more than two languages?
- Are there any context barriers?
- Does the lab foresee also offline activities?

Conclusive summary

It is recommended to bear in mind the following factors when selecting labs in order to facilitate the integration process of the Go-Lab portal:

Matching the curriculum

- Flexible activities: foreseen a multi-layer set of educational contents (e.g., explain collateral concepts suitable for younger students)
- Developing pedagogical guidelines for use of labs/Go-lab portal at different level of depth
- Try to involve related but different subtopics and scopes

- Be able to link up activities available in different labs (developing interconnected lesson plans, would allow teacher to fit them in their curriculum

Time constraints

- Labs:
  - Propose readymade lesson plans
  - Labs: Provide tutorials/guidelines
- Go-Lab portal:
  - Create a dedicated teacher forum (exchange of suggestions & teaching material)
- Both:
  - Simplify the complexity and amount of background info needed by teachers & students before starting to use a lab/the tool!
  - Design “ice-breaker” videos or shorter activities to introduce the Go-Lab portal/labs in the classroom (to help students & teachers get familiarised)
  - Provide a technical support interface/forum for technical enquiries

Translations

- Labs should be made available in various EU languages
- Otherwise: Combine English language & the scientific topic (would help to tackle: translation issues & competence issues)
- Labs to provide a technical glossary in case of combination of courses (language teacher support)

Teacher training

- Make teacher aware of the existence of Go-lab and its application to day to day teaching
- Organise trainings on specific labs and on curriculum integration possibilities (workshops, STEM MOOCS, seminars)

Use of a Checklist: for the selection of new online labs to be included in the Go-Lab portal a checklist may help addressing more precisely the process of compiling of labs activities and resources

ANNEX I

The data collection which reveals the situation in the selected countries is presented below.
Following each laboratory description and key features, tables are provided per country, detailing the relevant age-group, subject, topic, lesson (if applicable), and goals in relation to the laboratory described. In the final two columns of the table, activities are suggested concerning how the laboratory might be used to meet the goals of the topic to be taught. Moreover, comments are included where necessary, concerning the enablers or obstacles to using the laboratory in the specific country concerned in relation to the subject mentioned.

I. HYPATIA

About the laboratory

HYPATIA is part of the ATLAS ASEC (ATLAS Student Event Challenge), an educational project at the frontier of particle physics.
By using HYPATIA students will be looking at "traces" which particles leave in a graphical representation of the ATLAS detector.
Students using the virtual lab will be able to determine the total momentum from all particles tracked after a particle collision and calculate the missing momentum. They will also learn to identify the tracks of different particles and will seek to find events that could indicate the existences of the Higgs boson.
The real accelerator and the ATLAS detector acquire these data after proton collisions at very high speeds. The Large Hadron Collider (LHC) from CERN is the most powerful particle accelerator ever built. It has achieved unprecedented collision energies, making it possible to probe deeper into matter than ever before, observing processes which take place at large energies and short distances, typical for the very early universe. The particles are accelerated and steered inside the 27 km long underground tunnel by thousands of superconducting magnets and acceleration devices. Collisions are then detected by the ATLAS detector, a precision instrument the size of a seven storey building.

Key features

- *URL*: http://hypatia.iasa.gr; http://hypatia.phys.uoa.gr
- *Registration:* Not required
- *Subject:* Particle physics
- *Provider*: Institute of Accelerating Systems and Applications (IASA)

- *Target audience*: Upper Secondary Education (ages 15-18) and Higher Education Bachelor
- *Language*: English, Greek
- *Technical*: HYPATIA is available online as a java applet. Downloadable software is also available. The software also requires a learning curve for both students and teachers. For high school students a simpler version of HYPATIA (Simplified HYPATIA sv) is available.
- *User manual:*
  - Instructions: http://hypatia.iasa.gr/en/HYPATIA_Instructions_eng.pdf
  - "Use simplified version": http://hypatia.phys.uoa.gr/Simplified_Version/
  - "Use Hypatia": http://hypatia.phys.uoa.gr/UseASEC/
- *Logistics*: Can be used by individual student or teacher as well as in an organized Masterclass. The educational content of HYPATIA is directly connected to the current research in particle physics. Some parts of HYPATIA might be used by undergraduate and graduate physics students. Teachers must be familiar with the research in order to carry out the activities properly. Teacher guidance is needed at some stages of the process. Best if students work in teams.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Belgium-French[12]	14-18[13]	Physics	Structure and properties of matter, elementary particles: the structure of atom and nucleus; Links between		Learn about scientific methods: the scientific explanation of natural phenomena The nature and role of scientific experiments, analysis of their results	Introduction to particle physics and the ATLAS experiment in CERN Analysis of data from the ATLAS detector, using the HYPATIA software	

[12] As each of the regions of French-speaking community in Belgium has a separate curriculum (Programme d'études), for the purpose of this analysis the common competences framework (Référentiel de competences) for secondary education has been used. More information: http://www.enseignement.be/index.php?page=25189&navi=296

[13] As the common competences framework defines competences attained upon completion of the secondary level without further specification for particular grades, the Age – in this case – cover the whole upper secondary level.

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
			macro- and microscopic phenomena; Special theory of relativity; Energy: nuclear fusion and fission				
	14-18	Mathematics	Data processing and analysis		Applying mathematical knowledge to scientific problems	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
Belgium – Dutch	16-18	Physics	Matter and radiation: Cosmology and elementary particles		Learn about the nature of scientific theories, hypotheses and evidence Interpretation and analysis of the results of scientific experiments	Introduction to particle physics and the ATLAS experiment in CERN Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	16-18	Mathematics	Real functions; Statistics		Connect mathematical learning with other disciplines (science)	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
Cyprus	16 – 17	Physics (common core course)	1) Solar System 2) Atomic Physics	a) Theories about the origin of the Universe a) Atomic structure (Historical evolution of atomic model, Thomson model, Rutherford model, Bohr's conditions, modern conceptions of atomic structure)	The students should: - Know information and aspects concerning different scientific theories about the origin of the Universe. - Know the key point of the "Big Bang" theory. - Know that the scientific theories are improved or eliminated depending on the experimental data obtained and new theories are accepted because they interpret a wider range of phenomena. - Explain the development of the Rutherford atomic model.	- Study the evolution of different theories about the origin of the Universe. - Search for information about the "Big Bang" theory through the web.	Students and teachers MUST be familiar with higher level physics in order to use HYPATIA. Teachers and students should have a strong background on Particle physics.

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	16 – 17	Physics (major course)	Atomic Physics	Atomic structure	- Describe the historical evolution of the atomic model. - Describe the Rutherford experiment and report of its results. - Know that Bohr suggested the existence of energy levels in Rutherford's model. - Define ionization and the atomic excitation. - Explain why the absorption or the emission of radiation from the atom can occur only under specific values of photon energy. - Explain the linear absorption and emission spectra of gases concerning the Bohr's model. - Apply the basic principles of atomic physics in problem solving.	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	17 – 18	Physics (elective course)	1) Nuclear Physics	a)Fundamental particles and interactions	- Distinguish quarks as nucleon components. - Know the fundamental particles – three pairs of quarks and leptons. - Identify gravity, weak-electromagnetic and forceful interactions, gravitons, photons, particles W^+, W^- and Z and gluons. - Identify the basic features of each particle and distinguish the particles into fermions and bosons.	No suggested activities.	
			2) Electron transfer in electric and magnetic field	a) Particle accelerators : linear, cyclotron, synchrotron.	- Describe and explain each accelerator function. - Know the use of each one of the accelerators. - Appreciate the importance of the accelerators in the investigation of the matter structure.	- Study about CERN accelerator or others. - Using a simulation for studying cyclotron. http://www.phy.ntnu.edu.tw/java/cyclotron/cyclotron.html	
Estonia	13-16	Science	Structure of matter,		Learn about the nature of scientific	Particle physics, research at CERN	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
			Elementary particles, weak and strong interactions (suggested)		enquiry, experiments		
	16 - 19	Mathematics	Statistics		Applying mathematical knowledge to scientific problems	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
	16-19	Physics	Structure and properties of matter, elementary particles: the structure of atom and nucleus		Learn about scientific methods: the scientific explanation of natural phenomena The nature and role of scientific experiments, analysis of their results	Introduction to particle physics and the ATLAS experiment in CERN Analysis of data from the ATLAS detector, using the HYPATIA software	
	16-19	ICT	Data processing, data analysis, databases		Applications of ICT (in science) The use of computers and ICT in learning How to apply ICT learning in various contexts and in other	Exploring and using the HYPATIA software. Processing the data gained from HYPATIA	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					areas of learning		
	17-18 (12th grade)	Physics[14]	Nuclear Phenomena	Elementary particles and antiparticles	Describe how elementary particles are organized.	Identification of elementary particles based on their tracks	Teachers need to be acquainted with the lab beforehand.
Greece	14-15 (11th grade)	Mathematics	Vectors	Adding Vectors	Practice on adding vectors	Conservation of momentum	As this exercise requires a background in physics it is advised that teachers contact their colleagues who teach physics.
	15-16 (12th grade)	Physics	Quantities that are conserved	Conservation of momentum	Understand the conservation of momentum and that it applies in every scale of the universe.	Conservation of momentum	Teachers need to be acquainted with the lab beforehand. In this grade, the conservation of momentum is taught within the context of classical mechanics. However this activity

[14] http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGL-C107/%CE%94%CE%95%CE%A0%CE%A0%CE%A3-%CE%91%CE%A0%CE%A3/phys_fek_20030200150.pdf

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
							could be used in order to help teacher understand that the Conservation of momentum is applied in all scales of the universe.
	15-16 (10th grade)	Projects	-	-	Build a science project using HYPATIA	Identification of elementary particles based on their tracks. Conservation of momentum Searching for the Higgs boson	In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated in the making of their project should they use a related subject.
	16-19	Physics	Nuclear physics: the structure of atom and nucleus relations between mass and energy			Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Poland	15-18	Physics	Matter: the development of models for the building blocks of matter in the course of time Quantum world: quantum model of matter Nuclear and particle processes		Learn to carry out scientific research, use of scientific concepts in subject-specific research Learn about mathematical underpinnings of natural sciences	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
	16-19	Mathematics	Functions Statistics		Mathematical modelling of scientific phenomena	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
	16-19	ICT	Data processing, data analysis, databases		Applications of ICT (in science) The use of computers and ICT in learning How to apply ICT learning in various contexts and in other	Exploring and using the HYPATIA software. Processing the data gained from HYPATIA	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					areas of learning		
The Netherlands		Chemical and material behaviour; Energy, electricity and forces	Structure of matter, Elementary particles; weak and strong interactions or other		Learn about the nature of scientific enquiry, experiments	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
	15-18	Mathematics	Information processing Algebraic relations: graphs and formulas on the relationship between quantities and variables, mathematical models		Translate scientific problems into mathematical language	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	
UK - England	11-	Mathemati	Statistics		Applying mathematical	Analysis of data from the ATLAS detector, using the	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	14	cs			knowledge to scientific problems Analysing, interpreting data and communicating findings	HYPATIA software and general data processing software	
	14-16	Energy, electricity and radiations	Weak and strong interactions or other		Learn about the nature of scientific enquiry, experiments		
	14-16	Mathematics	Statistics		Applying mathematical knowledge to scientific problems Analysing, interpreting data and communicating findings	Analysis of data from the ATLAS detector, using the HYPATIA software and general data processing software	

Table 1. Curriculum analysis – HYPATIA

II. **CosmoQuest: Many Cratered Worlds**

About the laboratory

The goal of this lab is to create a community of people bent on together advancing their understanding of the universe; a community of people who are participating in doing science, who can explain why what they do matters, and what questions they are helping to answer. They partner directly with NASA missions to develop citizen science projects that help expand what science they can accomplish.
There are lots of ways to get involved: Participants can contribute to science, take a class, join a conversation, or just help them spread the word by sharing about them on social media sites.
By using Many Cratered Worlds section, users will be able to analyse and process images from Solar System bodies, taken from different space exploration missions.
This lab is appropriate 1) When discussing meteors and craters, 2) when discussing terrestrial planets, 3) when learning about the Earth-Moon system, Mars, or Mercury.

Key features

- *URL:* http://cosmoquest.org; http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds
- *Registration:* Required
- *Subject:* Astronomy, Technology
- *Provider:* NUCLIO
- *Target audience:* It is not specifically addressed to students but to a larger target audience - citizens scientists, professional scientists, educators, programmers.
- *Language*: English only
- *Technical*: No comment
- *User manual*:
    - Asteroid Mappers Tutorials: http://cosmoquest.org/Asteroid_Mappers:_Tutorials
    - Moon Mappers Tutorials: http://cosmoquest.org/Moon_Mappers:_Tutorials
    - Planet Mappers Mercury Tutorials: http://cosmoquest.org/Planet_Mappers_Mercury:_Tutorials

- Many Cratered Worlds: Presented through an online PDF and guided website, http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds
  - A full teacher guide, including related existing activities and demos, is provided: http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds
- *Logistics*: Computer and Internet requirements (Computer lab).

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Belgium – French[1]	14-18[2]	Physics	The space and the Earth: the nature of the main celestial objects Evolution of the Universe		Learn about the methods of science and the nature of scientific evidence (observation, experiments)	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, and planets). Learn about the underlying science	
Belgium – Dutch	16-18	Physics	Movement and force: motion of the moon; Gravitational force between bodies; Movement		Learn about the nature of scientific evidence and how its interpretation feeds into scientific knowledge	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
			in space				
Cyprus	15 – 16	Physics	1)Circular motion	a) The motion of the planets	The students should: - Argue about the role of the sun in the planet motion. - Present theories about the nature of the sun, the stars and their life cycle. - Understand the light-year as an astronomical unit of length. - Search and present information about scientific theories concerning the interpretation framework for the motion of planets.	No suggested activities.	The fact that COSMOQUEST requires a registration could have negative implications (if it requires too much effort, teachers will avoid using it because they don't have a lot of available time). Teachers and students should have a strong background on the motion of the planets.
	16 – 17	Physics (common core course)	1) The Solar system and the Universe	a) Solar system structure Discovering the solar system beyond Earth Moon –	- Describe the organization of the solar system. - Compare the properties of the Earth and the other planets of our solar system. - Know that the movements and positions of objects in our solar system are observable phenomena that can be explained.	- Construction of a solar system model. - Study the planetary system through the website http://www.hummet.ucla.edu/hummert/french/faculty/gans/java/SolarApplet.html - Analyse images and satellite pictures of the planets and study their surface features,	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
				Journey to the moon Units of distance measures in astronomy Theories about the origin of the Universe Space programs	- Describe a variety of techniques used to detect conditions beyond the Earth (telescopes, satellites, spacecraft spectroscopy). - Compare distances of objects in the space and recognize the need of measurement units in astronomy. - Describe the categorization of the stars based on their specific features. - Explain how the astronomical discoveries contribute a better understanding of the Universe - Know and explain how space programs have provided many benefits to the mankind. - Present information and beliefs according to the various theories about the origin of the Universe. - Identify the basic features of the "Big Bang" theory. - Describe of the historical dimension and stages of the journey to the moon.	from NASA website: http://www.nasa.org - Moon observation using telescopes and binoculars. - Watch videos and photos of the journey to the moon. - Use simple spectroscope to observe the spectrum of different elements in order to detect different chemical of the Universe. - Study and present the different theories for the origin of the Universe. - Learn about the "Big Bang" theory: http://www.astro.ubc.ca/~scharein/a311/Sim.html	
	16 – 17	Physics (major course)	1) Gravitation	a) The motions of the planets and satellites	- Apply basic principles of the circular motion in order to calculate the velocity and period of the motion of planets and satellites. - Define the types of the circular motion of the planets and satellites and their use.	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					- Define and explain a geostationary satellite. - Calculate the height of a geostationary satellite from the earth.		
Estonia	10-13	The environment, Earth and universe	Astronomy and space science: the nature and observed motions of the sun, moon, stars, planets and other celestial bodies		Learn about the nature of scientific evidence and the scientific working methods	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets)	
	16-19	ICT			Applications of ICT (in science) The use of computers and ICT in learning How to apply ICT learning in various contexts and in other areas of learning	Exploring and using the COSMOQUEST software.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	16-19	Physics	Gravitation and astronomy: Solar system, galaxies, evolution of the universe Movement in space			Exploring and mapping various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	
	16-19	Physics	Movement and force: motion of the moon; Gravitational force between bodies; Movement in space		Learn about the nature of scientific evidence and how its interpretation feeds into scientific knowledge	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	
Greece	11-12 (6th grade)	Geography	Means of recording and picturing geographical elements	-	Learn about mapping and identifying characteristics on a surface.	Moon Mapping	The lab could be a little simplistic. Improvements could be made.

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Poland	16-19	Physics	Gravitation and astronomy: Solar system, galaxies, evolution of the universe Movement in space			Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	
The Netherlands	15-18	Physics	Solar system and universe: the origins, development and characteristics of the universe, motion in the solar system		Learn to work with scientific theories and models in studying natural phenomena Learn how scientific knowledge is created, which questions are relevant to science	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
UK - England	11-14	The environment, Earth and universe	Astronomy and space science: the nature and observed motions of the sun, moon, stars, planets and other celestial bodies		Learn about the nature of scientific evidence and the scientific working methods	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets)	
	14-16	Environment, Earth and universe	The solar system as part of the universe, which has changed since its origin and continues to show long-term changes		Learn about scientific data and how they can be collected and analysed	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets). Learn about the underlying science	

Table 2. Curriculum analysis – CosmoQuest

III. VISIR Lab

About the laboratory

The VISIR system provides an extraordinarily flexible environment in which students can construct and test different circuits. The modularity of the VISIR hardware permits for some flexibility level concerning the resources (circuit components and lab equipment's) students have at their disposal to construct and test circuits. Beyond this, the VISIR platform is remarkable in the interactivity it presents to students. Electronic circuits can be built and tested by students with a degree of freedom normally associated with a traditional, hands-on electronics laboratory.

The original VISIR online workbench offers the following flash client modules:

- A Breadboard for wiring circuits
- Function generator, HP 33120A
- Oscilloscope, Agilent 54622A
- Triple Output DC Power Supply, E3631A
- Digital Multi-meter, Fluke 23

Series or parallel circuits, resistors, diodes and LEDs are only some of the terms and the concepts that can be found in the Physics.

Key features

- *URL*: http://ilabs.cti.ac.at/iLabServiceBroker
- *Registration*: Required
- *Subject*: Electronics
- Provider: CUAS
- *Target audience*: Lower and upper secondary school students, higher education bachelor and master
- *Languages*: available in English only
- *Technical*: requires Java software
- *User manual*: N/A
- *Logistics*: Electronics background required. Best if students work in teams.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Belgium – French[1]	14-18[2]	Physics	Electricity: Ohm's law, Kirchhoff's law, electrical circuits		Learn to plan, carry out scientific experiments and analyse their results	Electrical devices, measurement of electrical quantities	
Belgium - Dutch	16-18	Physics	Electricity and Magnetism: the relationship between voltage, change in electric potential energy and electric charge Electrical circuits		Learn to plan, carry out scientific experiments and analyse their results	Electrical devices, measurement of electrical quantities	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Cyprus	14 – 15	Physics	1)Electric circuit	a) Electrical resistance – Ohm's law Resistance and electrical energy Relations between the units U, I, P, E, t.	The students should: - Know the relation between electricity and voltage and how resistance affect the electricity value. - Create graphical representations of intensity and voltage and calculation of resistance. - Problem solving (qualitatively and quantitatively) concerning AC or DC electrical circuits. - Identify or calculate the electrical appliances power and energy transformation - Select the appropriate fuse in an electrical installation and provide arguments for their selection.	No suggested activities.	The fact that OpenLabs VISIR requires a registration could have negative implications (if it requires too much effort, teachers will avoid using it because they don't have a lot of available time). Teachers and students should have a strong background on Electric circuits.
	15 – 16	Physics	1)Electromagnetism	a)Electromagnetic induction Electrical energy transformation and distribution AC to DC and	- Know the relation between electricity and voltage and how resistance affect the electricity value. - Create graphical representations of intensity	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
				reverse	and voltage and calculation of resistance. - Problem solving (qualitatively and quantitatively) concerning AC or DC electrical circuits. - Identify or calculate the electrical appliances power and energy transformation - Select the appropriate fuse in an electrical installation and provide arguments for their selection.		
	16 – 17	Physics (common core course)	1) Electricity	a) Dynamic electricity b) Alternative current (AC)	- Construct a simple electrical circuit - Design an electrical circuit using symbols. - Use ammeter and voltmeter. - Define the electric intensity and its unit of measurement. - Define the voltage and its unit of measurement. - Describe the difference between AC and DC. - Identify the advantages and disadvantages of the AC. - Describe the electrons movement in a AC	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					conductor. - Explain the AC production. - Identify and describe the main constraints of an AC electrical generator. - Define period, frequency, instantaneous value, width and power. - Define and describe of the main constraints of a DC electric generator.		
	16 – 17	Physics (major course)	1) Direct electric current	a) Electric resistance b) Varying resistor c) Instruments for electricity measurements d) Ohm's law	- Identify and define the role of electric resistance. - Identify the role of the varying resistance. - Identify the ammeter and the circuit set up (parallel or in series). - Identify the voltmeter and the circuit set up (parallel or in series). - Identify the direct relation between intensity and voltage based on the electric conductor. - Interpret graphical representations I=f(V) of varying resistance in	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
				e) Resistance constructing materials f) Resistance set up	relation to the voltage at the two ends of a conductor and the temperature. - Define the Ohm's law. - Identify that the resistance of a resistive conductor depends on its length, cross-sectional area and type. - Investigate which variables affect the resistance of a circular conductor. - Define the equivalent resistance of a multiple resistance set up (in parallel and/or in series). - Define the short circuit. - Apply Ohm's law for problem solving with resistance in parallel, in series and both. - Apply the principle of conservation of energy (energy conversion to other formats). - Define Joule's law. - Define the electrical energy and power and link them with the intensity and voltage.		

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
				g) Electrical energy and power. Joule's law h) Source of electromotive force – Internal resistance i) Kirchhoff's laws for complex circuits	- List devices that operate on the thermal effects of electric current. - Define the electromotive force and internal resistance of a power supply. - Investigating the electromotive force and internal resistance of a power source (battery). - Define Kirchhoff's laws - Apply Kirchhoff's laws in circuits with one or two loop		
	17 – 18	Physics (elective course)	1) Alternating Current (AC)	a) RLC circuit in series	- Study RLC circuits in series. Design the vector diagram of voltage and current and define the impedance of the circuit. - Define the mathematical relations of current intensity, voltage U_R, U_L, U_C and instantaneous power as a function of time. Determine the average power and power factor.	No suggested activities.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
				b) RLC circuit in parallel c) LC circuit in parallel (Thomson circuit) – electromagnetic waves	- Identify that the circuits with two elements are sub cases of the general RLC circuit. - Understand the phenomenon of resonance, identify and explain the phenomenon and drawn conclusions. - Study RLC circuits in parallel. Design the vector diagram of voltage and current and define the impedance of the circuit. - Interpret the creation of the electromagnetic wave based on the oscillation in a LC circuit in parallel.		
Estonia	16-19	Mechatronics and robotics	Electronics, Electric current, electronic circuits The use of electricity: electrical current, ohmic resistance, series and parallel circuits.		Learn to plan and carry out practical and investigative activities, Learn about scientific data and how they can be collected and analysed	Electrical devices, measurement of electrical quantities	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	16-18	Physics	Electricity and Magnetism: the relationship between voltage, change in electric potential energy and electric charge Electrical circuits Electrical power: its transfers and control, the use of electrical power		Learn to plan, carry out scientific experiments and analyse their results, learn about the nature of scientific method.	Electrical devices, measurement of electrical quantities	
Greece	15-16 (10th grade)	Projects	-	-	Get acquainted with the elements used to build a circuit. Learn how to make electrical circuits using real elements.	Building circuits – making measurements.	In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated in the making of their project should they

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
							use a related subject.
	16-17 (11th grade)	Physics	Electric current	Making circuits	Get acquainted with the elements used to build a circuit. Learn how to make electrical circuits using real elements.	Building circuits – making measurements.	
Poland	13-16	Physics	Electricity: Electrical circuits, Ohm's law, measurement units of electricity and electrical current		Learn to plan, carry out scientific experiments and analyse their results. Make links between science and other subjects and areas of the curriculum.	Electrical devices, measurement of electrical quantities	
The Netherlands	15-18	Physics	The use of electricity: electrical current, ohmic resistance, series and parallel circuits		Learn about the process of nature of scientific experiments: defining a problem, formulating, testing and evaluating hypothesis	Electrical devices, measurement of electrical quantities	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
UK - England	11-14; 14-16	Energy, electricity and forces	Electric current, electronic circuits Electrical power: its transfers and control, the use of electrical power		Learn to plan and carry out practical and investigative activities, learn about the nature of scientific method Learn about scientific data and how they can be collected and analysed	Electrical devices, measurement of electrical quantities	

Table 3. Curriculum analysis – Visir Lab

IV. Faulkes Telescope Project

About the laboratory

The aim of the Faulkes Telescope (FT) Project is to get students and teachers participating in research-based science education and therefore improving their motivation to push the barriers of science education further. They provide free access to robotic telescopes and a fully supported education programme. Access to resources and to those of FT partners is provided at no charge to teachers and students.

FT has operated a UK-wide educational programme since 2004, and currently works with science education projects across Europe and further afield (e.g., USA, Russia, Israel), including many EU-based science, maths and ICT programmes.

The Faulkes Telescope (FT) Project is an education partner of Las Cumbres Observatory Global Telescope Network (LCOGTN). LCOGTN operates a network of research class robotic telescopes. Currently there are two telescopes, one in Hawaii and the other in Australia. It is possible to book time for real time observation or virtual visit. These telescopes are available to teachers for them to use as part of their curricular or extra-curricular activities and are fully supported by a range of educational materials (astronomy video tutorials, online astronomy training, paper-based documents for use in the classroom, and pre-packaged data from the telescopes to use with the exercises detailed online) and a team of educators and professional astronomers.

Key features

- *URL*: http://www.faulkes-telescope.com/
- *Registration*: Required. Registration for a telescope is currently only open to education organizations in UK (through Faulkes Telescope Project) and Hawaii. In the framework of the Go-Lab project access will be provided to pilot schools (http://rti.faulkes-telescope.com/control/Register.isa)
- *Subject*: Astronomy - Physics
- *Provider*: University of Glamorgan (UoG)
- *Target audience*: Upper Secondary Education (15 -18), School or colleague teachers and other users (science centres, education groups, university physics and astronomy departments, astronomical societies). FTP operates a broad range of educational programmes, with a strong emphasis on teacher training
- *Languages*: available in English only
- *Technical*: JAVA plugin required for simulation software. Compatible with Windows, MacOS, Linux, iOS, Android, IE, Firefox, Safari.
- *User manual*: N/A
- *Logistics*: This lab is designed to be used in a computer lab during an approximate 2 hour lesson. Currently only UK and IE schools are allowed to book time on the telescopes but this will be expanded. Teachers are provided with personalised training and support that is tailored to the age range of students they teach, the topics they teach. FT team is also able to take in to account teachers personal background in science and teaching as part of putting together a package of training for them. Teacher guidance to use the lab is needed at some stages of the process.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
Belgium – French[1]	14-18[2]	Physics	The space and the Earth: the nature of the main celestial objects Evolution of the Universe		Learn about the nature of scientific evidence (observation). Learn about the structure, operation, origin and the evolution of the universe	Exploring celestial bodies (observations of the solar system and distant galaxies).	
	14-18	Mathematics	Geometry and Trigonometry		Applying mathematical knowledge to astronomy	Understanding data and mathematical related concepts from FT observations (degrees, rotation, altitude, eccentricity, etc.)	
Belgium - Dutch	14-18	Mathematics	Geometry		Applying mathematical knowledge to astronomy	Understanding data and mathematical related concepts from FT observations (degrees, rotation, altitude, eccentricity, etc.)	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
	16-18	Physics	Physics and the Cosmos; Cosmology and elementary particles		Learn about the structure, operation, origin and the evolution of the universe	Exploring celestial bodies (observations of the solar system and distant galaxies).	
Cyprus	16 - 17	Physics (common core course)	1) The Solar system and the Universe	a) Solar system structure Discovering the solar system beyond Earth Moon – Journey to the moon Units of distance measures in astronomy Theories about the origin of the Universe Space programs	The students should: - Describe the organization of the solar system. - Compare the properties of the Earth and the other planets of our solar system. - Know that the movements and positions of objects in our solar system are observable phenomena that can be explained. - Describe a variety of techniques used to detect conditions beyond the Earth (telescopes, satellites, spacecraft spectroscopy). - Compare distances of objects in the space and recognize	- Construction of a solar system model. - Analyze images and satellite pictures for the comparison of the planets, study of their surface features. - Moon observation using telescopes and binoculars. - Watch videos and photos of the journey to the moon.	The fact that Faulkes Telescope requires a registration could have negative implications (if it requires too much effort, teachers will avoid using it because they don't have a lot of available time). Also, not being able to book time with the telescopes could repel teachers.

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					the need of measurement units in astronomy. - Describe the categorization of the stars based on their specific features. - Explain how the astronomical discoveries contribute a better understanding of the Universe - Know and explain how space programs have provided many benefits to the mankind. - Present information and beliefs according to the various theories about the origin of the Universe. - Identify the basic features of the "Big Bang" theory. - Describe of the historical dimension and stages of the		Teachers and students should have a strong background on Astronomy which is not the case in Cyprus.

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					journey to the moon.		
Estonia	10-13	The environment, Earth and universe	Astronomy and space science: the nature and observed motions of the sun, moon, stars, planets and other celestial bodies		Learn about the nature of scientific evidence and the scientific working methods	Exploring and mapping the surface of various celestial bodies (the Moon, asteroids, planets)	
	13-16	Science	Solar System and Universe; Earth and universe		Learn about the structure of solar system, the universe and how astronomical data is collected – the use of telescopes	Exploring celestial bodies (observations of the solar system and distant galaxies).	
	16-19	Mathematics	Geometry; Trigonometry		Applying geometry knowledge to astronomy	Understanding data and related mathematical concepts from FT observations	N/A in Estonia
	16-19	Astronomy, Physics	Solar System and Universe; Earth and universe		Learn about the structure of solar system, the universe and how astronomical data is	Exploring celestial bodies (observations of the solar system and distant galaxies).	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
					collected – the use of telescopes		
Greece	10-11 (5th grade) and 11-12 (6th grade)	Natural Sciences in our everyday life.[15]	Research in Astronomy	Interdisciplinary course	Understand how astronomical observations are made. Study the formation of galaxies, nebulas etc.	Classification of Galaxies, Constellations.	Teachers need to be acquainted with the lab beforehand. It is best if it is combined with other lab like for example SalsaJ.
	15-16 (10th grade)	Projects	-	-	Build a science project using HYPATIA	Identification of elementary particles based on their tracks. Conservation of momentum Searching for the Higgs boson	In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated in the making of their

[15] http://www.pi-schools.gr/programs/depps/

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
							project should they use a related subject.
	16-17 (11th grade)	Astronomy[16] (optional subject)	○ Stars ○ Galaxies ○ Space	Making Observations	Understand how astronomical observations are made. Study the formation of galaxies, nebulas etc.	Crashing Galaxies Making Open Cluster Classification of Galaxies.	Teachers need to be acquainted with the lab beforehand. It is best if it is combined with other lab like for example SalsaJ.
Poland	16-19	Physics	Gravity and elements of astronomy		Learn about the nature of scientific evidence. Critically analyse and evaluate evidence from observations	Exploring celestial bodies ranging from observations of the solar system to distant galaxies.	
	16-19	Mathematics	Geometry; Trigonometry		Applying geometry knowledge to astronomy	Understanding data and related mathematical	

[16] http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGL-B114/%CE%94%CE%95%CE%A0%CE%A0%CE%A3-%CE%91%CE%A0%CE%A3/depps_aps_astronomia.pdf

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
						concepts from FT observations	
The Netherlands	12-17; 12-18	General sciences; Physics	Solar System and Universe; Earth and universe		Learn about the structure of solar system, the universe and how astronomical data is collected – the use of telescopes	Exploring celestial bodies (observations of the solar system and distant galaxies).	VWO and HAVO
	12-17; 12-18	Mathematics	Measurement and Geometry		Applying geometry knowledge to astronomy	Understanding data and related mathematical concepts from FT observations	VWO and HAVO
	12-16	Mathematics	Measurement and Geometry		Applying geometry knowledge to astronomy	Understanding data and related mathematical concepts from FT observations	VMBObb
UK - England	11-14	The environment, Earth and universe	Astronomy and space science; motions of the sun, moon, stars, planets and other		Learn about the nature of scientific evidence. Critically analyse and evaluate evidence	Exploring celestial bodies ranging from observations of the solar system to distant galaxies.	

Country	Age	Subject	Topic	*Lesson	Goals	Activities	Comments
			celestial bodies		from observations	Learn about the underlying science	
	14-16	Environment, Earth and universe	The solar system		Learn about scientific data and how they can be collected, analysed and interpreted. Use both qualitative and quantitative approaches to communicate scientific facts	Exploring celestial bodies (observations of the solar system and distant galaxies). Learn about the underlying science	

Table 4. Curriculum analysis – Faulkes Telescope

V. **SimQuest Elektro**

About the laboratory

This laboratory allows students to conduct experiments to create and investigate (measure voltages and currents) static electrical circuits. The circuits are limited to static situations. There are four SimQuest Electro simulations about the DC circuits: SQ Elektro 3.2 Les 1-4 while there is alsoone about AC circuits: Edison-Vier.sqz.

Key features

– *URL:* http://www.simquest.nl/

- *Registration*: Not required
- *Subject:* Electronics
- *Provider:* University of Twente (UT)
- *Target audience*: Students of 10+
  - Primary (10 -12) and Secondary Education (12-18)
  - Higher Education Bachelor (18+)
  - Higher Education Master (21+)
- *Languages:* Dutch only (at the time of the production of this draft)
- *Technical:* Compatibility: Platforms (Windows, MacOS, Linux, iOS, Android …), Special plugin(s) with version (flash, java …), Browser(s) with version (Explorer > xx, Firefox, Google Chrome …); IE 9+, Firefox. The SimQuest program needs to be installed on every computer.
- *User manual:* Not yet available
- *Logistics*: Electronics background required. The circuits are limited to static situations. Best if students worked in teams. Teachers are required to have basic ICT skills to be able to install the SimQuest Learner Environment and SimQuest ELEKTRO simulations.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	Lesson	Goals	Activities	Comments
Belgium – Dutch	15-18 (3rd stage)	Nature	Electricity and Magnetism		Explain the relationship between voltage, change in electric potential energy and electric charge. Applying the relationship between voltage, current and resistance for a conductor in a direct current circuit. Energy conversions in		Only in windows, some schools use macs

					electrical circuits' examples illustrate and calculate the power.		
Belgium – French	12 – 14 and 14 - 16	Scientific Training Physics	Electricity	Electric field, voltage and current intensity. Electromagnetic forces, induced currents	Interpret electrostatic phenomena by electron transfer. Predict the motion of an electric charge in an electric field and a magnetic field. Distinguish connections in series from parallel connections.		Only in windows, some schools use macs
Cyprus	13 – 14	Physics	Electricity	a) Static electricity b)Electrostatic and electrodynamics	The students should: - Recognize static electricity daily problems and know how some appliances utilize the effects of static electricity. - Design and perform experiments to classify materials into conductors and insulators. - Communicate the results with peers. - Explain the phenomena the phenomenon of	No suggested activities.	Teachers and students should have a background on Electrical engineering/circuits since the level can reach higher education.

					electrolyses. - Explain the relation between static electricity and dynamic electricity (microscopic level).		
	16 – 17	Physics (major course)	Static Electricity	a) Atomic structure and electric charge b) Coulomb's law	- Define the atomic structure and the relation with charge (protons and neutrons). - Perform experiments and interpret data concerning static electricity. - Know the differences between conductors and insulators. - Define Coulomb's law and recognize the differences and similarities between Coulomb's law and Newton's law of universal gravitation. - Apply Coulomb's law in problem solving.	No suggested activities.	
	16 – 17	Physics (common core course)	Electricity	Static electricity (Friction, positive and negative charges, electric pendulum, electroscope,	- Justify the existence of two types of charges. - Describe the forces between charged bodies. - Explain the operation of the electric pendulum and	- Conduct simple experiments with friction. - Demonstrate attraction and repulsion between	

				forces between charged bodies, Coulomb's law)	electroscope. - Define Coulomb's law. - Explain lightning and thunder.	charges. - Check whether a body is charged or not. - Conduct the experiment of diverting water. - Small studies on pphotocopier function, Electrostatic filters, Lightning rod	
Estonia	13-16	Physics	Electricity	Circuit	Explain the meaning and means of measurement of the terms voltage, electrical resistance and resistivity and know the units of measurement used;	Conduct experiments in the domain of electrical circuits. Create electrical circuits and measure voltages and currents.	
	16-19	Physics, Energy	Electric current		Use the rules of calculating voltage, power and resistance in series and parallel circuits in solving problems of application; use multimeters to measure voltage, current and resistance	Conduct experiments in the domain of electrical circuits. Create electrical circuits and measure voltages and currents.	

	16-19	ICT, applications	Practical work and use of ICT		Investigate the operation of circuits using computer simulations.	Investigating, using a multimeter, the relationship between voltage, current and resistance (obligatory practical work).	
	16-19	Mechatrinics & Robotics	Applications of alternating current		Apply Ohm's law for a part of a circuit and for the whole circuit and the equations for the work and power of electric current in solving problems		
Greece	14-15 (9th grade)	Physics[17]	Electricity – Simple Circuits	-Use of the Ampere-meter - Use of the Voltmeter - Ohm's law - Making simple circuits	- Learn about the use of the devices used to measure current and voltage - Learn to build circuits - Learn about Ohm's law	Activities with building circuits and making measurements.	In Greece many schools don't have a real lab for such experiments or a very much under-supplied. Plus, as making real experiments with electricity could be proved a source of hazard for students, this lab could be very

[17] http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGYM-B200/%CE%94%CE%95%CE%A0%CE%A0%CE%A3%20-%20%CE%91%CE%A0%CE%A3/25deppsaps_FisikisXimias.pdf

							useful.
	15-16 (10th grade)	Physics[18]	Electricity – Direct Current	- Kirchhoff's laws - Building DC circuits	-Build electrical circuits - Making measurements in electrical circuits	Activities with building circuits and making measurements.	In Greece many schools don't have a real lab for such experiments or a very much under-supplied. Plus, as making real experiments with electricity could be proved a source of hazard for students, this lab could be very useful.
	15-16 (10th grade)	Projects	-	-	Build a science project with SimQuest	Activities with building circuits and making measurements.	In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated

18 http://users.sch.gr/akouts/programs.htm

							in the making of their project should they use a related subject.
Poland	15-16	Physics	Electricity	Building a simple electric circuits and draws their schemes	Building electric circuits	Create static and measure electric circuits	
	16-19	Physics	Current		Building electric circuits	Create static and measure electric circuits	
The Netherlands	12-14 VMBO	Nask-1 (Physics and chemistry) Human & Nature Technology	Energy		Primary objective 32: The student learns to work with theories and models by investigating physical and chemical phenomena such as electricity, sound, light, movement, energy and matter.	Experiments with different types of circuits and measurements	
	14-16 VMBO	Nask-1 (Physics and chemistry) Human & Nature	Energy		Final attainment level K5 (7,8): Electrical energy at home - electrical circuit design and analysis, and performing calculations with them	Experiments with different types of circuits and measurements	

		Technology					
	15-17 HAVO	Physics	Energy, Domain G: Measurement and Control.	Recognizing different electrical circuits Describing what the influence is of series and parallel circuits on current and voltage The use of a V and A meter in a circuit. Applying Ohm's law.	Subdomain G1: Use of electricity: Goal 26. The student can describe and analyse the generation, transport and applications of electricity using physical concepts.	Experiments with different types of circuits and measurements	
	15-18 VWO	Physics	Energy, Domain D Charge and field	Explaining different types of electrical circuits Deducing how big the voltage and current will be in a circuit. Design of various circuits. Explaining the use of the V-and A-meter in a circuit. Applying Ohm's	Subdomain D1 Electrical systems, Goal 21: The student can analyse electrical circuits in specific contexts using the laws of Kirchhoff. With that the student can analyse energy conversions.	Experiments with different types of circuits and measurements	

				law.			
	16-20 MBO	Electrical engineering	Electricity		Explaining different types of electrical circuits Deducing how big the voltage and current will be in a circuit. Design of various circuits. Explaining the use of the V-and A-meter in a circuit. Applying Ohm's law.	Experiments with different types of circuits and measurements	
UK –England	8-11	Key Stage 2 – Science – Sc4 Physical processes	Electricity		Construct simple circuits	a. to construct circuits, incorporating a battery or power supply and a range of switches, to make electrical devices work [for example, buzzers, motors] b. how changing the number or type of components [for example, batteries, bulbs, wires] in a series circuit can make bulbs brighter or dimmer c. how to represent	Curriculum until 2014

						series circuits by drawings and conventional symbols, and how to construct series circuits on the basis of drawings and diagrams using conventional symbols.	
	8-11	Key Stage 2 – Design and technology	Knowledge and understanding of materials and components			d. how electrical circuits, including those with simple switches, can be used to achieve results that work.	
	8-11	Key Stage 2 – Science – Sc1 Scientific enquiry	Knowledge, skills and understanding			Ideas and evidence in science, Investigative skills, Planning, Obtaining and presenting evidence, Considering evidence and evaluating	
	12-14	Key Stage 3 – Science	Energy, electricity and forces			The activities include current and voltage in series and parallel circuits.	Curriculum until 2014 Only remotely related to SimQuest Elektro.

Table 5. Curriculum analysis – SimQuest Elektro

VI. ELVIS / OP – AMP Labs

About the laboratory

This lab allows users to perform some experiments with an OP Amplifier. There are four real instruments connected to a PC over GPIB (scope, function generator, variable power supply and a digital multimeter). It aims to demonstrate how operational amplifiers work. Students can work on predefine circuits with operational amplifiers and test their behaviour in different configurations.

Key features

- *URL:* http://ilabs.cti.ac.at/ServiceBroker/
- *Registration*: Required (http://ilabs.cti.ac.at/ServiceBroker)
- *Subject*: Engineering - Electronics
- *Provider*: Carinthia University of Applied Sciences (CUAS)
- *Target audience*: Upper Secondary Education (ages 15-18), Higher Education Bachelor and Master
- *Languages*: English
- *Technical*: Compatibility: Platforms: Windows, MacOS, Linux; Special plugin(s) Java Runtime Engine; Browser(s) with version (Explorer > 8, Firefox, Google Chrome, …)
- *User manual:* http://exp04.cti.ac.at/elvis/video/ASIC_Demo2_1.swf
- *Logistics*: No teacher guidance is needed

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	Lesson	Goals	Activities	Comments
Belgium – Dutch	15-18 (3rd stage)	Nature	Electricity and Magnetism	physical information in printed and electronic sources systematically find and display in graphs, charts or tables, possibly with the help of ICT.	Describe the operation of the generator by means of electromagnetic induction. Explain the relationship between voltage, change in electric potential energy and electric charge. Applying the relationship between voltage, current and resistance for a conductor in a direct current circuit. Energy conversions in electrical circuits' examples illustrate and calculate the power.		No issue with teachers competencies

Belgium – French	14 - 16	Physics	Electricity	Electric field, voltage and current intensity. Electromagnetic forces, induced currents	Distinguish connections in series from parallel connections. Justify measures of security and maintenance of some facilities and electrical appliances. Construct a program corresponding to a simple wiring diagram and vice versa. Interpret electrostatic phenomena by electron transfer. Predict the motion of an electric charge in an electric field and a magnetic field.		No issue with teachers competencies
Cyprus		N/A					Not direct matching with the curriculum was found

Estonia	15 -18	Engineering	N/A				No specific topic has been identified within this subject
North Rheine-Westphalia, Germany	16-18	Physics	Electronic	Charge & fields	Field strength (E) Coulumb's law Potential engery in electric fields, electric tension Electric capacity Magnetic fields (B) Lorentz force Movement of charge carriers in electric and magnetic fields	Assignment with the operational amplifier including suggestions in connection to magnetic fields and movement of charge carriers Creating groups with different tasks on electric fields, capacity and charge carriers by using the operational amplifier	In combination: electric loaded particles in electric and magnetic fields
Greece	15-16 (10th grade)	Projects	-	-	Build a science project with ELVIS / OP – AMP LABS		In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated in the making of their project should they use a related subject.

	16-17 (11th Grade) and 17-18 (12th Grade)	Department of Engineering and Department of Electronics	Electrical elements	- Measuring of quantities - Working with measuring devices			This subjects are only taught in the Greek Technical/Vocational Secondary Schools
Poland	15-16	Physics	Electricity		To demonstrate how operational amplifiers work	Test amplifier behaviour in different configurations	
	16-19	Physics	Current				
The Netherlands	15-18 VWO	Physics	Energy, Domain D: Charge and field		Subdomain D1 Electrical systems, Goal 21: The student can analyse electrical circuits in specific contexts using the laws of Kirchhoff. With that the student can analyse energy conversions.	Experiments with different types of circuits and measurements	

UK – England		N/A					No matching with the curriculum was found

Table 6. Curriculum analysis – Elvis / OP – AMP Labs

VII. WebLab-DEUSTO Aquarium

About the laboratory

The aquarium laboratory creates an access to a real aquarium located in the University of Deusto. On it, it is possible to feed the fish, turn on and off the lights, and, if the submarine is in the water and it is charged, control the submarine.
The main learning objective is Archimedes' Principle. There are three balls filled with different liquids (water, oil and alcohol). The user can throw the balls into the water and can take the balls out of the water using a web interface. The user through a web cam will see how much of the ball is over or below the water. Doing this he will be able to calculate the density of the ball, as well as other parameters.

Key features

- *URL*: http://weblabdeusto.readthedocs.org/en/latest/sample_labs.html#aquarium
- *Registration*: Required
- *Subject*: Physic principles – Biology
- *Provider*: University of Deusto (UD)
- *Target audience*: Primary Education (ages 10-12) and Lower Secondary Education (ages 12-15)
- *Languages*: English, Spanish, Basque, French, German, Czech, Slovak, Portuguese, Romanian, Hungarian
- *Technical*: Compatibility: WebLab-Deusto is available for all the OS with any web browser and without plug-ins.
- *User manual*: Not available yet
- *Logistics*: No teacher guidance is needed.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	Lesson	Goals	Activities	Comments
Belgium – Dutch	8-12	Environmental Studies	Environment		Perform in the care of animals and plants in their environment independently basics		
Belgium – French	8-12	Scientific Initiation	Nature	The digestive and absorptive functions, degradation, uptake and storage Light			
Cyprus	14 – 15	Physics	1) Buoyancy	a) Buoyancy, Archimedes' principle, boat floating/sinking, hot air balloon flight	The student should: - Plan and design experiments selecting the appropriate materials in order to investigate which variables affect the buoyancy of a sinking object.	- Run experiments to proof the existence of buoyancy. - Run experiments to discover what variables affect the buoyancy. - Buoyancy problem solving using the appropriate equation. - Explain phenomena concerning the	Teachers and students should be familiar with Archimedes' Principle. Queuing for the lab could be an issue if there are too many students waiting to use the remote lab.

				b) Create and use of densitometer. Use the concept of density to explain phenomena.	- Interpret the boat floating and hot air balloon flight based on mathematical relations. - Predict the results if the fluid density changes.	buoyancy. - Create densitometer. - Present the experimental procedures and results using multimedia, notes, graphs, etc. - Explain phenomena such as floating or levitation of a hot air balloon using the concept of density.	If an account is required from every student then this could be an obstacle. If its required only for the teacher it should net be a problem.
Estonia	13-16	Science, Physics	Quantitative Description of Bodies	13-16	Science, Physics	Quantitative Description of Bodies	
North Rheine-Westphalia, Germany	13-16	Physics	Force, compression, mechanic and inner energy	Buoyant force in liquids	Understanding the buoyant force and Archimedes' principle by dropping the balls into the water and taking notes on the result.	Demonstration of the buoyant force and Archimedes' principle integrated to one lesson or as homework.	North Rheine-Westphalia, Germany

Greece	10-11 (5th grade)	Physics	Materials and the structure of matter		- Understand the quantities of mass, volume and density	Activities with floating objects	
	13-14 (8th grade)	Physics	Pressure	Archimedes' Law - Buoyancy	- Understand the quantities of mass, volume and density - Understand Archimedes' law, buoyancy, and hydrostatic pressure	Activities with buoyancy	
Poland	15-16	Physics	Properties of matter		To analyse & compare the buoyancy of bodies immersed in a fluid; To explain swimming bodies under the law of Archimedes	Test the Archimedes principle	Gymnasium
	16-19	Physics	Rigid body mechanics (suggested)		To apply the concept of mass & balance of forces in a fluid; To explain swimming bodies	Test the Archimedes principle	No specific topic has been identified within this subject

					under the law of Archimedes		
The Netherlands	10-12 PO	Orientation on yourself and the world	Nature and technology	Floating and sinking	Primary objective 42: The students learn to do research on materials and physical phenomena such as light, sound, electricity, power, magnetism and temperature	Small experiment with balls in an aquarium	Interface is not very user friendly
UK –England	8-11	Key Stage 2 – Science – Sc1 Scientific enquiry	Investigative skills			Planning Obtaining and presenting evidence Considering evidence and evaluating	*Condition: The lab must be turned into online lab.* Curriculum until 2014 Cross reference to ICT – Developing ideas and making things happen and Exchanging and sharing information. The use of ICT is for data logging during observations and measurements and communicating data.

	8-11	Key Stage 2 – Science – Sc3 Materials and their properties	Grouping and classifying materials			a. Pupils compare everyday materials and objects on the basis of their material properties, including hardness, strength, flexibility and magnetic behaviour, and to relate these properties to everyday uses of the materials	Curriculum until 2014
	8-11	Key Stage 2 – Science – Sc4 Physical processes	Forces and motion			b. that objects are pulled downwards because of the gravitational attraction between them and the Earth d. that when objects [for example, a spring, a table] are pushed or pulled, an opposing pull or push can be felt e. how to measure forces and identify the direction in which they act.	

	12-14	Key Stage 3 - Science	Energy, electricity and forces			b. forces are interactions between objects and can affect their shape and motion	

Table 7. Curriculum analysis – Aquarium WebLab

VIII. Galaxy Crash

About the laboratory

Students are asked to make predictions on how galaxies form and evolve in the Universe. They will use the 'Galaxy Crash' tool to simulate the evolution of 2 disc galaxies over time, and see if the results match their predictions. Finally, the students will search the data archive of the robotic Faulkes Telescopes and find observations of interacting galaxies. They will then try and use the 'Galaxy Crash' software to reproduce the images which they have found and draw conclusions on the initial conditions from which the interacting galaxies came from, and what they might expect to happen to the galaxies in the future. This lab aims to demonstrate how scientists work, how, through the use of simulations astronomers can draw conclusions on what they observe in the Universe and to help explain how galaxies evolve in the Universe.

Key features

- *URL:* http://burro.cwru.edu/JavaLab/GalCrashWeb/
- *Registration*: Not required
- *Subject:* Astronomy - Physics
- *Provider*: University of Glamorgan (UoG)
- *Target audience*: Upper secondary school students (ages 15-18)
- *Languages*: English
- *Technical*: JAVA plugin required for simulation software. Compatible with Windows, MacOS, Linux, iOS, Android, IE, Firefox, Safari.
- *User manual:* Not available
- *Logistics*: Teacher Guidance is needed at some stages of the process. The material can be enlarged on screen for those students with visual impairments. This lab is designed to be used in a computer lab during an approximate two hours lesson.

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	Lesson	Goals	Activities	Comments
Belgium – Dutch	12 -14	Natural sciences	Scientific skills		under supervision : a scientific problem traced to a research question and formulate a hypothesis or expectation about this question; gather at a research question data and perform an experiment, a measurement or observation site according to a prescribed method; the essential steps of the scientific method to distinguish a simple research; collected and available data handling, to classify or to identify or to formulate a decision.		

	14 - 16	Natural sciences	Physics		The gravitational potential energy at the earth's surface, elastic potential energy and the kinetic energy of an object calculated.		
Belgium – French	14 -16	Physics	The universe and earth		Master the spatial and temporal orders of magnitude. Describe the life of a star and the fundamental role of gravity in cosmology qualitatively. Use a simple model explaining the movement of satellites. Use a scientific approach to understand natural phenomena, technological processes.		
Cyprus	15 – 16	Physics	Circular motion	The motion of the planets	The students should: - Argue about the role of the sun in the planet motion. - Present theories about the nature of the sun, the stars and their life cycle. - Understand the light-year as an astronomical unit of	No suggested activities.	Teachers and students should have a strong background on Astronomy which is not the case in

					length. - Search and present information about scientific theories concerning the interpretation framework for the motion of planets.		Cyprus. Teachers need to have a basic knowledge of ICT. Some knowledge of digital image processing is advisable Requires a substantial amount of time to perform the lab (2 hours) which could be a drawback.
	16 – 17	Physics (common core course)	The Solar system and the Universe	Solar system structure Discovering the solar system beyond Earth Moon – Journey to the moon Units of distance measures in astronomy Theories about the origin of the Universe Space programs	- Describe the organization of the solar system. - Compare the properties of the Earth and the other planets of our solar system. - Know that the movements and positions of objects in our solar system are observable phenomena that can be explained. - Describe a variety of techniques used to detect conditions beyond the Earth (telescopes, satellites, spacecraft spectroscopy). - Compare distances of objects in the space and recognize the need of	No suggested activities.	

					measurement units in astronomy. - Describe the categorization of the stars based on their specific features. - Explain how the astronomical discoveries contribute a better understanding of the Universe - Know and explain how space programs have provided many benefits to the mankind. - Present information and beliefs according to the various theories about the origin of the Universe. - Identify the basic features of the “Big Bang” theory. - Describe of the historical dimension and stages of the journey to the moon.		
	16 – 17	Physics (major course)	Gravitation	The motions of the planets and satellites	- Apply basic principles of the circular motion in order to calculate the velocity and period of the motion of planets and satellites. - Define the types of the circular motion of the planets and satellites and their use. - Define and explain a geostationary satellite.		

					- Calculate the height of a geostationary satellite from the earth.		
Estonia	15-18	Astronomy	Physics of the mega world	Galaxy Crash	Demonstrate how scientists work Demonstrate how, through the use of simulations, astronomers can draw conclusions on what they observe in the Universe Help explain how galaxies evolve in the Universe		
	15-18	Optional course „Another Kinds of Physics"	Galaxies	Galaxies	Composition and structure of the Milky Way; clusters of stars; galaxies; clusters of galaxies; cellular structure of the universe; dark matter and dark energy.		
Greece	10-11 (5th grade) and 11-12 (6th grade)	Natural Sciences in our everyday life.[19]	Research in Astronomy	Interdisciplinary course	Understand how astronomical observations are made. Study the formation of galaxies, nebulas etc.	Classification of Galaxies Constellations	It is best if the use of this lab is combined with others like the Faulkes telescopes and SalsaJ.

[19] http://www.pi-schools.gr/programs/depps/

	14-15 (8th grade)	Physics[20]	Matter and Energy - Forces	Forces that act from a distance	Understand how the gravitational force formulates galaxies.	Crashing Galaxies Classification of Galaxies	In this grade it could be used as an optional additional example for the gravitational force. It is best if the use of this lab is combined with others like the Faulkes telescopes and SalsaJ.
	15-16 (10th grade)	Projects	-	-	Build a science project using Galaxy Crash		In Greece, 10th grade students are required to create a project of their own making in any subject they choose to. Thus potentially any lab could be integrated in the making of their project should they use a related subject.

[20] http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGYM-B200/%CE%94%CE%95%CE%A0%CE%A0%CE%A3%20-%20%CE%91%CE%A0%CE%A3/25deppsaps_FisikisXimias.pdf

	16-17 (11th grade)	Astronomy[21] (optional subject)	○ Galaxies	Studying the structure of Galaxies	Study the formation of galaxies, nebulas etc.	Crashing Galaxies Making Open Cluster Classification of Galaxies.	It is best if the use of this lab is combined with others like the Faulkes telescopes and SalsaJ.
Poland	16-19	Physics	Gravity and elements of astronomy		To study the structure of the galaxy; to use real astronomical data	To make predictions on how galaxies form and evolve & use simulations to test their predictions	
The Netherlands	15-18 VWO	Nature, life and technology	Domain C: Earth, nature and universe		Subdomain C1 Processes in living nature, earth and space. Goal 16: The student can apply scientific and mathematical concepts in explaining interdisciplinary processes in nature, earth sciences and astronomy.		
	15-18 VWO	General science (ANW)	Domain F: Solar system and universe		Subdomain F3: Development of knowledge about the universe: the development of knowledge and ideas about the		

[21] http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGL-B114/%CE%94%CE%95%CE%A0%CE%A0%CE%A3-%CE%91%CE%A0%CE%A3/depps_aps_astronomia.pdf

					construction and history of the solar system and universe.		
	15-17 HAVO	Physics	Domain E: Earth and universe		Subdomain E1: Solar system and universe. Goal 23 The student can describe the development of structures in the universe and can analyse movements in the solar system, and can explain these by using physical principles.		
UK –England	12-14	Key Stage 3 - Science	The environment, Earth and universe			Astronomy and space science provide insight into the nature and observed motions of the sun, moon, stars, planets and other celestial bodies	Curriculum until 2014
	15-16	Key Stage 4 - Science	Environment, Earth and universe			The solar system is part of the universe, which has changed since its origin	Curriculum until 2014 Only remotely related to Galaxy Crash.

						and continues to show long-term changes.	

Table 9. Curriculum analysis – Galaxy Crash

IX. Microcontroller platform in roboticlab.eu

About the laboratory

This remote lab consists of standard Robotic kit modules, like Controller module, User Interface module and special Combo module. Different types of motors and sensors are connected to Combo board and can be controlled by user programme. User can also program indicators and display on their front. The primary aims of this lab are to study microcontroller technology and to perform lessons about sensors and actuators, controlled by microcontrollers.

Key features

- *URL*: http://distance.roboticlab.eu
- *Registration*: Required (+ booking)
- *Subject*: Robotics – Technology - Engineering
- *Provider*: Võru County VEC
- *Target audience*: Upper Secondary Education (ages 15-18), Higher Education Bachelor and Master
- *Languages*: English, Estonian
- *Technical*: Compatibility - Windows, MacOS, Linux; Special plugins: flash, java; Browsers: Firefox, Google Chrome.
- *User manual*: http://distance.roboticlab.eu/menu/index/11 or request demo user at: info@ittgroup.ee
- *Logistics*: This lab is used for robotic, computer science, mechatronic and embedded system courses in different levels of education. Teacher Guidance is needed at some stages of the process. For practical work, the students need computers and special sets for learning mechatronics/robotics, which consist of modern, programmable micro-controllers, sensors and actuator systems. Depending on the nature of their team work project, the students may also need additional equipment and tools to develop their solution. Recommended software:
  1) IDE for programming micro-controllers;
  2) Software for compiling electronic circuits;

3) CAD system; and
4) Presentation software

Linking the curriculum to the use of the laboratory

Country	Age	Subject	Topic	Lesson	Goals	Activities	Comments
Belgium – Dutch	14 -16	Natural sciences	Physics	Work, energy and power	Mechanical energy and other forms of energy and recognize specify in concrete situations.		
Belgium – French	14 - 16	Sciences	Forces, movements, pressures	Energy	Interpret movements in terms of conservation or modified by the forces		
Cyprus		N/A					Not direct matching with the curriculum was found
Estonia	15-18	Optional course „Mechatronics and Robotics"	Designing mechatronic and robotic system	Micro-controllers	1) gain an overview of mechatronics and robotics in the world; 2) become interested in the field of technology; 3) explain the constructions and	1) Investigations using micro-controllers; 2) Investigations using sensors and motors; 3) group work (teams of 2–3 students) to design and build a simple mechatronic system;	

					components of robotic systems; 4) solve simple, practical technological problems with the help of mechatronics and robotics; 5) gain an overview of sensors and motors and know their working principles; 6) use and programme micro-controllers; 7) keep records of their work and present their work; and 8) adopt a ‘do-it-yourself’ way of thinking.	4) searching for evaluated information from electronic sources (including thematic forums, demonstration projects and video materials); 5) activities developing creativity: students identify and find their own solutions to a technical problem; 6) developing team work skills: planning the timeframe and work volume, using problem solving techniques and drafting a budget; 7) presentation of the work (public presentation, if possible); and 8) planning and carrying out innovative projects	
Greece	15-16 (10th grade)	Projects	-	-	Build a science project using MICROCONTROLLER PLATFORM		In Greece, 10th grade students are required to create a project of their own making in any subject they

							choose to. Thus potentially any lab could be integrated in the making of their project should they use a related subject.
Poland	15-16	Informatics - Computer programming			To use computers and ICT interests to develop extracurricular activities	To programme indicators, motors and sensors of a robot.	No specific topic has been identified within this subject
	16-19	Informatics - Computer programming					
The Netherlands	17-21 HBO	Bachelor of ICT	Software		Development of software		
UK –England	12-14	ICT - Key Stage 3				c. use of different ICT tools, including a range of software applications, in terms of meeting user needs and solving problems	Curriculum until 2014 No specific topic has been identified within this subject

	15-16	ICT - Key Stage 4				b. use of a range of ICT tools to meet the needs of the user and solve problems	Curriculum until 2014 No specific topic has been identified within this subject.

Table 10. Curriculum analysis – Microcontroller platform in roboticlab.eu

ANNEX II

Innovative Practices for Engaging STEM Teaching

Contents

General introduction to the course

The course content plan has been written for the trainers of the course. Foreseen trainers are European Schoolnet staff and experts in the area of each module of the course.

Target audience

This course is addressed to STEM teachers/educators.

Aims of the course

- To understand the reasons behind students' demotivation regarding STEM subjects at school, and explore how to reverse the situation.
- To understand the main reasons for which STEM jobs are needed and in which areas.
- To understand the importance of STEM in the view of industries.
- To inspire students through their teachers to follow STEM studies/careers.
- To explore some examples of STEM applied to real life.
- To discover STEM by giving a try to remote and virtual labs in the aim of acquiring experience to further implementing practices in the classroom.
- To explore some STEM passionate topics, areas and technologies currently used through virtual visits to research centres.
- To provide guidance to teachers and STEM educators on how to better disseminate the results of their projects (European, national, regional, or other publically funded) and to make sure they access new teaching materials and methods from European STEM projects.
- To give relevant guidance and advice that can be applied in the classroom about STEM job market needs and possibilities: job opportunities in industries and key skills that students should learn to be prepared for working in STEM
- To uncover the reality under the gender issue related to STEM careers and jobs.

Structure overview

Course Modules

The course comprises of eight different modules within which there are a set of course activities. Half of the modules address the question of how to motivate and engage students in the STEM area, and the other half, focus more on helping students to understand STEM jobs possibilities including the career counselling aspect.

Each module's video content is foreseen to last approximately 1 hour. This includes:

- the module's introductory video intended to give an overview of the module (by an EUN staff)
- the main video lecture (by an expert in the specific area of the module)
- the introduction to the activity video (by an EUN staff)
- depending on case by case: the summary/conclusions of the module ((by an EUN staff)

MODULE 1: Increasing students' motivation to study STEM?

Learning objectives - Aims of module: To understand the reasons behind students' demotivation regarding STEM subjects at school, and explore how to reverse the situation based on participant's discussions and exchanges.

Summary: Study after study highlights the worrying disengagement of young people from STEM subjects in school, and a decreasing interest in STEM careers. Questions such as "Is there a real problem?", "What is not motivating about STEM?", "The image problem of the science" will be tackled by the trainer to introduce the STEM issue. How to reverse the situation will be explored though the presentation of the ESERA paper 1, "The future of European STEM workforce: what do secondary school pupils of Europe think about STEM industry and careers"[1].The module's activity that will be carried out using the platform forum will be based on the discussion of the paper's findings: the role of pupil's views on different STEM aspects in fostering young people's inclination towards STEM-related careers (key factors that will decide if a student will be interested in pursuing STEM as a career – or not) as well as on the exchange of personal experiences. Participants should finally reflect on how they can use their knowledge on these key factors to enhance their STEM teaching.

MODULE 2: Innovative teaching practices in the STEM classroom

Learning objectives - Aims of module: To understand innovative teaching practices and explore the opportunities and challenges

Summary: The trainer will present the teaching practices developed by industry to communicate the value of STEM and stimulate young people's interest in STEM subjects. Teaching practices can be industry visits, hands-on experiments, games and competitions.
The module's activity will involve the discussion and exchange of best teaching practices that will be carried out by participants though the platform's forum. Participants will be able to share and discuss good teaching practices that they might know. The output of the activity will be the creation of a lesson plan that will be uploaded to the forum for peer assessment and one summary of discussions per group.

MODULE 3: Innovative STEM teaching: using STEM resources from across Europe

Learning objectives - Aims of module: Providing guidance on how to access teaching resources from educational STEM projects (European, national, regional, or other publically funded) and how to effectively exchange resources with fellow STEM educators.

Summary: Accessing the latest STEM teaching materials – DESIRE Survival Toolkit: As introduction, the trainer exchange with the participants on their experience to find new STEM materials and methods from European and national STEM projects. Challenges, barriers and facilitators to come across the results from STEM education project will be tackled though the module's activity – via the platform forum.
After the participants exchange activity, the DESIRE Toolkit recommendations for teachers will be presented (main lecture presentation) with the aim of answering the following questions: What is an innovative teacher? Why is it important for STEM teachers to be innovative?; Where and how

can teachers best find new inspiration?; How can teachers become good communicators and inspire colleagues to take on new practices?.
Participants will be able to exchange and discuss between them and with the trainer/s through the forum.

MODULE 4: Discovering virtual/remote labs and how to use them in the classroom

Learning objectives - Aims of module: To discover remote and/or virtual labs as innovative teaching tools for the STEM classroom.
Summary: Participants will be introduced to the virtual and remote labs concepts thus, to further introduce the Go-Lab project which has as a mission to federate these type of labs. The trainer will highlight the benefit to use this type of approach in the classroom and will give tips to guide teachers in its introduction to students. The activity will consist in trying out labs. As the activity output, participants will reflect on how to introduce them in the classroom by creating a lesson plan and/or produce a list of suggestions on how to do it in the best way, both activities to be peer assessed.

MODULE 5: Exploring STEM in the real world - Virtual visits to research centres

Learning objectives - Aims of module: To understand (through some examples) how STEM are applied to real life. To explore some STEM passionate topics, areas and technologies currently used through a virtual visit to a research centre.

Summary: A guided virtual visit to:

- The Nanotechnology centre (Cambridge, England)
- The Institute for Biocomputation and Physics of Complex Systems (BIFI) and the biotechnology laboratory working with human stem cells (Zaragoza, Spain)
- Doñana National Park (Andalusia, Spain)
- The European Organisation for Nuclear Research – CERN (Geneva, Switzerland)

will allow participants to explore some of the technologies currently used in some STEM areas. The trainer will present the facilities that will be virtually/remote visited and give an introduction to the type of STEM area they are related to. Advice on how to book virtual visits will be given to participants on how to introduce it in their classroom. Participants will be able to interact between them via de platform forum. An expert per site visited will be available for an online chat on a certain date/s in order to clarify concepts and answer questions. Participants will be automatically assessed though a quiz on the main processes used by each facility visited OR, forum discussions or survey on how teachers would use these visits to engage students.

MODULE 6: Helping students to understand what STEM jobs are - Career counselling

Learning objectives - Aims of module: To give relevant guidance and advice to science teachers and other science educators that can be applied in the classroom to inform students about STEM job market needs and possibilities: job opportunities in industries and skills that students should learn to be prepared for working in STEM.

Summary: The trainer will expose the panoply of the current market needs regarding the availability of STEM job opportunities. Specificities on job requirements, and the main current job shortages per country groups will be presented. Based on the analysed job opportunities, the different skills needed to access STEM jobs in industries will be defined and presented by the trainers. The real importance of a training will be explored though examples. The activity will involve a questionnaire provided by de trainer that will help participants identify skills to be developed in the particular context of their schools, regions/countries. Questionnaires will be uploaded to the forum. Discussion and exchange between participants and trainer will be done via the forum.

MODULE 7: Meeting real life STEM professionals

Learning objectives - Aims of module: To inspire students through their teachers to follow STEM studies/careers. To explore some examples of STEM applied to real life. To understand the main reasons for which STEM jobs are needed and in which areas.

Summary: The "Why STEM jobs are needed and in which areas?" question will be tackled by the trainer who will then give a general introduction to innovative STEM careers applications as example. E.g., aeronautics, nanotechnology, robotics, neuroscience, biophysics, etc. Three professionals working in different STEM areas will be then live interviewed online. Before, the trainer will present more in depth the three different areas where the professionals who will be interviewed work in. During the interview, participants will have the possibility to interact with them directly via a chat. They will also be able to further discuss introduced subjects with peers via the MOOC platform's forum. As the output of the activity, participants will produce record cards that will be peer assessed.

MODULE 8: Dealing with stereotypes

Learning objectives - Aims of module: To uncover the reality under the gender issue related to STEM careers and jobs.

Summary: Possible subjects such as "Careers perception", "Girls in ICT", "Gender diversity in STEM", "Women in research & innovation", "Why STEM Jobs Need to Compete for Women"[1], "Encouraging girls to pursue STEM careers" will be addressed. Main questions as why do we associate certain jobs with a particular gender? And, is this a real perception? will be addressed by the trainers. Participants will be able to ask questions on (video) chats to experts, and exchange experiences and opinions via the platform forum. At the end of this period, a summary of discussions of chats will be published by the trainer/s.

SOURCES

- Eurypedia - The European Encyclopedia on National Education Systems, http://eacea.ec.europa.eu/education/eurydice/eurypedia_en.php

- Eurostat, 2013: Population as a percentage of EU27 population, http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tps00005&plugin=1

National and local curriculum source/s per country:

Belgium – French

Enseignement.be - Le portail de l'Enseignement en Fédération Wallonie-Bruxelles, Référentiels de compétences:

- Compétences terminales et savoirs requis – sciences, http://www.enseignement.be/download.php?do_id=190&do_check=
- Compétences terminales et savoirs requis – mathématiques, http://www.enseignement.be/download.php?do_id=503&do_check=

Belgium – Dutch

Vlaams Ministerie van Onderwijs en Vorming, Curriculum: Secundair onderwijs – Algemene uitgangspunten, derde graad:

- Natuurwetenschappen (Sciences), http://onderwijs.vlaanderen.be/curriculum/secundair-onderwijs/derde-graad/aso/vakgebonden/natuurwetenschappen/algemeen.htm
- Wiskunde (Mathematics), http://onderwijs.vlaanderen.be/curriculum/secundair-onderwijs/derde-graad/aso/vakgebonden/wiskunde/algemeen.htm

Cyprus

- The National Curriculum. Cyprus Pedagogical Institute: http://www.nap.pi.ac.cy
- The National Curriculum. Cyprus Ministry of Education and Culture:
  - http://www.moec.gov.cy/analytika_programmata/programmata_spoudon.html

Estonia

- National Curricula for Basic Schools and Upper Secondary Schools 2011 http://www.hm.ee/index.php?1511576
- National Curriculum for Basic Schools 2011 (general part and appendixes) http://www.hm.ee/index.php?1512622
- National Curriculum for Upper Secondary Schools 2011 (general part and appendixes) http://www.hm.ee/index.php?1512619

Germany

- National Curriculahttp://www.standardsicherung.nrw.de/cms/
- SI and SII navigators: http://www.standardsicherung.schulministerium.nrw.de/lehrplaene/lehrplannavigator-s-i/
  - http://www.standardsicherung.schulministerium.nrw.de/lehrplaene/lehrplannavigator-sek-ii/

Greece

- Ministry of Education: http://www.minedu.gov.gr/
- Greek Pedagogical institute: http://www.pi-schools.gr/
    - http://www.pi-schools.gr/programs/depps
- Greek Digital School: http://digitalschool.minedu.gov.gr
    - http://digitalschool.minedu.gov.gr/modules/document/file.php/DSGL-C107/%CE%94%CE%95%CE%A0%CE%A0%CE%A3-%CE%91%CE%A0%CE%A3/phys_fek_20030200150.pdf
    - http://digitalschool.minedu.gov.gr/modules/auth/listfaculte.php
- Official Announcement for Greek Analytical Programmes for 2012-2013: http://users.sch.gr/akouts/programs.htm

Poland

Ministerstwo Edukacji Narodowej, Podstawa programowa:

- Tom 5. - Edukacja przyrodnicza w szkole podstawowej, gimnazjum i lyceum (Environmental education), http://www.men.gov.pl/images/stories/pdf/Reforma/men_tom_5.pdf
- Tom 6. - Edukacja matematyczna i techniczna (Mathematics and Technical education), http://www.men.gov.pl/images/stories/pdf/Reforma/men_tom_6.pdf

The Netherlands

SLO, nationaal expertisecentrum leerplanontwikkeling (national institute for curriculum development in the Netherlands): http://leerplaninbeeld.slo.nl/

- PO (primary education):
    - Kerndoelen PO (Core objectives primary education): http://www.slo.nl/primair/kerndoelen/Dutch_Core_objectives_Primary_Education__2006_.pdf/

- Onderbouw VO
    - Karakteristieken en kerndoelen voor de onderbouw (2006): http://www.slo.nl/voortgezet/onderbouw/kerndoelen/Karakteristieken_en_kerndoelen_voor_de_onderbouw.pdf/

- VMBO:
    - Wiskunde – vmbo: Leerlijnen landelijke kaders (Mathematics), http://www.slo.nl/downloads/2009/wiskunde-vmbo.pdf/
    - Mens en natuur - vmbo : Leerlijnen landelijke kaders (Man & Nature), http://www.slo.nl/downloads/2009/mens-en-natuur-vmbo.pdf/

- HAVO and VWO:
    - Doorlopende leerlijn in de Mens en natuurvakken (PO – havo/vwo) (Man & Nature), http://www.slo.nl/voortgezet/onderbouw/themas/leerlijn/progr/MenN/Leerlijn_MN_inhoud_havo_vwo.pdf/
    - Doorlopende leerlijn vaardigheden in de Mens en natuurvakken (PO - havo/vwo) (Man & Nature),

http://www.slo.nl/voortgezet/onderbouw/themas/leerlijn/progr/MenN/Poster_vaardigheden_havo_vwo1.pdf/
    - Wiskunde – havo/vwo: Leerlijnen landelijke kaders (Mathematics), http://www.slo.nl/downloads/2009/Wiskunde_HAVO-VWO.pdf/

- HAVO
    - Examenprogramma Natuurkunde Havo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://www.examenblad.nl/9336000/1/j9vvhinitagymgn_m7mviq7lq25vpaf/vj1bav59y0px/f=/examenprogramma_natuurkunde_havo_2014_2015.pdf
    - Examenprogramma Scheikunde Havo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://www.examenblad.nl/9336000/1/j9vvhinitagymgn_m7mviq7lq25vpaf/vj1bapmn2938/f=/examenprogramma_scheikunde_havo_2014_2015.pdf
    - Examenprogramma Biologie Havo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-biologie-h.pdf/
    - Examenprogramma Natuur, leven en technologie Havo. Ingangsdatum: 1 augustus 2012. http://betavak-nlt.nl/downloads/Staatscourant_examenregeleing.pdf/
    - Examenprogramma wiskunde A havo http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-wiskunde-a-h.pdf/
    - Examenprogramma wiskunde B havo http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-wiskunde-b-h.pdf/

- VWO:
    - Examenprogramma Natuurkunde Vwo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://www.slo.nl/downloads/archief/Examenprogramma_natuurkunde_DEFINITIEF.pdf/
    - Examenprogramma Scheikunde Vwo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://www.examenblad.nl/9336000/1/j9vvhinitagymgn_m7mviwvlaj75kw6_n11vg41h1h4i9qe/vj2aafrnzvwq/f=/bestand.pdf
    - Examenprogramma Biologie Vwo. Ingangsdatum: schooljaar 201-2014 (klas 4). http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-biologie-v.pdf/
    - Examenprogramma Natuur, leven en technologie Vwo. Ingangsdatum: 1 augustus 2012 http://betavak-nlt.nl/downloads/Staatscourant_examenregeleing.pdf/
    - Examenprogramma wiskunde A Vwo http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-wiskunde-a-v.pdf/
    - Examenprogramma wiskunde B Vwo http://leerplaninbeeld.slo.nl/examenprogrammas/examenprogramma-wiskunde-b-v.pdf/

- MBO (vocational education)
    - Kwalificaties MBO: http://prod.pub.kwalificatiesmbo.nl/DossierOverzicht.aspx

- HBO
  - Opleidingsprofielen: http://www.vereniginghogescholen.nl/opleidingsprofielen
  - Bachelor on ICT: http://www.vereniginghogescholen.nl/images/stories/competenties/hbo-i%20bachelor%20of%20ict-engels6879.pdf

United Kingdom

- Secondary National Curriculum (until 2014) http://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary
- Primary National Curriculum (until 2014) - http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary
- Department of Education, England, UK, The school curriculum – Science (Key Stage 3 and 4), https://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary/b00198831/science

References

Atkin, J.M. (1998). The OECD study of innovations in science, mathematics and technology education. *Journal of Curriculum Studies, 30(6)*, 647-660.

Ballstaedt, S. (1995). Interdisziplinäres Lernen: Aspekte des fächerverbindenden Unterrichts. [Interdisciplinary learning: Aspects of subject-integrative courses]. *Tübingen: DIFF*.

Czerniak, C.M. (2007). Interdisciplinary science teaching. S. Abell, & N., Lederman, eds. *Handbook of research on science education. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.*, 537-559.

European Commission. (2013). *The Structure of the European Education Systems 2013/14.*

James E. et al. (1997). Innovations in science, mathematics and technology education. *Journal of Studies, 29(4)*, 471-484.

Riquarts, K., Hansen, H.K. (1998). Collaboration among teachers, researchers and inservice trainers to develop an integrated science curriculum. *Journal of Curriculum Studies, 30(6)*, 661-676.

St. Clair, B., Hough, D.L. (1992). Interdisciplinary teaching: a review of the literature. *ERIC Document. Reproduction Service No. 373 056. Jefferson City, MO.*