Go-Lab

Global Online Science Labs for Inquiry Learning at School

Collaborative Project in European Union's Seventh Framework Programme

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The Go-Lab Inventory and Integration of Online Labs – Labs Offered by Large Scientific Organisations

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Executive Summary

This document represents the work done in WP2 for the 1st year of the project. More specifically, the document represents the work done in "*Task 2.1 Review of existing online Labs*", in *"Task 2.2 - Organizing Online Labs for the Go-Lab Federation: from Small to Big Ideas of Science*", in "*Task 2.3 – The Go-lab Inventory of Online Labs*", as well as in "*Task 2.4 Populating the Go-Lab Inventory*".

To this end, the document describes:

- The typology of Go-Lab Online lab, which are organized in three main categories, (a) remote labs, (b) virtual labs, and (c) data sets/Analysis Tools. Moreover, the document presents additional resources that will be offered by the Go-Lab Project and they will be used to support students' inquiry.
- The Initial pool of the Go-Lab Online Labs. Each online lab is described based on a common template and a quantitative analysis was performed based on several characteristics like the languages the labs are available in, the age range covered and the availability of learning activities.
- The Go-Lab Methodology for Organizing Online Labs, which includes metadata elements that can be used to describe the Go-Lab online labs with the aim to facilitate their integration in the Go-Lab Inventory of Online Labs with a common and systematic way. Moreover, the document describes a set of vocabularies for the different metadata elements of the Go-Lab Methodology that are used for classifying the Go-Lab online labs in the Go-Lab Inventory (presented in Section 11). The Go-Lab online labs that are included in the Go-Lab Inventory will be integrated into the Go-Lab Portal.
- The method for populating the Go-Lab Inventory for the 1st year. Several parameters were considered such as: the variety of the thematic areas covered (curriculum coverage) by the labs, the technical maturity of each lab, the number of its current users and the availability of the lab interface in different languages.
- The Go-Lab Inventory, which was populated including online labs from the initial pool of the Go-Lab Online labs, as well as from other (external) partners.

The main outcome of this document is the development of the Go-Lab Inventory of Online Labs for the 1st year of the project, which includes thirteen (13) online labs, described following the Go-Lab methodology and they will be used (a) in WP1 in order to support the work of the pedagogical team for designing relevant educational scenarios based on the selected Go-Lab online labs and (b) in WP5 for integrating these online labs in the Go-Lab Portal.

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1 Introduction

1.1 Scope

The overall goal of WP2 is to create a structured inventory of online labs for their further implementation through the Go-Lab Portal. The inventory will be populated with online labs offered by the Go-Lab partners and it will be extended with online labs offered by lab owners outside the Go-Lab consortium.

To this end, the scope of this deliverable is to present:

- The initial pool of the Go-Lab Online Labs (which includes twenty labs) that will be used as the initial sample for selecting appropriate online labs for the Go-Lab Inventory.
- The Go-Lab Methodology for Organizing Online Labs, which includes metadata elements that can be used for describing the characteristics of the Go-Lab online labs towards their inclusion to the Go-Lab Inventory of Online Labs with a common and systematic way, as well as a set of vocabularies for the different metadata elements of the Go-Lab Methodology that can be used for classifying Go-Lab online labs in the Go-Lab Inventory and their further storage into the Go-Lab Portal
- The first version of the Go-Lab Inventory, which has been populated with thirteen online labs for the 1st Year of the project and they have been described according to the Go-Lab Methodology for Organizing Online Labs

1.2 Audience

This document targets the various Go-Lab partners, in order to be aware of (a) the initial pool of the Go-Lab online labs, (b) a common methodology for organizing the Go-Lab online labs and (c) the Go-Lab online labs that were selected and characterized based on the Go-Lab Methodology, in order to populate the Go-Lab Inventory for the 1st year of the project.

The results of this deliverable will be of particular interest for (a) partners involved in WP1 as it will support the work of the pedagogical team for designing relevant scenarios based on the selected Go-Lab online labs and (b) partners involved in WP5 for integrating these online labs in the Go-Lab Repository, which is part of the Go-Lab Portal.

2 Typology of Go-Lab Online Labs and Additional Tools and Resources

Online labs, in the framework of the Go-Lab project, are organized in three main categories, (a) remote labs, (b) virtual labs, and (c) data sets/analysis tools. This section describes the three different categories of Go-Lab online labs, as well as the typology of additional tools and resources that will be offered by Go-Lab and they can support students' inquiry.

2.1 Remote Labs

This category includes the remotely-operated educational labs. These are physical laboratories that can be operated at a distance and they offer the students the ability to conduct real experiments and collect real data from a physical laboratory in a remote location. The main advantage of remote labs is that students are operating actual equipment and not simulations. This gives them a more realistic view of scientific work including difficulties and complications such as unexpected factors interfering with measurements, experimental inconsistencies, occupied equipment etc.

Remote labs in general give students an experience that is as similar as possible to physically conducting the experiment. Another important factor is the presence of real measurements with errors that are a part of every measurement in real scientific work. Those errors are not simulated, like they may be in virtual labs, and offer the students an opportunity to learn about the physical factors that cause them, techniques to minimize them and how to account for them in the conclusions of their work (Toth et al., 2009). They can also be used for acquiring proficiency in the use of laboratory equipment.

The main disadvantage of remote labs is that they are more difficult to setup and costly to maintain compared to virtual labs. They also need specialized facilities depending on the experiment being conducted. Ideally, they can be operated in parallel with laboratories used in actual scientific work to reduce cost and make use of the trained scientific personnel and facilities that already exist. Examples of such coexistence are the two large remotely operated telescopes in Hawaii (Figure 1) and in Australia used by the Faulkes Telescope Project, and the network of robotic telescopes used by Discovery Space Network (Figure 2**Error! Reference source not found.**). The Discovery Space (D-Space) service contributes to the access to and sharing of advanced tools, services and learning resources for schools. The service aims at the deployment of a virtual science thematic park that connects schools, universities and science museums with a network of robotic telescopes around the world.

Figure 1. The Faulkes Telescope North at Haleakala, Hawaii, one of the main attractions of the Go-Lab Federation.

Figure 2. The Discovery Space (D-Space) service contributes to the access to and sharing of advanced tools, services and learning resources for schools. The service aims at the deployment of a virtual science thematic park that connects schools, universities and science museums with a network of robotic telescopes around the world. The system is based on the use of Grid technology to facilitate fast and reliable access to the network of the telescopes and the databases of the participating observatories.

2.2 Virtual Labs

Virtual labs are software that mimic physical equipment. Depending on the level of sophistication they can range from simple illustrations of physical processes that allow students to manipulate very few variables all the way up to accurate simulations of the experimental process complete with measurement errors. They are an alternative to remote labs and offer some distinct advantages.

Virtual labs are in general considerably less expensive than remote labs. They don't require specialized facilities and equipment or personnel to maintain them. They can be setup on any server infrastructure which is readily available, cheap and easy to maintain. Through them, the students can experiment without any cost to them and with almost no cost to the lab operator. They also impose no restrictions on their availability to the students who can use them at any time and for as many times they want even from their own homes usually without having to book time in advance since in general virtual labs can be simultaneously used by a large number of students.

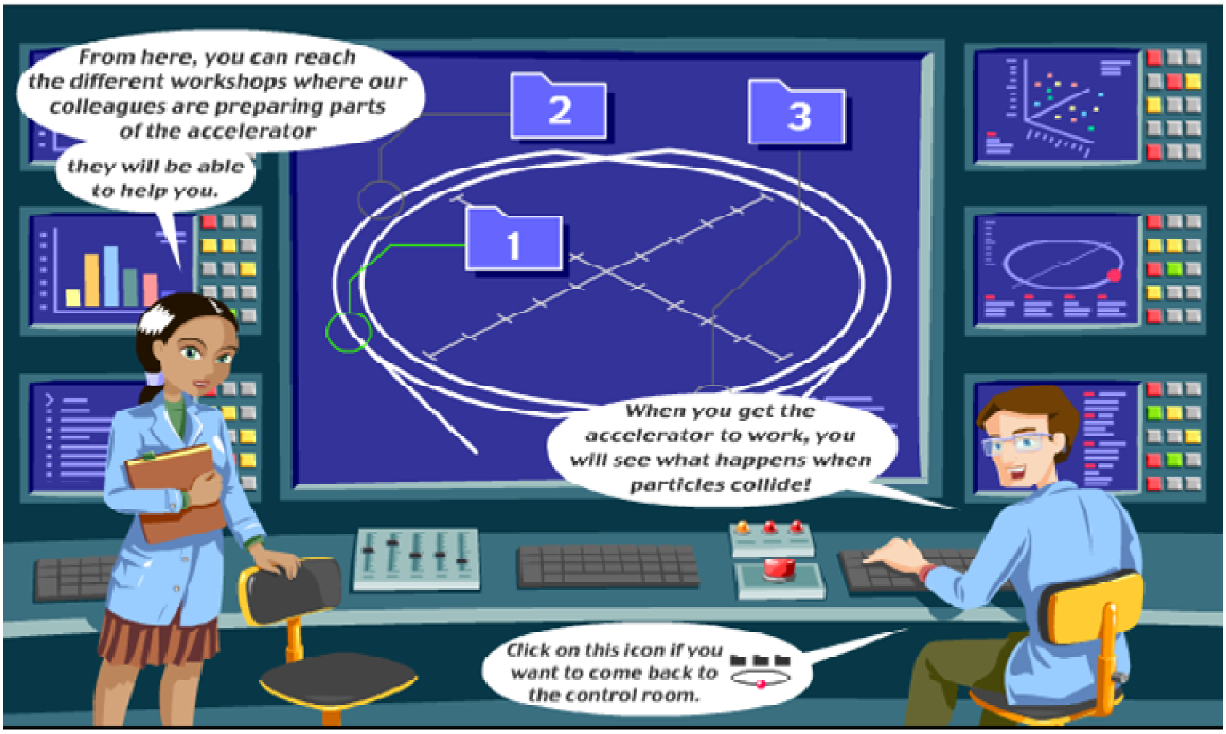

Figure 3. The LHC Game introduces students to the High Energy Physics world through a series of virtual experiments that connect research with the basic concepts thought at school.

Virtual labs are also completely safe to operate. They obviously pose no risk to the student, but also since no expensive or potentially dangerous equipment is used, they also pose no risk to the lab owner. Thus they are able to simulate physical processes that may be hazardous or even dangerous to study in a real lab. Additionally, the student usually needs no experience to operate them, other than basic computer skills, to manipulate virtual labs and can test any parameters even, in some cases, those that would lead to damage of the physical equipment in a real lab.

Furthermore, virtual labs offer extreme flexibility in the range of phenomena that can be simulated. There is a large number of experiments that are either very difficult, expensive or even impossible to conduct in a real laboratory. Virtual labs on the other hand can easily simulate processes that are extremely large (merging galaxies), small (splitting an atom), dangerous (explosions, chemical reactions), require huge equipment (LHC at CERN) or are simply too costly. An example virtual lab of this kind is the LHC game (Figure 3) which introduces to students the work done at CERN using a series of virtual experiments. In addition to that, the user can study all those phenomena closely and in detail something that would be impossible in most of the above mentioned cases. Measurements are, in general, very easy to read on a virtual lab and automated help can be offered instantly to the user to guide him/her without requiring constant supervision. Finally, a virtual lab can simulate reality in whatever level of complexity and realism is necessary. That can range from simple simulations of physical processes as they are described by equations without taking into account measurement errors, friction, environmental conditions etc. (low fidelity) all the way up to accurate simulations with a multitude of parameters and details (high fidelity). Adjusting the level of complexity can ensure that a virtual lab can become suitable for several levels of students depending on their age, background etc.

2.3 Data sets/Analysis tools

Data sets are databases which contain scientific data gathered in real experiments. These can be used directly in place of real experiments and measurements when access to such experiments is limited. For example, students cannot perform experiments using the LHC (Large Hadron Collider) accelerator and the ATLAS detector that are parts of the experimental equipment at CERN. However, the data received during the experiments performed at CERN using this equipment are stored into data sets; they are made available to the public and are apt for use by students. Data sets like those available by CERN are often accompanied by respective analysis tools that allow the manipulation of the data. One such example is HYPATIA (Figure 4) which allows the manipulation of the data from the ATLAS experiment. HYPATIA is an analysis tool specifically designed for the visualization and manipulation of the data derived for the ATLAS experiment.

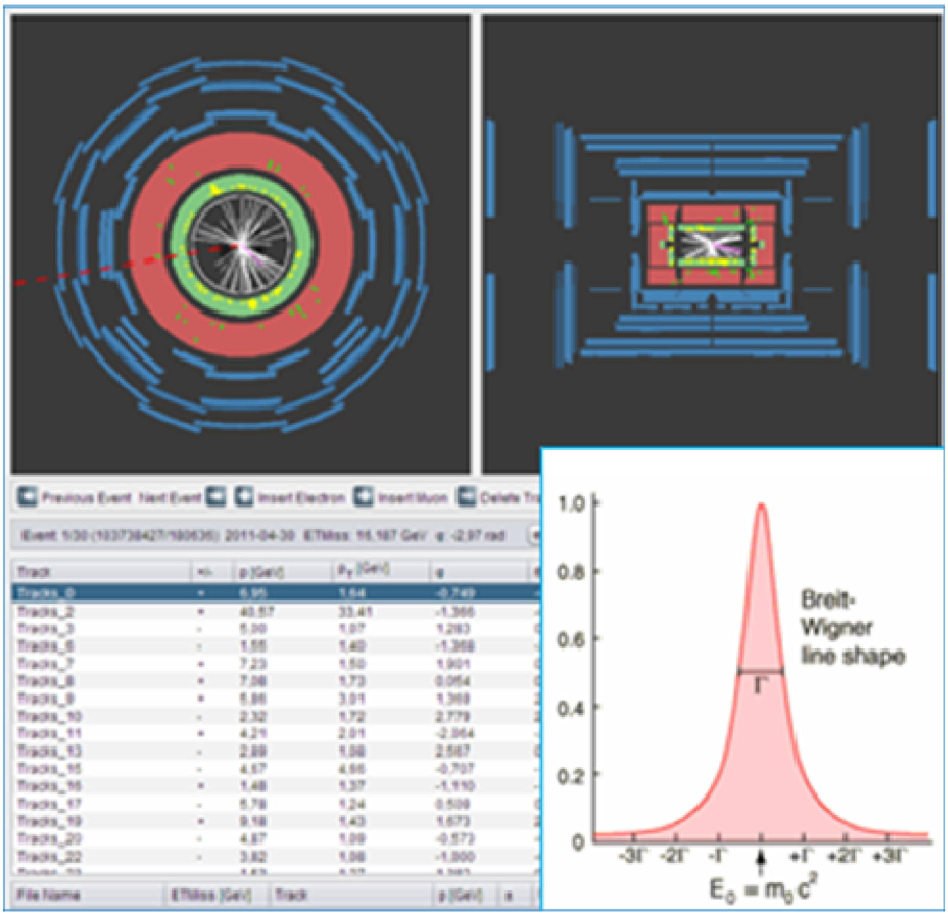

Figure 4. Using the HYPATIA lab students can analyze real data from the CERN detector ATLAS and search for Higgs-like particles.

Another example of a data set is the Sun4All project (Figure 5), which includes 30,000 images of the Sun that have been taken over the last 80 years. Students can use the data sets like Sun4All which will be included in the Go-Lab federation in order to access raw data from real scientific research and perform their own experiments. One big advantage of such data sets is that they allow students to perform experiments that if conducted in real time it would take years to complete. For example, students can directly access observations of the sun that have been taken over a period of 20 years and investigate the solar activity cycle. Additionally, during experimentation there is the possibility of receiving distorted or no data due to some malfunction of the equipment or other sources (for example a cloudy sky during an observation). In that case, unless the experiment can be repeated, students would have lost their opportunity to perform an activity. However, having data from past experiments stored would allow students to retrieve them and use them as a backup solution to proceed with their experimentation.

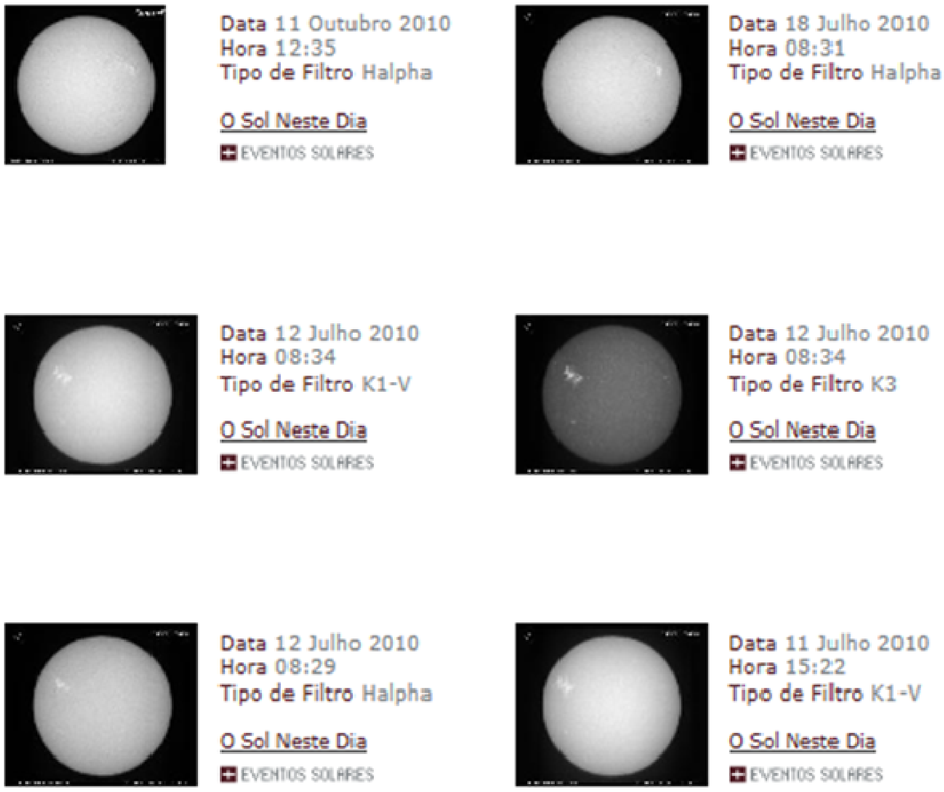

Figure 5. The Sun4All Repository includes 30,000 images of the Sun.

In the case of data sets like Sun4All additional tools like image analysis tools allow students to explore, model and visualize the experimental data. Such tools can be a major component of experimentation (virtual or remote). Students can perform analyses and gain insight of data in a fraction of the time required with spread sheets or traditional programming languages. These tools usually combine a powerful numeric engine and programming environment with interactive tools for statistical analysis, image processing, signal processing, and other domains. In many cases these tools are necessary in order to analyse data from remote labs. For example, in the case of telescope observations the images are provided in a specific format (FITS) and students need a specific analysis tool to get the information that is coming along with the image of the astronomical object. One such tool is the SalsaJ image analysis tool (Figure 6) which allows the processing of images and observations.

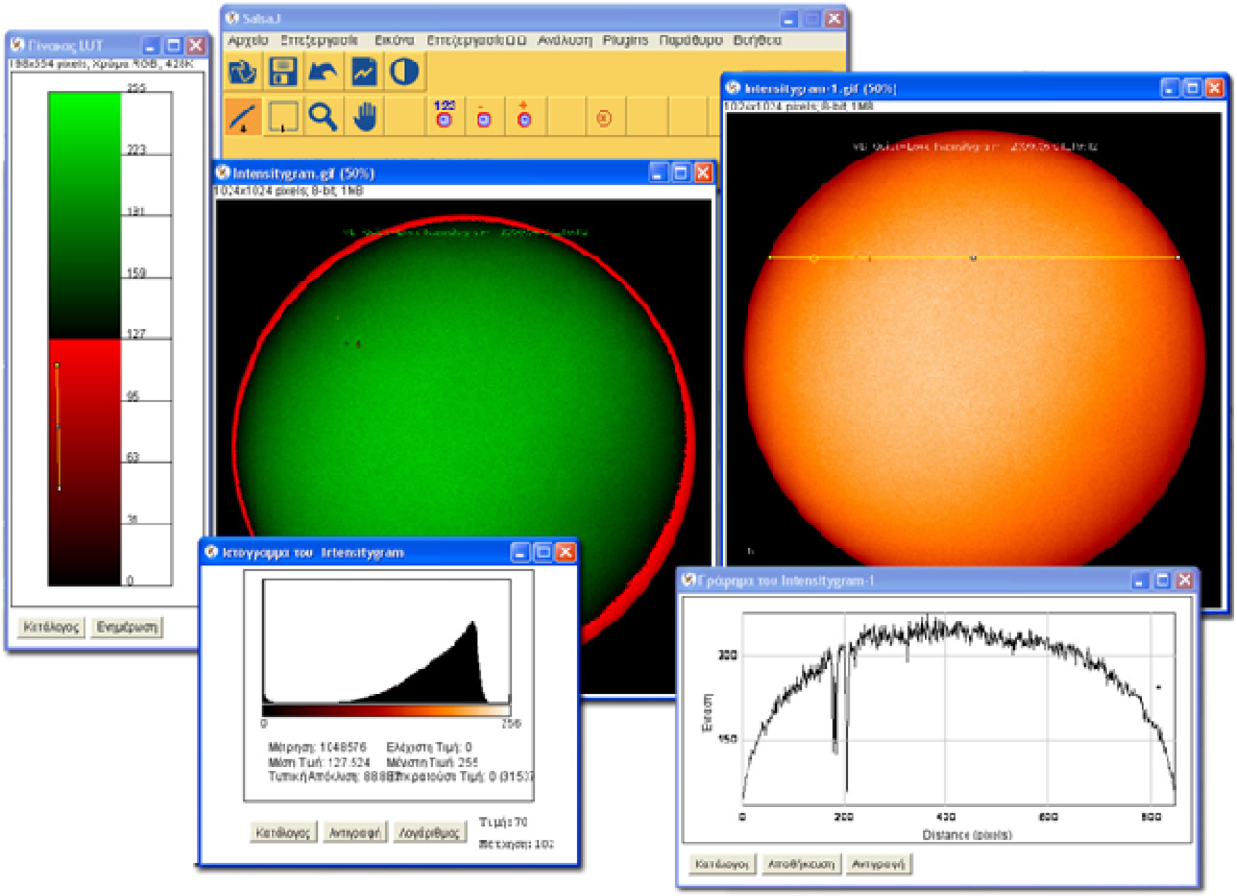

Figure 6. The SalsaJ image analysis tool allows students to process observations from different sources like the Faulkes telescopes remote lab or the Sun4All data set.

With the analysis tools students can:

- Access data from files, spreadsheets, databases, test equipment, data acquisition hardware, other software, or the Web
- Explore their data to identify trends, test hypotheses, and estimate uncertainty

Create customized algorithms, visualizations, and models and publish customized reports.

2.4 Additional Tools and Resources

Aside from the three different types of labs Go-Lab will also offer access to additional resources that can support students' inquiry. Additional resources include online courses and educational materials that have been developed by major research institutions like the European Space Agency (ESA) (Figure 7). These resources could be used mainly for the introductory steps of the inquiry cycle (problem orientation or questioning) or during the discussion and reflection on the students' findings. The enrichment of the Go-Lab repository with such resources could facilitate the development of MOOCs (Massive Open Online Courses) focusing on STEM issues. These courses could be developed by scientists (e.g., describing the research findings in their field of expertise related with the use of specific online labs from the Go-Lab repository) or by teachers who are using the Go-Lab services in their lessons.

Figure 8. The Astrobiology Lecture Series from ESA could form a great basis for the development of innovative school based activities with the Go-Lab online labs.

3 A Characterization Scheme for the Go-Lab Online Labs

In the framework of the work done in *Task 2.1-Review of existing online labs*, the Go-Lab consortium developed an initial template which aimed to collect the basic information required from each lab from the initial pool of online labs that will be integrated to the Go-Lab portal. The development of the template was based on the specific characteristics of the Go-Lab approach. In the framework of the Go-Lab approach the identification of online labs that support the implementation of the inquiry cycle or essential features of inquiry learning is of major importance. It is worth noticing here that at the time when this initial template was introduced to lab owners, the Go-Lab inquiry cycle was not yet finalized so the inquiry cycle phases vary a little. In the second template that was distribute for describing the labs that would be a part of the Go-Lab inventory at this stage, the inquiry cycle was modified so as to much the phases of the inquiry cycle proposed by WP1.

Additionally, the provision of guidance for students learning during their work with the online lab was explored in detail as the Go-Lab Portal aims to provide guidance (including scaffolds) and support tools (like tools for making tables, drawing pads, or tool for making graphical representations) as an additional service. Finally specific technical characteristics of the online labs had to be described in order for the technical team of the project to be able to organize their integration to the system.

The proposed template includes three main parts: The first one includes General Information about the online lab, the second part asks for the description of the pedagogical characteristics of each lab as well as the identification of the different phases of the inquiry cycle that the online lab proposes, and finally the technical part that asks for the technical parameters of each online lab. The template is presented in Table 1**Error! Reference source not found.**.

Table 1. The Go-Lab initial template for the characterization of the online labs.

General Information	
Lab Title	
Lab Category	*Please select one of the following:* • Remote lab • Virtual lab(s) • Data-set/Analysis Tool
Lab Owner	
Lab URL	
User Interface Language(s)	
Primary aims of the lab	*For example:* • Demonstrate how scientists work • Help explain the scientific process
Current number of lab users	
Demographic information of users (if available)	
Average time of use (per experiment/session)	
Brief description of the lab	*Please provide a description of the lab's content*

Pedagogical Information	
Subject domain(s)	• Chemistry • Biology • Physics • Earth Sciences and Environment • Technology • Engineering • Mathematics • Other (*please specify*)
Grade Level	• Primary Education (10-12 years old) • Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	*Please describe how the use of the lab can support students in manipulating, testing, exploring, predicting, questioning, observing, analyzing and making sense of the natural and physical world.*
Inquiry Cycle Phase *Please describe how the lab promotes the inquiry process.*	*Which inquiry phases are supported by the lab?* Orientation Questioning Hypothesis Experiment planning Observing Analysing Conclusion Evaluation Reflection
Use of guidance tools and scaffolds	*Please describe if the lab provides scaffolds in other words, are students given specific tools for one or more of the processes in the inquiry cycle.*
Teacher ICT competency level	*Please explain the ICT skills teachers need for effective use of the lab.*
Level of difficulty	*Please choose one of the following levels:* • Easy, Simple to Use (No teacher guidance is needed) • Medium (Teacher Guidance is needed at some stages of the process) • Advanced (Teacher has to support students during the whole process)
Level of interaction	*Please choose one of the following levels:* • Low (Users may only change very few parameters or can only follow one line of action) • Medium (Users may choose over a number

Pedagogical Information	
	of parameters to manipulate) • High (All parameters of the experiment should be defined by the use)
Context of use	*Please describe the context of use (e.g., to be used in the computer lab, in the framework of the school programme, in the framework of specific events, e.g., CERN Masterclasses).*
Supporting students with learning difficulties and special needs	*Please describe if the lab (and the supportive materials) could be used by students with special needs.*
User manual	
Additional supportive materials (e.g., usage scenarios)	
Description of a use case	*Please describe a common use case.*

Technical Information	
Web client (link to client app(s)	
APIs (server)	• *Do you provide APIs for other clients (operation and monitoring, …)* • *Full technical specs (inputs, outputs, data, video channels, parameters …)*
Alternative clients	• *If it is a remote labs, provide the link to its simulation (if it exists)* • *If it is a simulation, provide the link to the actual remote lab (if it exists)*
Compatibility	• *Platforms (Windows, MacOS, Linux, iOS, Android etc.)* • *Special plugin(s) with version (flash, java, etc.)* • *Browser(s) with version (Explorer > xx, Firefox, Google Chrome etc.)*
Registration needed	• *If Yes, give details:* • *If it is the case we will need a lot of information to enable interoperability*
Does the lab require to book time/schedule beforehand?	
Conditions of use	• *Free, bartering, paying?* • *First in first served or access through booking? Do you grant Go-Lab the right to make these conditions of use public?* • *Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How?*
Additional software/hardware needed?	

Technical Information	
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	*If so, is this available and in which format? Is this experimental data searchable?*
Does the lab track user interactions?	*If Yes, provide some details*

In the next section, we present the templates completed by the lab providers for each online lab.

4 The Initial Pool of the Go-Lab Online Labs

Below we present the templates of the labs that have been included in the initial pool of the twenty Go-Lab Online Labs. The templates are presented as they were completed by the respective lab owners. Based on the definitions given for the terms remote lab, virtual lab, data set/analysis tool and on our preliminary analysis of the footage provided by the lab owners, some of the tools and resources provided were not included in our initial pool as they did not fully match our definition of an online lab.

Finally, as mentioned in Section 2, along with the online labs, a series of additional resources will also be integrated in the Go-Lab Portal. These resources will aim to facilitate students in working more effectively with the online labs and carry out more advanced activities. Examples of such resources are mentioned in Section 5.5

4.1 HYPATIA (IASA)

General Information	
Lab name	HY.P.A.T.I.A.
Lab category	Data Set/Analysis Tool
Lab Owner	University of Athens, department of Physics / Institute of Accelerating Systems and Applications (IASA) Christine Kourkoumelis hkourkou@phys.uoa.gr
Lab URL	http://hypatia.iasa.gr
User Interface Language(s)	Greek, English
Primary aims of the lab	HYPATIA aims to show students how real high energy physic research is done. It provides the students with real data and an environment that closely resembles what actual researchers use, to give them the opportunity to conduct their own analysis and "discover" new particles.
Current number of lab users	300/month
Demographic information of users (if available)	Users from all over the world, but mostly from Europe. Data provided by Google analytics. No individual user data is available.
Average time of use (per experiment/session)	Depending on the experiment. One hour is typical.
Brief description of the lab	HYPATIA is an event analysis tool for data collected by the ATLAS experiment of the LHC at CERN. Its goal is to allow high school and university students to visualize the complexity of the hadron - hadron interactions through the graphical representation of ATLAS event data and interact with them in order to study different aspects of the fundamental building blocks of nature.

Pedagogical Information	
Subject domain(s)	Particle Physics
Grade Level	• Upper Secondary Education (15-18 years old) • Higher Education Bachelor
Engaging in scientific reasoning	HYPATIA is designed so that the user can view real events as they are detected by the ATLAS experiment at CERN. The scenarios involving HYPATIA mimic the process used by actual researchers during their work on event analysis. Thus, the user can analyse real data using real methods and get a taste of what it feels like to be a particle physics researcher. The user is given instructions on how to identify the various kinds of events that he will have to go through. Then every user (or pair) has to apply those criteria to the available events (which are different for every group of students) and identify then on his own. Then he has to study the histograms and reach a conclusion based on his analysis.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Analysing Conclusion Evaluation
Use of guidance tools and scaffolds	No guidance tools and scaffolds provided. Guidance and assignments are however incorporated in the webpage along with the applet.
Teacher ICT competency level	*No special ICT skill level required*
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	Flexible. Can be used by individual student or teacher as well as in an organized Masterclass
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://hypatia.iasa.gr/en/HYPATIA_Instructions_eng.pdf
Additional supportive materials (e.g., usage scenarios)	Help page http://hypatia.iasa.gr/en/help.html

Pedagogical Information	
Description of a use case	Students can examine real Z boson decays and calculate their mass through the use of the built-in invariant mass table. They can do the same with simulated Higgs boson decays. Then they create histograms that give them the invariant mass and width of the particle.

Technical Information	
Web client (link to client app(s)	http://hypatia.iasa.gr
APIs (server)	N/A
Alternative clients	N/A
Compatibility	Runs on all Platforms but requires java (java plug-in installed in the browser)
Registration needed	*No*
Does the lab require to book time/schedule beforehand?	*No*
Conditions of use	• Free • *Do you grant Go-Lab the right to make these conditions of use public?* Yes • *Is the lab already referenced in an educational repository?* Yes *http://portal.discoverthecosmos.eu*
Additional software/hardware needed?	*No*
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	The user can export the results of his experiment as images (histograms) of text (invariant masses). The lab itself does not store user data.
Does the lab track user interactions?	*No*

4.2 The Faulkes Telescope Project (USW)

General Information	
Lab name	Faulkes Telescope Project
Lab category	Remote Lab (Two robotic telescopes)
Lab Owner	Dr Paul Roche
Lab URL	http://www.faulkes-telescope.com

User Interface Language(s)	English
Primary aims of the lab	• Demonstrate how scientists work • Demonstrate how, through the use of telescopes, astronomers can draw conclusions on what they observe in the Universe • Demonstrate how a very complex scientific instrument works
Current number of lab users	About 5,000 users (teachers and students)
Demographic information of users (if available)	This lab is aimed at school students, ages 15-18
Average time of use (per experiment/session)	1 hour
Brief description of the lab	The Faulkes Telescope Project is an education partner of Las Cumbres Observatory Global Telescope Network (LCOGTN). The aim is to provide free access to robotic telescopes and a fully supported education programme to encourage teachers and students to engage in research-based science education. Access to our resources and those of our partners is provided at no charge to teachers and students. Robotic Telescopes LCOGTN operates a network of research class robotic telescopes. Currently there are two telescopes, one in Hawaii and the other in Australia. 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 and a team of educators and professional astronomers. http://www.faulkes-telescope.com/resources/videos/ft-lcogt_introduction

Pedagogical Information	
Subject domain(s)	• Astronomy • Physics
Grade Level	• Upper Secondary Education (15-18 years old)
Engaging in scientific reasoning	Through the use of the telescopes, students can manipulate different scenarios on how universe evolves and on how astronomical objects move. They can select the parameters of the observation; identify the most appropriate period for an observation, to compare their images with professional images. By examining telescope observations of currently interacting galaxies, students will be encouraged to predict what will happen to these galaxies in the future – they can then test their predictions by running the simulation software until their simulated galaxies match the observations, and then run time

Pedagogical Information	
	forward to see what may happen to the galaxies.
Inquiry Cycle Phase	Observing
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Teachers will need to be competent in the following ICT areas: Searching the internet for information Accessing data from websites Using JAVA tools (simulation software) and navigating websites for further information which may aid in the use of the tools
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	This lab is designed to be used in a computer lab during an approximately 2 hour lesson.
Supporting students with learning difficulties and special needs	The material can be enlarged on screen for those students with visual impairments.
User manual	There is a support section which among others includes documentation. http://www.faulkes-telescope.com/support/documentation
Additional supportive materials (e.g., usage scenarios)	**Multimedia Resources** **Web Applications** These applications are designed and built by the FT team and run in your internet browser. These applications go hand in hand with our educational projects but can also be used independently. **Interactive Animations** Have a look at our interactive animations which help explain scientific concepts and methods. These animations are fun to play with and good educational tools which aid our educational programmes. **Google Sky** Add Faulkes Telescope images to Google Sky. These packs are constantly updated and could include images that you have taken. **Videos** Have a browse through our video library. These videos and podcasts are produced by members of the FT team and include topics from information about the Faulkes Telescope Project through to how stars are formed.

Pedagogical Information	
Description of a use case	There are numerous showcases available on the web site of the telescope http://www.faulkes-telescope.com/showcases/schools

Technical Information	
Web client (link to client app(s)	*N/A*
APIs (server)	There is no API involved in this lab
Alternative clients	*http://rti.faulkes-telescope.com/control/Login.isa*
Compatibility	• Compatible with Windows, MacOS, Linux, iOS, Android • JAVA plugin required for simulation software • Compatible with IE, Firefox, Safari
Registration needed	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. By filling out the form and accepting the Las Cumbres Observatory terms and conditions you are registering your organization for telescope use. http://rti.faulkes-telescope.com/control/Register.isa
Does the lab require to book time/schedule beforehand?	Yes
Conditions of use	• Free • http://www.faulkes-telescope.com/information/registration
Additional software/hardware needed?	None
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	Yes. There are several ways to search through all our public observations. Use any combination of the options below to help narrow your search. http://lcogt.net/observations/search
Does the lab track user interactions?	Yes. Though an internal system that provides web analytics.

4.3 WebLab-DEUSTO Aquarium (DEUSTO)

General Information	
Lab name	WebLab-DEUSTO Aquarium
Lab category	Remote lab
Lab Owner	WebLab-Deusto, University of Deusto Javier Garcia-Zubia [zubia@deusto.es]
Lab URL	http://www.weblab.deusto.es/weblab
User Interface Language(s)	English, Spanish, Basque, French, German, Czech, Slovak, Portuguese, Romanian, Hungarian
Primary aims of the lab	Demonstrate how scientists work
Current number of lab users	Around 200
Demographic information of users (if available)	*N/A*
Average time of use (per experiment/session)	One session may need more than one connection. The Go-Lab scenario will determine the duration of a connection. We estimate that it will be around 3 minutes depending on the pedagogical scenario.
Brief description of the lab	The main learning objective is Archimedes' Principle. There is an aquarium with 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, etc.

Pedagogical Information	
Subject domain(s)	Physics
Grade Level	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old)
Engaging in scientific reasoning	The user can see a different behaviour of the balls with different liquids in the water. After this experiment they can discuss why it happens. Finally, with the help of a teacher or a scaffold, they will connect this experience with Archimedes' Principle.
Inquiry Cycle Phase	Hypothesis Experiment planning Observing Analysing
Use of guidance tools and scaffolds	The remote lab offers different levels of analysis to a user. In the first level a user can see the behaviour of the ball in the water using a web cam.

Pedagogical Information	
	In the second level a user can take pictures of the aquarium, and after this she/he can analyse the picture using software tools, e.g., Paint. In the third level the WebLab-Deusto offers to a user a possibility of processing the interface picture. Using this tool a user will obtain some data (volume, volume over the water….) ready to be used them to calculate the density or to conclude where is an oil, or an alcohol. The teacher will decide the scaffold that he needs to teach or to perform the experiment in the classroom. The technical data such as density of water and alcohol, volume of the balls, etc. is provided.
Teacher ICT competency level	*No*
Level of difficulty	Easy, Simple to Use (No teacher guidance is needed)
Level of interaction	Low
Context of use	The Archimedes' Principle is suitable for all these scenarios.
Supporting students with learning difficulties and special needs	No specific provisions
User manual	None
Additional supportive materials (e.g., usage scenarios)	To be designed
Description of a use case	Students can use the lab in the classroom while learning about buoyancy.

4.4 Galaxy Crash (USW)

General Information	
Lab name	Galaxy Crash
Lab category	Virtual Lab
Lab Owner	Dr Fraser Lewis fraser.lewis@southwales.ac.uk
Lab URL	http://burro.cwru.edu/JavaLab/GalCrashWeb
User Interface Language(s)	English
Primary aims of the lab	• 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
Current number of lab users	N/A

Demographic information of users (if available)	This lab is aimed at school students, ages 15-18
Average time of use (per experiment/session)	2 hours
Brief description of the lab	Students are asked to make predictions on how galaxies form and evolve in the Universe. They 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 search the data archive of the robotic Faulkes Telescopes and find observations of interacting galaxies. 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.

Pedagogical Information	
Subject domain(s)	• Astronomy • Physics
Grade Level	• Upper Secondary Education (15-18 years old)
Engaging in scientific reasoning	Through the use of galaxy simulation software, students can manipulate different scenarios on how galaxies form. They can change the parameters of the galaxies in the software, such as the mass, distance from each other, angle of inclination etc, and test any theories or hypotheses that they may have on how galaxies interact and evolve over time. By examining telescope observations of currently interacting galaxies, students will be encouraged to predict what will happen to these galaxies in the future – they can then test their predictions by running the simulation software until their simulated galaxies match the observations, and then run time forward to see what may happen to the galaxies. By analyzing the results of the simulation software, students can estimate the likely time for galaxies of different masses, etc to interact and merge, or investigate what parameters affect whether galaxies merge or not, or how tidal tails are formed in interacting galaxies.
Inquiry Cycle Phase	Which inquiry phases are supported by the lab? **Orientation/Questioning** – students will be encouraged to think about how galaxies form and evolve over time with such questions as: How do galaxies form? What types of galaxies are

Pedagogical Information	
	there in the Universe? How long does it take for galaxies to form? Do all galaxies merge together? What evidence is there for galaxy interactions? **Hypothesis** – After thinking about the different types of galaxies, and how they form, students will come up with ideas on how galaxies may form, and how they can investigate this using simulations. They will be encouraged to predict how galaxies form. **Experiment planning** – After students have made their predictions, they will be guided through the 'Galaxy Crash' simulation software. This will give them the background knowledge which they will need for planning their experiment. After they have become familiar with the software, they will plan an experiment to investigate how galaxies form e.g., they will choose what parameters to change/keep constant in the simulations and see how this may affect their hypotheses. **Observing** – The students will observe the outputs of their simulated galaxy collisions and draw conclusions on what parameters affect a galaxy's evolution. They will also be asked to search the Faulkes Telescope data archive for evidence of galaxy interactions that have been imaged by the telescopes. They can then attempt to recreate these interactions using the simulation software, and observe how closely their simulations and observations match up. **Analyzing** – By comparing the observed galaxy images and the results of the simulations, students can investigate how the interactions may have taken place – they can look at what initial parameters the galaxies may have had, and what will happen to the 2 galaxies in the future. **Conclusion** – Students can draw conclusions based on their analysis e.g., which parameters best model the observed galaxy interaction? How long did it take for this interaction to reach the observed shape? Based on the simulation, what do they think will happen to these galaxies in the future? **Evaluation** – Students can evaluate their findings by e.g., commenting on any shortcomings that the simulation software may have. They can discuss how they used the simulation software and what settings they adjusted, and compare how the simulation ran under different initial parameters. **Reflection** – by sharing their results with others in the class, students can communicate their explanations with each other, comment on any similarities/differences between their results and

Pedagogical Information	
	others in the class, and reflect on how they (individually) carried out the activity, and what they might change in future experiments which may affect their results.
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided*
Teacher ICT competency level	Teachers will need to be competent in the following ICT areas: Searching the internet for information Accessing data from websites Using JAVA tools (simulation software) and navigating websites for further information which may aid in the use of the tools
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	This lab is designed to be used in a computer lab during an approx. 2 hour lesson.
Supporting students with learning difficulties and special needs	The material can be enlarged on screen for those students with visual impairments.
User manual	There is a section in the labs webpage explaining the controls of the applet. http://burro.cwru.edu/JavaLab/GalCrashWeb/controls.html
Additional supportive materials (e.g., usage scenarios)	There is a section in the labs webpage that includes activities. http://burro.cwru.edu/JavaLab/GalCrashWeb/labIntro.html
Description of a use case	This lab can be used to introduce the topic of simulation, and comparison with real observational data.

Technical Information	
Web client (link to client app(s)	*N/A*
APIs (server)	There is no API involved in this lab
Alternative clients	Galaxy Crash Simulation software: http://burro.cwru.edu/JavaLab/GalCrashWeb Data archive of Faulkes robotic telescopes: http://lcogt.net/observations/search
Compatibility	• Compatible with Windows, MacOS, Linux, iOS, Android • JAVA plug-in required for simulation software

Technical Information	
	• Compatible with IE, Firefox, Safari
Registration needed	No
Does the lab require to book time/schedule beforehand?	No
Conditions of use	**Simulations software** The credit to this software states: All applets © 1999-2004 Chris Mihos. If desired, you may include these applets on your website via direct links, provided you also acknowledge the source via an accompanying link to the main page of the website (http://burro.astr.cwru.edu/JavaLab/).
Additional software/hardware needed?	None
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	No

4.5 CERNland (CERN)

General Information	
Lab name	CERNland
Lab category	Virtual Lab
Lab Owner	Antonella Del Rosso
Lab URL	http://www.cern.ch/cernland http://www.cernland.net
User Interface Language(s)	English, French, German, Italian, Polish, Spanish
Primary aims of the lab	CERNland is the virtual theme park developed to bring the excitement of CERN's research to a young audience aged between 7 and 12. CERNland is designed to show children what we do at CERN and inspire them with some physics at the same time.
Current number of lab users	CERNland has an average number of daily visits around 270, (80% are new visitors and the rest is returning visitors)
Demographic information of users (if available)	In the last month, this is the ranking by country (first countries only): United Kingdom, France, United States, Switzerland, Germany, Spain, Italy, Mexico, Turkey, India
Average time of use (per experiment/session)	Not available.
Brief description of the lab	CERNland contains games on all topics related to the CERN activity.

Pedagogical Information	
Subject domain(s)	• Particle Physics • Technology • Engineering • Cosmology
Grade level	Primary Education (10 -12 years old)
Engaging in scientific reasoning	CERNland is designed to show children what we do at CERN and inspire them with some physics at the same time. Kids do not need any particle-physics expertise to enjoy CERNland but those who click on the information links will be better placed to answer the questions and improve their scores. As with many real theme parks there is no real age limit to enjoying CERNland: anyone can follow SuperBob round the LHC or try building atoms by collecting electrons, protons and neutrons.
Inquiry Cycle Phase	Experiment planning Observing Analysing
Use of guidance tools and scaffolds	No extra guidance tools and scaffolds provided. Small assignments and guidance is however included in the game.
Teacher ICT competency level	Basic skills, CERNland aims at young kids
Level of difficulty	• Easy, Simple to Use (No teacher guidance is needed)
Level of interaction:	• High (All parameters of the experiment should be defined by the use)
Context of use	In the classroom, during a field trip at a CERN exhibition, in the computer lab.
Supporting students with learning difficulties and special needs	It has been used with kids with some difficulties but there are no specific provisions.
User manual	Help included in each game
Additional supportive materials (e.g., usage scenarios)	CERNland is included as a follow-up activity in structured inquiry-based teaching scenarios supporting parents and primary school teachers to organize better their visits with their young pupils to CERN permanent and travelling exhibitions. These scenarios are available at the Open Science Resources (OSR) Portal as well as the Discover the COSMOS Portal and have been used extensively by parents and teachers in the framework of the CERN mini-expo tours in Greece and Spain over the last two years.

Description of a use case	CERNland, a virtual thematic park composed mainly of games but also videos and other multimedia material about CERN and its experiments, physics, cosmology and technology, can be used by primary school students individually or in groups during in-class and out-class activities, including visits to CERN and its associated travelling exhibitions. A typical case includes the use of CERNland following a family or school visit to CERN as described in inquiry-based learning scenarios available at the Discover the COSMOS Portal under the title "Visiting the CERN Mini Expo".

Technical Information	
Web client (link to client app(s)	Any browser
APIs (server)	N/A
Alternative clients	N/A
Compatibility	Optimized for Flash 11.4.402.287
Registration needed	No
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• Free
	• Do you grant Go-Lab the right to make these conditions of use public? YES • Is the lab already referenced in an educational repository? (If yes, which?) MANY • Are there usage restrictions because of this? NO
Additional software/hardware needed?	No
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	No

4.6 LHC Game (CERN)

General Information	
Lab name	LHC Game
Lab category	Virtual Lab
Lab owner & contact person	Emma Sanders, CERN
Lab URL	http://education.web.cern.ch/education/Chapter2/Teaching/games/LHCGame
User Interface Language(s)	English, Italian, French, German

Primary aims of the lab	Introduce the principal elements of a particle accelerator such as the Large Hadron Collider at CERN.
Current number of lab users	N/A
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	45 minutes
Brief description of the lab	A computer interactive developed for the Microcosm exhibition at CERN introducing the workings of a particle accelerator like the Large Hadron Collider. Users of the interactive discover how, for example, protons are accelerated using electromagnetic fields. They then put their knowledge to the test as they are asked to regulate the accelerating field to accelerate a proton before passing to the next stage. On successful completion of the 3 steps (acceleration, bending and focusing) collisions occur and data taking can commence.

Pedagogical Information	
Subject domain(s)	Physics
Grade Level	Lower Secondary Education (12 -15 years old)
Engaging in scientific reasoning	*N/A*
Inquiry Cycle Phase	Observing Analysing
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided*
Teacher ICT competency level	*N/A*
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	Medium
Context of use	*N/A*
Supporting students with learning difficulties and special needs	*No*
User manual	*N/A*
Additional supportive materials (e.g., usage scenarios)	The LHC Game has been included in various inquiry-based teaching scenarios targeting students at primary and lower secondary level who are either visiting CERN or engage in learning activities associated with understanding Big-Science infrastructures for the experimental study of particle physics.

Pedagogical Information	
Description of a use case	Students are prepared to visit CERN or CERN mini-expo in a nearby location. The teacher, before the visit, informs and encourages the students to explore about the LHC by watching the LHC video on YouTube and also to play the LHC Game at home in combination with similar games such as the Hunt for Higgs.

Technical Information	
Web client (link to client app(s)	*N/A*
APIs (server)	*N/A*
Alternative clients	*N/A*
Compatibility	*N/A*
Registration needed	*Not necessary*
Does the lab require to book time/schedule beforehand?	*No*
Conditions of use	• Free • First in first served • Do you grant Go-Lab the right to make these conditions of use public? YES
Additional software/hardware needed?	*No*
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	*No*
Does the lab track user interactions?	*No*

4.7 Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS (DEUSTO)

General Information	
Lab name	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS
Lab category	Remote lab
Lab owner & contact person	WebLab-Deusto, University of Deusto Javier Garcia-Zubia [zubia@deusto.es]
Lab URL	The remote experiment is accessed directly from the Boole-Deusto software. http://boole-deusto.sourceforge.net/ E-mail to zubia@deusto.es to obtain the last version of Boole-Deusto

User Interface Language(s)	English and Spanish
Primary aims of the lab	Design basic digital systems.
Current number of lab users	Around 100
Demographic information of users (if available)	*N/A*
Average time of use (per experiment/session)	The user has 200 seconds in each connection. Depends on the pedagogical scenario one lesson/session can need more than one connection.
Brief description of the lab	Digital systems are everywhere. For instance, a computer is a digital system. This experiment shows the principles of digital systems and devices. Users may use a combination of a Designing tool (Boole-Deusto) and a Remote Lab (WebLab-Deusto). Student can design the behaviour of a digital system using a truth table in Boole-Deusto. The systems designed by the students can be implemented in the WebLab-Deusto with only one mouse click. Therefore students can experiment in a real scenario with switches, leds, etc. The system provides a rapid prototyping environment for digital systems.

Pedagogical Information	
Subject domain(s)	• Technology • Engineering
Grade Level	Upper Secondary Education (15 -18 years old)
Engaging in scientific reasoning	The teacher can use the laboratory in the classroom to show students different examples of digital systems/circuits from basic to complex. The Boole-Deusto helps a user to describe a digital system, and to follow the design process using Truth-Table, K-Map, minimization, Boolean expression and digital circuit. The implemented design shows how digital system runs in reality.
Inquiry Cycle Phase	Experiment planning Observing Analyzing
Use of guidance tools and scaffolds	Boole-Deusto software helps a student design the digital system. Two specific remote experiments provide a practice with binary codes and logic gates. They can be used as scaffold. www.weblab.deusto.es -> binary codes www.weblab.deusto.es -> chose ud-logic.
Teacher ICT competency level	Basic knowledge

Pedagogical Information	
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	The system Boole-Deusto + WebLab-Deusto can be used by the teacher in many different scenarios that depend on educational objectives of the teacher. For example, (1) the teacher can teach the students what is a binary code, and after his explanation the students can design their own binary codes. (2) the teacher can explain the students the binary system and after this he (and the students) can implement an adder, calculator…. (3) the teacher can explain the students how to control a motor using a digital system. Based on this knowledge the students can design their own systems. Boole-Deusto is used since more than 10 years (especially in Spain and Latin America). The connection with WebLab-Deusto has started this year.
Supporting students with learning difficulties and special needs	*Not analysed*
User manual	There is a user manual.
Additional supportive materials (e.g., usage scenarios)	There are a lot of exercises available.
Description of a use case	*One example or scenario:* The student designs a new binary code using the truth table and tests it on the WebLab-Deusto. He provides the new binary code to another student. The task of the other student is to discover the binary code, a key or an idea.

Technical Information	
Web client (link to client app(s)	http://www.weblab.deusto.es/weblab/client/?locale=es#page=experiment&exp.category=PLD%20experiments&exp.name=ud-pld
APIs (server)	• APIs in JSON over HTTP, XML-RPC or SOAP. Not documented, though. • Specs: not documented yet.
Alternative clients	The Boole-Deusto provides a simulator. Moreover there are other free simulators.
Compatibility	WebLab-Deusto is available for all the OS with any web browser and without plug-ins.
Registration needed	At this moment no registration is needed, the Boole-Deusto directly connects with WebLab-Deusto.

Technical Information	
Does the lab require to book time/schedule beforehand?	The WebLab-Deusto uses a queue for the schedule. The maximum time is 200 seconds per connection; no restriction for quantity of the connection exists.
Conditions of use	• Free, • First in first served (but with privileges) • Do you grant Go-Lab the right to make these conditions of use public? YES • Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? This remote lab is available on the OLAREX web page (www.olarex.eu). OLAREX is a KA3 European project. All the information (biological module, examples…) is available.
Additional software/hardware needed?	*No*
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	*No*
Does the lab track user interactions?	The login info (who, when, how much time) and input commands are tracking data

4.8 ELVIS / OP – AMP Labs (CUAS)

General Information	
Lab name	ELVIS / OP – AMP Labs
Lab category	Remote lab
Lab Owner	Carinthia University of Applied Sciences Danilo Garbi Zutin
Lab URL	http://ilabs.cti.ac.at/ServiceBroker
User Interface Language(s)	English
Primary aims of the lab	Demonstrate how operational amplifiers work
Current number of lab users	20
Demographic information of users (if available)	*N/A*
Average time of use (per experiment/session)	20 – 30 minutes
Brief description of the lab	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 multi-meter)

Pedagogical Information	
Subject domain(s)	Engineering

Pedagogical Information	
Grade Level	• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	Students can work on predefine circuits with operational amplifiers and test their behaviour in different configurations.
Inquiry Cycle Phase	Orientation Experiment planning Observing Analysing Conclusion Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Basic knowledge, create user accounts, assign permissions.
Level of difficulty	Easy, Simple to Use (No teacher guidance is needed)
Level of interaction	Low
Context of use	These remote labs can be accessed in the lab under teacher supervision or from home. This depends on the way that the teacher wants to organize the course. No special guidance is mandatory during working with the system.
Supporting students with learning difficulties and special needs	The system can be used by any kind of students as long as they have Internet access and are able to work with a computer. No specific material realized for this purpose.
User manual	*N/A*
Additional supportive materials (e.g., usage scenarios)	N/A
Description of a use case	During a lecture teacher explains the relationship between the resistors in a non-inverting amplifier circuit and its gain. After the theoretical part a lab assignment is given where students have to test different combinations of resistors, measure the gain of the amplifier and finally compare with the calculated results.

Technical Information	
Web client (link to client app(s))	http://ilabs.cti.ac.at/ServiceBroker
APIs (server)	http://ilabs.cti.ac.at/ServiceBroker

Technical Information	
Alternative clients	http://exp04.cti.ac.at/elvis/video/ASIC_Demo2_1.swf
Compatibility	• Platforms: Windows, MacOS, Linux • Special plugin(s) Java Runtime Engine
Registration needed	Anybody who wants to access the lab needs to register first to http://ilabs.cti.ac.at/ServiceBroker. After they will have access and can realize experiments.
Does the lab require to book time/schedule beforehand?	No schedule is required.
Conditions of use	• Free • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? Yes. It is indexed in Lab2go. This implies no additional restrictions.
Additional software/hardware needed?	Java Runtime Engine
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	Yes, the lab stores experimental data (specification of lab experiment and the results)
Does the lab track user interactions?	It tracks user access, experiment submission time.

4.9 VISIR (CUAS)

General Information	
Lab name	VISIR
Lab category	Remote lab
Lab Owner	Carinthia University of Applied Sciences Danilo Garbi Zutin
Lab URL	http://ilabs.cti.ac.at/ServiceBroker
User Interface Language(s)	English
Primary aims of the lab	• Understand basic laws (ohm's and Kirchhoff's law) • Create simple electric circuits • Understand the behaviour of electronic components
Current number of lab users	20
Demographic information of users (if available)	*N/A*
Average time of use (per experiment/session)	No more than 20 minutes for a session

<table>
<tr><td>Brief description of the lab</td><td>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 can 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.</td></tr>
</table>

Pedagogical Information	
Subject domain(s)	Physics - electronics
Grade Level	• Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	Using VISIR students can improve their knowledge in basic laws of electric circuits. They can study and analyse how electrical components are working and how they can create a circuit. Students can work on predefine circuits or design their own ones. For this they can use real laboratory equipment such as multi-meter, direct current (DC) Power, Oscilloscope, and Function Generator into remote world.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Experiment planning Observing Analysing Conclusion Evaluation Reflection

Pedagogical Information	
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Teachers need to have basics knowledge of IT for system administration. Typical administration tasks would be: • creating user accounts • setting permissions • changing lab configuration
Level of difficulty	Easy, Simple to Use (No teacher guidance is needed)
Level of interaction	High
Context of use	These remote labs can be accessed in the lab under teacher supervision or from home, typical following a specific lab assignment. Use of the remote lab is not mandatory, but optional for students to acquire understanding of the concepts presented during the theoretical lecture. No special guidance is mandatory during working with VISIR.
Supporting students with learning difficulties and special needs	The system can be used by any kind of students as long as they have Internet access and are able to work with a computer. No specific material realized for this purpose.
User manual	Not available
Additional supportive materials (e.g., usage scenarios)	Not available
Description of a use case	During a lecture the teacher explains how resistor's combination in series and parallel work. After the theoretical part a lab assignment is given where students have to test different combinations of resistors, measure the equivalent resistance and compare with the calculated results.

Technical Information	
Web client (link to client app(s)	http://ilabs.cti.ac.at/ServiceBroker
APIs (server)	http://ilabs.cti.ac.at/ServiceBroker
Alternative clients	http://exp04.cti.ac.at/elvis/video/ASIC_Demo2_1.swf
Compatibility	• Platforms: Windows, MacOS, Linux • Special plugin(s) Java Runtime Engine
Registration needed	Anybody who wants to access the lab needs to register first to http://ilabs.cti.ac.at/ServiceBroker. After they will have access and can realize experiments.
Does the lab require to book time/schedule beforehand?	Yes, it requires time schedule.

Technical Information	
Conditions of use	• Free • Booking necessary • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? Yes, it is referenced in Lab2go (www.lab2go.net). This implies in no additional usage restrictions
Additional software/hardware needed?	Flash Player
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	It tracks user access, booking time, usage time.

4.10 CPLD Lab (CUAS)

General Information	
Lab name	CPLD Lab
Lab category	Remote lab
Lab Owner	Carinthia University of Applied Sciences Danilo Garbi Zutin
Lab URL	http://ilabs.cti.ac.at/ServiceBroker
User Interface Language(s)	English
Primary aims of the lab	To improve prototyping and testing skills for digital systems
Current number of lab users	20
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	Up to 60 minutes
Brief description of the lab	The presented lab is a system for remote prototyping and testing of digital systems that allows users to perform tests on real devices remotely over the Internet as well as design digital systems with the Altera Max+PlusII development environment. The access to this software is delivered via a Citrix Presentation Server. LabView was used to deliver the user interface and control the data acquisition and data generation with a DAQ card from National Instruments. Such systems are especially suited for manufacturing process monitoring, control and for learning purposes.

Pedagogical Information	
Subject domain(s)	• Technology • Engineering • Hardware programming (VHDL)
Grade Level	• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	Get acquainted with digital systems. Learn about technology and how to use different instruments.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Experiment planning Observing Analysing Conclusion Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Basic level, create user account, set permissions
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	Medium
Context of use	These remote labs can be accessed in the lab under teacher supervision or from home. This depends on the way that the teacher wants to organize the course. No special guidance is mandatory during working with the system.
Supporting students with learning difficulties and special needs	The system can be used by any kind of students as long as they have Internet access and are able to work with a computer. No specific provisions for this purpose.
User manual	Not available
Additional supportive materials (e.g., usage scenarios)	Not available
Description of a use case	In a lecture about simple Boolean algebra a teacher explains how simple blocks like AND, OR can be used to assemble more complex Boolean expressions. The students receive a lab assignment to use these blocks to create a Boolean function. Students can test the function with the hardware and compare with the true-table calculated.

Technical Information	
Web client (link to client app(s)	http://ilabs.cti.ac.at/iLabServiceBroker
APIs (server)	http://ilabs.cti.ac.at/iLabServiceBroker
Alternative clients	Not available
Compatibility	• Platforms: Windows • Special plugin(s) LabView Virtual Machine
Registration needed	Anybody who wants to access the lab needs to register first to http://ilabs.cti.ac.at/iLabServiceBroker . After they will have access and can realize experiments.
Does the lab require to book time/schedule beforehand?	Booking necessary
Conditions of use	• Free • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? Yes. Lab is indexed in Lab2go. This implies no additional restrictions.
Additional software/hardware needed?	LabView Virtual Machine
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No measurement data is stored.
Does the lab track user interactions?	The lab stores usage data, like access logs, booking time, duration of lab session.

4.11 MINERVA (CERN)

General Information	
Lab name	Minerva
Lab category	Data Set/Analysis Tool
Lab Owner	Prof Peter Watkins (pmw@hep.ph.bham.ac.uk)
Lab URL	http://atlas-minerva.web.cern.ch/atlas-minerva
User Interface Language(s)	English
Primary aims of the lab	MINERVA is a tool developed to help students learn more about the ATLAS experiment and particle physics at CERN. It is based on Atlantis, the event display used at ATLAS to visualise what happens in the detector. The aim of MINERVA is to give students a better understanding of how particle detectors work and the physics that they study.

Current number of lab users	N/A
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	1 hour
Brief description of the lab	Currently, in MINERVA, students are able to study W and Z boson events by observing their decay products and apply this knowledge to search for the Higgs boson. Students can also search for the decay of neutral hadrons by searching for oppositely charged pairs of tracks originating from a vertex displaced from the main interaction.

Pedagogical Information	
Subject domain(s)	High Energy Physics
Grade Level	• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor
Engaging in scientific reasoning	MINERVA is a tool for students to learn more about the ATLAS experiment at CERN. It is based on a simplified setup of the ATLAS event display, Atlantis, which allows users to visualise what is happening in the detector. The aim is to look at ATLAS events and try to recognise what particles are seen in the detector.
Inquiry Cycle Phase	Experiment planning Observing Analysing Conclusion
Use of guidance tools and scaffolds	No extra guidance tools and scaffolds provided. Guidance and preparation information is provided through separate files.
Teacher ICT competency level	No special ICT skill level required
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	Medium (Users may choose over a number of parameters to manipulate)
Context of use	Flexible. Can be used by individual student or teacher as well as in an organized Masterclass
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://atlas-minerva.web.cern.ch/atlas-minerva/support.php
Additional supportive materials (e.g., usage scenarios)	Structured inquiry-based teaching scenarios using MINVERVA to plan and conduct measurements of Z and W bosons are available at the Discover the COSMOS Portal
Description of a use case	Currently, in MINERVA, students are able to study W and Z boson events by observing their decay

Pedagogical Information	
	products and apply this knowledge to search for the Higgs boson.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	Runs on all Platforms but requires java
Registration needed	No
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• Free • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? Yes [http://ippog.web.cern.ch]
Additional software/hardware needed?	No
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	No

4.12 Many Cratered Worlds (NUCLIO)

General Information	
Lab name	Many Cratered Worlds
Lab category	Virtual Lab
Lab Owner	Dr. Pamela L. Gay / Rosa Doran (NUCLIO)
Lab URL	http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds
User Interface Language(s)	English
Primary aims of the lab	• Demonstrate that the same science applies everywhere • Show that planets evolve • Show how we learn about the solar systems history through modern images
Current number of lab users	N/A (Project still in development)
Demographic information of users (if available)	N/A

Average time of use (per experiment/session)	2 hours
Brief description of the lab	Users will be able to analyse and process images from Solar System bodies, taken from different space exploration missions.

Pedagogical Information	
Subject domain(s)	• Earth Sciences and Environment • Technology • Mathematics • Planetary Science
Grade Level	• Lower Secondary Education (12 -15 years old)
Engaging in scientific reasoning	Students participating in this tool will use images of other worlds (the Moon, Mercury, and Mars initially) to observe how different surface regions are different ages, and to explore how differences in a world's physical characteristics change crater morphologies. They will analyse crater counts, and draw conclusions about which areas among the different regions are younger and older. They will use what they learn to reflect about craters on Earth
Inquiry Cycle Phase	Observing analysing Conclusion Evaluation Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	This lab requires ICT Basic Tools, including applications software, a web browser, and presentation software.
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	Medium
Context of use	This is a highly flexible lab that may be incorporated into the class using only hand-outs, or (preferred) can engage students in a computer lab.
Supporting students with learning difficulties and special needs	We are in the process of developing adaptations to use this activity with students with autism and other learning disabilities that make them non-verbal. Note: This program is not appropriate for the visually impaired.
User manual	Presented through an online PDF and guided website. http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds

Pedagogical Information	
Additional supportive materials (e.g., usage scenarios)	A full teacher guide, including related existing activities and demos, is provided. http://cosmoquest.org/blog/educatorszone/labs/many-cratered-worlds
Description of a use case	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.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	• Windows, MacOS, Linux, iOS (iPad only), Android (tablets only) • Browser(s) with version (Explorer 9 and higher, Firefox 4 and higher, Google Chrome 10 and higher, Safari 6 and higher)
Registration needed	Teachers may seek a set of logins for their class, but individual registrations are preferred. This requires an email address.
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• Free • Always available • Do you grant Go-Lab the right to make these conditions of use public? Yes
Additional software/hardware needed?	No
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	Yes, and it may be downloaded as a comma separated table
Does the lab track user interactions?	Yes. All user interactions with the site are recorded, including pages viewed, and measurements made. This data is stored relative to an anonymous user id. Links between user ids and personally identifying information is stored separately.

4.13 Sun4All (NUCLIO)

General Information	
Lab name	Sun4All
Lab category	Data Set/Analysis Tool
Lab Owner	University of Coimbra Astronomical Observatory Prof. João Fernandes / Rosa Doran (NUCLIO)
Lab URL	http://www.mat.uc.pt/sun4all/index.php/en/
User Interface Language(s)	The site is in Portuguese and English. The database search interface is in Portuguese only.
Primary aims of the lab	• Demonstrate how scientists work • Help explain the scientific process • Get acquainted with the use of sun images repositories.
Current number of lab users	About 10,000 – it's widely used by Portuguese schools and also by EU-HOU, GHOU and GTTP partners and teachers all over the world
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	Depends on the task to be accomplished. Can range from 5 minutes to several hours.
Brief description of the lab	The repository has more than 30,000 sun images (spectroheliograms) obtained at the Coimbra Observatory since 1926.

Pedagogical Information	
Subject domain(s)	• Physics • Mathematics • Astronomy
Grade Level	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	The repository provides real science grade images of the sun, more precisely spetroheliograms. These images can be used for many different research paths, from individual images sunspot counting or measuring of Solar flares, to more in depth analysis of the yearly sun activity and its correlation (or not) to the climate.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Experiment planning Observing Analysing

Pedagogical Information	
	Conclusion Evaluation Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Teachers need to have a basic knowledge of ICT. Some knowledge of digital image processing is advisable.
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	Medium
Context of use	Sun4all can be used in different contexts. Shorter activities can be performed in the classroom, longer projects are ideal for science/astronomy clubs.
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://www.mat.uc.pt/sun4all/index.php/en/
Additional supportive materials (e.g., usage scenarios)	A large collection of activities have been developed by the Coimbra Observatory and is available in the Discover the COSMOS portal (portal.discoverthecomos.eu)
Description of a use case	A student goes to the website and downloads images of the Sun. The purpose is to evaluate the synodic rotation period of the Sun (one complete rotation of the Sun related to the Earth). They express the number in earth days unit. The easier way to do this is through observing solar spots. The teacher can start by introducing the student to the problems face by Galileo Galilei when he observed the Sun and concluded that the solar spots are indeed features in the solar surface. His/her ingenious observations led him to the correct conclusion that the spots where not objects passing in front of the Sun but actually belonging to the Solar Surface. The teacher should invite the students to think about this problem and build their own hypothesis for solving this riddle. Students learn how to build a movie of the rotating Sun using SalsaJ and continue exploring selected images in order to acquire the necessary data to work in their hypothesis. They can open each individual image using SalsaJ and measure their position in each one using the specific tools for this purpose in the software. Students have now to be introduced to the

Pedagogical Information	
	heliographic coordinates and how the Sun's north and south pole are titled towards us. Teachers have also to introduce the concept that the Sun's rotation is differential, which introduces a further challenge to the student. Students learn how to use the Stoney Hurst disks in order to find the proper latitude and longitude in the Sun and further analyse their images in order to find the rotation period for the images they have chosen. Students have the opportunity to discuss their ideas and share their findings with the rest of the class.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	Any web browser.
Registration needed	*Teachers may seek a set of logins for their class, but individual registrations are preferred. This requires an email address.*
Does the lab require to book time/schedule beforehand?	The images are available to anyone. You only have to register if you want to submit your results.
Conditions of use	• Free • Not an online tool. So there are no restrictions on the number of users, or access rights. • Do you grant Go-Lab the right to make these conditions of use public? Yes
Additional software/hardware needed?	Depending on the task you might need access to a spread sheet and image analysis tool.
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	Yes. The original images and the measured proprieties of the images provided by the users.
Does the lab track user interactions?	Only of the registered users.

4.14 The Discovery Space Portal (DSpace) (EA)

General Information	
Lab name	The Discovery Space Portal (DSpace)
Lab category	Remote lab

Lab Owner	Sofoklis Sotiriou (sotiriou@ea.gr)
Lab URL	http://www.discoveryspace.net/
User Interface Language(s)	English
Primary aims of the lab	• Demonstrate how science works • Increase students' interest in astronomy • Improve inquiry skills, critical thinking skills • Promote the use of ICT during the teaching process
Current number of lab users	1,100 registered users
Demographic information of users (if available)	Europe (mainly from Greece, UK, Spain)
Average time of use (per experiment/session)	45 minutes
Brief description of the lab	The portal offers access to 6 robotic telescopes seamlessly into one virtual observatory and provides the services required to operate this facility, including a scheduling service, tools for data manipulation and access to related educational materials. The portal gives students the opportunity to use remotely controlled telescopes in a real-time. In this way it enables students to increase their knowledge on astronomy, astrophysics, mathematics and other science subjects and improve their computer literacy while strengthening their critical thinking skills. Students are able to graphically view all quantities under study and the data correlations. The service has 1,100 registered users (teachers and students).

Pedagogical Information	
Subject domain(s)	• Physics • Mathematics • Astronomy
Grade Level	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	DSpace gives students the opportunity to use remotely controlled telescopes and use them in real-time. Students are able to manipulate and process the data received from the telescopes through appropriate tools and software that are provided. The educational activities available allow students to learn how scientific work is done, and work following the same procedure with scientists; from observing and making hypotheses to analysing data, drawing conclusions and communicating findings. Overall the use of the lab contributes in raising

Pedagogical Information	
	awareness of astronomy related themes and in increasing students' interest in science and mathematics.
Inquiry Cycle Phase	Observing
Use of guidance tools and scaffolds	Image processing tools are offered.
Teacher ICT competency level	Teachers need to have basic ICT skills involving using a computer, being able to browse in the internet and manipulate documents in formats like word, excel and PowerPoint.
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	School connected on the web
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://www.discoveryspace.net/index.asp?Cat_ID=570
Additional supportive materials (e.g., usage scenarios)	http://www.discoveryspace.net/index.asp?Cat_id=581 More scenarios are available at http://www.discoverthecosmos.eu
Description of a use case	***Measuring the height of the Lunar Craters - Educational Phase*** **Stimulation:** 1x45 min • Presentation of selected photos and/or videos of the Moon's surface • Short discussion on the Moon's surface and crater formation mechanisms • Draw up a list on a blackboard with the proposed methods of measuring of the height of the lunar craters **Experimental Activities:** *First phase (1x45 min)* The users of the D-Space service must: • select a Robotic Telescope among the Network of Robotic Telescopes • check the meteorological status for the site where the selected Robotic Telescope is located • fill in the celestial coordinates of the Moon and the proper time of observation or (better) just select the moon and submit their request(s) *Second phase (1x45 min)* The users of the D-Space service must: • take the Moon's image from the Database Library • study and understand the analysis method

Pedagogical Information	
	followed in the theory • estimate the height of the lunar craters using the proposed software for the analysis of the image(s) **Observation - Discussion:** Discussion of the theoretical issues arising from the observational (experimental) activities This is facilitated with the assistance of the website's theory tutorial and links • Theory and observation (experiment) comparison • Comparison with the Eratosthenes experiment, observe similarities and differences **Consolidation:** Questions, exercises and tasks aiming at consolidation of the acquired knowledge **Exercises:** • Estimate the height of a tree measuring the shadow of the tree

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	Windows, MacOS, Linux, Flash Explorer, Firefox, Google Chrome
Registration needed	Basic Information is required (valid email address, Name, Role (Teacher/student)
Does the lab require to book time/schedule beforehand?	Only for Skinakas Observatory. In this case uses need to present a project to the DSPACE team and get their approval to operate the telescope.
Conditions of use	• Free • Access through booking • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? DSPACE is part of the Discover the COSMOS repository (portal.discoverthecosmos.eu). There are no usage restrictions. Discover the COSMOS portal provides guidelines on the Harvesting process.
Additional software/hardware needed?	For the analysis of the images LTImage and Salsaj

Technical Information	
	analysis tools are recommended.
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	Images are stored in both jpeg and FITS formats. Only FITS images can be used for further analysis.
Does the lab track user interactions?	No

4.15 Microcontroller platform in robolabor.ee (UTE)

General Information	
Lab name	Microcontroller platform in robolabor.ee
Lab category	Remote lab
Lab Owner	Võru County VEC Lembit Pähnapuu lembit@vkhk.ee
Lab URL	http://distance.roboticlab.eu/lab/view/8
User Interface Language(s)	English Estonian German
Primary aims of the lab	• Study microcontroller technology • Perform lessons about sensors and actuators, controlled by microcontroller
Current number of lab users	30
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	20min
Brief description of the lab	This remote lab is a testbed for Robotic HomeLab kit v5.1 The lab consists of standard Robotic HomeLab kit modules, like Controller module and User Interface module and special Combo module. Different types of motors and sensors are connected to Combo board and can be controlled by user program. User can also program indicators and display seen on the front.

Pedagogical Information	
Subject domain(s)	• Technology • Engineering
Grade Level	• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	Demonstrate how science works.

Pedagogical Information	
	Acquaintance with robotics.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Experiment planning Observing analysing Conclusion Evaluation Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Basic programming
Level of difficulty	• Easy, Simple to Use (No teacher guidance is needed) • Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High
Context of use	• Lab is used for robotic, computer science, mechatronic and embedded system courses in different levels of education; Upper Secondary Education, Higher Education Bachelor and Master
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://distance.roboticlab.eu/menu/index/11
Additional supportive materials (e.g., usage scenarios)	http://home.roboticlab.eu
Description of a use case	N/A

Technical Information	
Web client (link to client app(s)	Common web browser (Firefox is suggested)
APIs (server)	N/A
Alternative clients	N/A
Compatibility	• Platforms : Windows, MacOS, Linux • Special plugins : flash, java • Browsers: Firefox, Google Chrome

Technical Information	
Registration needed	Yes. Ask demo user from: info@ittgroup.ee
Does the lab require to book time/schedule beforehand?	Yes
Conditions of use	All options are available (Free, bartering, paying)
Additional software/hardware needed?	No
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	It is stored into the server's database, accessible for supervisors.
Does the lab track user interactions?	No

4.16 SimQuest Elektro (UT)

General Information	
Lab name	SimQuest Elektro
Lab category	Virtual Lab
Lab Owner	Jakob Sikken J.Sikken@utwente.nl
Lab URL	On request
User Interface Language(s)	English, Dutch and which are needed
Primary aims of the lab	Conduct experiments in the domain of electrical circuits
Current number of lab users	N/A
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	2-3 hours
Brief description of the lab	Create electrical circuits and measure voltages and currents. The circuits are limited to static situations.

Pedagogical Information	
Subject domain(s)	Electrical engineering
Grade Level	• Lower Secondary Education (12 -15 years old)
Engaging in scientific reasoning	The lab allows students to create and investigate static electrical circuits.

Pedagogical Information	
Inquiry Cycle Phase	Exploring Experimenting
Use of guidance tools and scaffolds	No guidance tools and scaffolds provided.
Teacher ICT competency level	Basic ICT skills
Level of difficulty	Medium
Level of interaction	Medium
Context of use	Computer lab.
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://www.simquest.nl/manuals.htm
Additional supportive materials (e.g., usage scenarios)	Support is integrated in the learning environment. This environment contains a tutorial instructing the students how to operate the lab and series of assignments guiding the students through the experimentation processes. It is designed in such a way that students can work on their own.
Description of a use case	SimQuest Elektro is a virtual lab-based inquiry learning environment. In the environment, the students are presented with virtual electrical circuits. Students can add or remove electrical components (such as light bulbs and resistors), adjust the voltage, and perform measurements using virtual multi-meters. Students are given assignments that are integrated within the virtual lab environment and that are designed to structure their experimentation processes. These assignments have the following structure. First, the students are asked to predict the outcome of a change in a given circuit. This part of the assignment is meant to activate prior knowledge and to have students articulate their own ideas about the behaviour of the connection. Then the students use the virtual lab to experiment, collect empirical data and make observations that will help them to find out what really happens in the situation described in the first step. After the second step, the students are asked to reflect upon whether their initial prediction was confirmed or disconfirmed by the data and to draw conclusions on the basis of their observations in the virtual lab.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A

Technical Information	
Alternative clients	N/A
Compatibility	Windows only
Registration needed	No registration needed
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• *First in first served or access through booking?* Not applicable • *Do you grant Go-Lab the right to make these conditions of use public?* Yes • *Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How?* No
Additional software/hardware needed?	*SimQuest (http://www.simquest.nl/index.htm)*
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	No

4.17 MATLAB Simulations (CUAS)

General Information	
Lab name	Matlab Simulations
Lab category	Virtual lab
Lab Owner	Carinthia University of Applied Sciences Contact: Danilo G. Zutin (d.garbizutin@fh-kaernten.at)
Lab URL	http://sim01.cti.ac.at/
User Interface Language(s)	German
Primary aims of the lab	Simulate several phenomena from different domains(electrical circuits, physics, electromagnetism, etc)
Current number of lab users	20
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	15 min
Brief description of the lab	This lab provides a set of simulations carried out in a server running Matlab with pre-defined mathematical models. Users can change input parameters, but not the simulation model. Outputs of these simulations are typically arrays with measurement data and images.

Pedagogical Information	
Subject domain(s)	• Chemistry • Physics • Earth Sciences and Environment • Technology • Engineering • Mathematics
Grade level	• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master
Engaging in scientific reasoning	This lab uses simulations to explain some physical phenomena. It helps students to improve their understanding of nature. Simulations are not always the best way to achieve this, but in special cases where resources (lab equipment) are scarce or not feasible they can add great value to the learning process.
Inquiry Cycle Phase	Hypothesis Experiment planning Observing Analysing Conclusion Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Basic Knowledge (Internet as a user)
Level of difficulty	• Medium *(Teacher Guidance is needed at some stages of the process)* • Advanced (*Teacher has to support students during the whole process)*
Level of interaction	• Low *(Users may only change very few parameters or can only follow one line of action)*
Context of use	This lab is used as part of the curriculum of the following subjects: Mathematical Modelling, Signal Transformations and signal processing.
Supporting students with learning difficulties and special needs	No specific provisions
User manual	Not available
Additional supportive materials (e.g., usage scenarios)	Not available
Description of a use case	Experiments with this lab are carried out as part of lab assignments handed out after the theoretical lessons.

Technical Information	
Web client (link to client app(s)	http://sim01.cti.ac.at/

APIs (server)	*http://sim01.cti.ac.at/*
Alternative clients	N/A
Compatibility	Special plugin(s): Java VM
Registration needed	No registration needed
Does the lab require to book time/schedule beforehand?	No booking necessary
Conditions of use	• Free
	• First in first served
	• Do you grant Go-Lab the right to make these conditions of use public? YES Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? Available through Lab2go (www.lab2go.net)
Additional software/hardware needed?	No
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No need to store any data.
Does the lab track user interactions?	*No*

4.18 LearnIT 3D Games Based Go Lab Simulations

General Information	
Lab name	3D Games Based Go Lab Simulations
Lab category	Virtual lab
Lab Owner	Learnit3D (Andy McPherson) Ellinogermaniki Agogi/Nuclio
Lab URL	To be determined
User Interface Language(s)	English
Primary aims of the lab	• Immerse students in an enquiry based 3D simulation • Demonstrate how scientists work • Help explain the scientific process • Support students in manipulating, testing, exploring, predicting, questioning, observing, analysing and making sense of the natural and

General Information	
	physical world.
Current number of lab users	N/A
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	30-60 minutes
Brief description of the lab	Labs will immerse students in rich 3D immersive environments where they will experience branching and unfolding learning journeys based on enquiry/investigation of various science topics such as: • Nature of Light • Environment and Climate Change • Electromagnetism • Energy/Renewable Energy • Geography and Geology • Health • Rain Forest • Mechanics
Pedagogical Information	
Subject domain(s)	• Biology • Physics • Earth Sciences and Environment • Technology • Engineering
Grade Level	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old)
Engaging in scientific reasoning	Through virtual engagement in simulated 3D environments and scenarios, students will be placed in the role of scientist and challenged to carry our scientific enquiries.
Inquiry Cycle Phase	Orientation Questioning Hypothesis Experiment planning Observing Analysing Conclusion Evaluation Reflection
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Teacher ICT capability will be minimal. Simulations

General Information	
	will be inherently scaffolded and support students throughout the proves.
Level of difficulty	• *Easy, Simple to Use (No teacher guidance is needed)* • *Medium (Teacher Guidance is needed at some stages of the process)*
Level of interaction	Medium
Context of use	To be used in computer lab or remotely from home or as part of event/masterclass etc.
Supporting students with learning difficulties and special needs	To be determined
User manual	No – all guidance built in to simulations
Additional supportive materials (e.g., usage scenarios)	To be developed
Description of a use case	Used by students as self-directed individual enquiry into topic as part of wider study/lesson on topic. Either as pre study before teacher interventions, mid process or as an opportunity to apply and test understanding of concepts covered through wider study.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	• Platform Windows • Requires Java • Browsers Explorer, Google Chrome
Registration needed	No
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• *First in first served or access through booking?* Not applicable • *Do you grant Go-Lab the right to make these conditions of use public?* Yes • *Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How?* No
Additional software/hardware needed?	• Platforms : Windows XP • Special plugins : DirectX 9.0

Technical Information	
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	YES – to be determined
Does the lab track user interactions?	YES – to be determined

4.19 International Space Station 3D teaching tool (ESA)

General Information	
Lab name	International Space Station 3D teaching tool
Lab category	Virtual lab
Lab Owner	European Space Agency Monica Talevi, +31 71 565 3223 Monica.Talevi@esa.int
Lab URL	http://www.esa.int/esaHS/SEM3TFYO4HD_education_0.html
User Interface Language(s)	English, French, German, Spanish, Italian, Dutch, Portuguese, Danish, Swedish, Finnish, Norwegian, Greek
Primary aims of the lab	To introduce various scientific topics using the context of the International Space Station
Current number of lab users	N/A
Demographic information of users (if available)	N/A
Average time of use (per experiment/session)	45 minutes
Brief description of the lab	Role playing adventure game or set of interactive exercises that can be accessed in any order. Includes scientific explanations and background info.

Pedagogical Information	
Subject domain(s)	• Chemistry • Biology • Physics • Earth Sciences and Environment • Technology • Engineering • Mathematics • Space
Grade Level	• Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old)
Engaging in scientific reasoning	Learn about how spaceships are build and how

Pedagogical Information	
	astronauts navigate in them.
Inquiry Cycle Phase	Orientation Questioning Exploration
Use of guidance tools and scaffolds	*No guidance tools and scaffolds provided.*
Teacher ICT competency level	Basic ICT skills
Level of difficulty	*Easy, Simple to Use (No teacher guidance is needed)*
Level of interaction	Medium
Context of use	Can be used at school or at home
Supporting students with learning difficulties and special needs	No specific provisions
User manual	No
Additional supportive materials (e.g., usage scenarios)	No
Description of a use case	No

Technical Information	
Web client (link to client app(s)	Standard browser
APIs (server)	*N/A*
Alternative clients	*N/A*
Compatibility	Compatible with all platforms
Registration needed	No
Does the lab require to book time/schedule beforehand?	No
Conditions of use	• Free • Open access • Do you grant Go-Lab the right to make these conditions of use public? Yes • Is the lab already referenced in an educational repository? No
Additional software/hardware needed?	PC With minimum spec • Windows XP SP2 or above • 500mb of hard disk space • 1gb of RAM • Net framework 2.0

Technical Information	
	• DirectX 9.0 • Modern graphics card with latest drivers, 64mb of RAM and Direct3D support.
Does the lab store experimental data (measurements performed by users, images collected, etc.)?	No
Does the lab track user interactions?	No

4.20 SalsaJ (NUCLIO)

General Information	
Tool/resource Name	SalsaJ
Tool/resource Category	Data Set/Analysis Tool
Owner	EU-HOU project Rosa Doran (NUCLIO)
URL	http://www.euhou.net/index.php/salsaj-software-mainmenu-9
User Interface Language(s)	English, French, Spanish, Italian, Polish, Greek, Portuguese, Swedish, Northern Sami, Arabic, Chinese.
Primary aims	• Demonstrate how scientists work • Help explain the scientific process • Astronomical (and other) image processing and analysis tool
Current number of users	About 10,000
Demographic information of users (if available)	From different countries across the world
Average time of use	From 5 minutes to several hours.
Brief description of the resource/tool	It allows students to display, analyze, and explore real astronomical images and other data in the same way that professional astronomers do, making the same kind of discoveries that lead to true excitement about science.

Pedagogical Information	
Subject domain(s)	• Biology • Physics • Mathematics • Astronomy
Grade Level	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old)
Engaging in scientific reasoning	SalsaJ is a data analysis tool that can process images and spectra. It can accomplish most of the tasks that professional astronomers use in order to make real research. It's capabilities as a generic image manipulation tool means that it can also be used to analyze and process images from other sciences, like biology, earth sciences, and so on…
Inquiry Cycle Phase	Questioning Hypothesis Experiment planning

Pedagogical Information	
	Exploring Analysing
Use of guidance tools and scaffolds	No extra guidance tools and scaffolds provided. An "About" section is however included in the tool.
Teacher ICT competency level	Teachers need to have a basic knowledge of ICT. Some knowledge of digital image processing is advisable.
Level of difficulty	Medium (Teacher Guidance is needed at some stages of the process)
Level of interaction	High (All parameters of the experiment should be defined by the use)
Context of use	Classroom Use, Computer Lab
Supporting students with learning difficulties and special needs	No specific provisions
User manual	http://www.euhou.net/index.php/salsaj-software-mainmenu-9/manual-salsaj-2
Additional supportive materials (e.g., usage scenarios)	A large collection of activities have been developed within the EU-HOU, GHOU and GTTP collaborations. http://www.euhou.net/index.php/exercises-mainmenu-1
Description of a use case	A very simple and quick use of the tool is to demonstrate the rotation of the sun. As a 1st step the user accesses the SOHO website (http://sohowww.nascom.nasa.gov) and downloads recent images that span a couple of weeks. Load all images on SalsaJ and produce a short movie of the rotating Sun.

Technical Information	
Web client (link to client app(s)	N/A
APIs (server)	N/A
Alternative clients	N/A
Compatibility	SalsaJ is a standalone Java application, so it runs on Windows, MacOS and Linux, provided that Java is installed.
Registration needed	Not necessary
Does the resource/tool require to book time/schedule beforehand?	No

Technical Information	
Conditions of use	• Free • Off-line tool. So there are no restrictions on the number of users, or access rights. • Do you grant Go-Lab the right to make these conditions of use public? Yes
Additional software/hardware needed?	None
Does the resource/tool store experimental data (measurements performed by users, images collected, etc.)?	SalsaJ can save data in common image formats, jpg, png, tiff, bmp,gif. In the astronomy specific fits format. It can also produce movies in the avi format.
Does the lab track user interactions?	No

5 Analysis of the Initial Pool of the Go-Lab Online Labs

The online labs available from all the partners of Go-Lab cover a wide range of subject domains, age groups and levels. Our analysis is based on the information provided by the lab owners which covers both the educational aspects of the labs as well as the technical side. All information is presented unchanged, as it was provided, with the exception of lab type which was corrected in a few cases as it did not follow the online labs definition. The labs are classified under three categories, Remote Labs, Virtual Labs and Data Sets/Analysis Tools.

The analysis focuses on the labs' types, age classification, lab domains and languages. In the case of age classification we have categorized the labs not only by the intended age group but also by their type. This allows for easy checking of the distribution of labs in both of these fields. In the case of lab domains, we have presented the original domains as stated by the lab owners. However those domains are in some cases very general (e.g., physics) and in others very specific (e.g., Hardware programming VHDL). In order to give a better picture of the distribution of labs across their domains, we have also classified them according to the STEM (Science, Technology, Engineering and Mathematics) system and, as in the case of age classification; we have also separated them by lab type. We have also presented the language distribution which covers both the consortium languages as well as several other European languages. We have also summarized the available learning activities from each lab in Table 5. The inquiry cycle phases that each lab follows are presented in a separate graph with details shown in Table 21 in the annex.

In Table 18 we have aggregated a number of other important factors such as the availability of learning activities and whether they follow some form of inquiry cycle, the use of scaffolds, as indicated by the lab owners and the levels of interactivity and difficulty. We have also included some important technical aspects of the labs, in particular whether they require registration or booking to use, the current number of users, if available and any other special requirements that may be necessary to use each lab. Those parameters are only presented in Table 18 as they are mostly yes or no answers that do not lend themselves to further analysis.

Overall, this analysis provides a general idea about the labs' parameters and requirements both individually, in Table 18, and as a whole. More information regarding the specific details of each lab can be found in their respective questionnaires.

5.1 Lab Types

Currently there are twenty labs available from our partners. In respect to their type, most of them are Remote Labs and Virtual Labs and only four (20%) are classified as a Data Set/Analysis Tool.

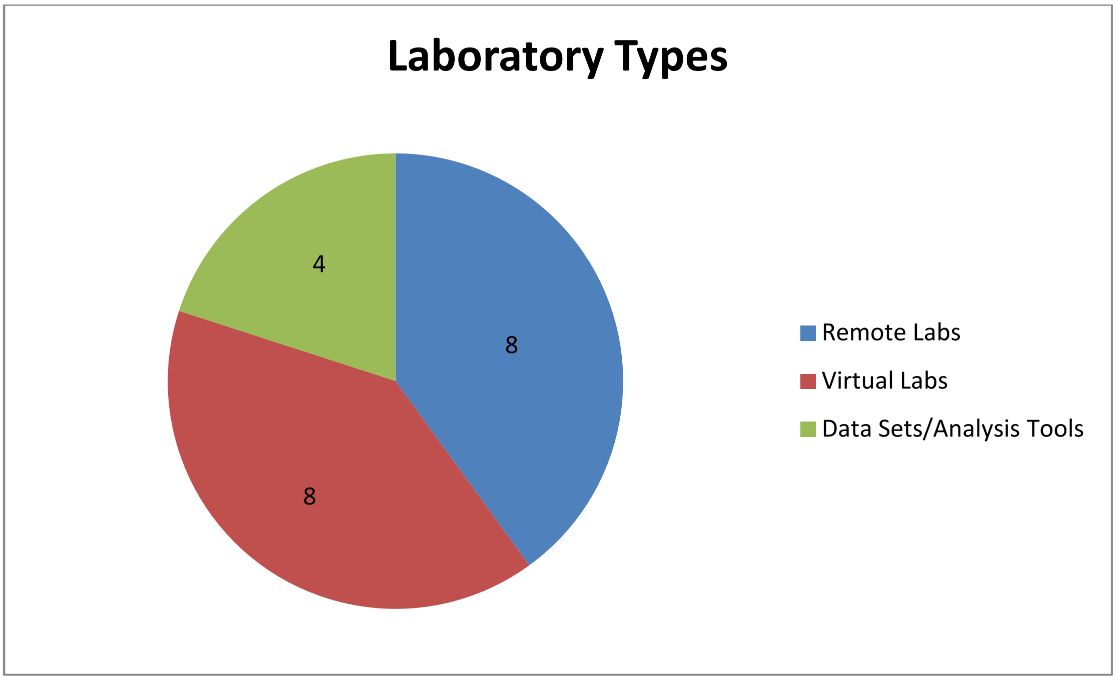

Figure 9. Available labs per type

Table 2. Type classification

Type	Name
Remote Labs (8)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CPLD Lab DSpace ELVIS / OP – AMP Labs Faulkes Microcontroller platform in robolabor.ee VISIR WebLab-DEUSTO Aquarium
Virtual Labs (8)	CERNland International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations LHC Game Many cratered Worlds Matlab Simulations SimQuest Elektro Galaxy Crash
Data Sets/ Analysis Tools (4)	HYPATIA (Hybrid Pupil's Analysis Tool for Interactions in Atlas) MINERVA Sun4all SalsaJ

5.2 Age Classification

All of the age groups are well covered with a multitude of labs in each group starting from ten years old all the way up to postgraduate university level. The majority of the labs are intended – not exclusively- for fifteen to eighteen year old students. A large number of the available labs are suitable for more than one age group.

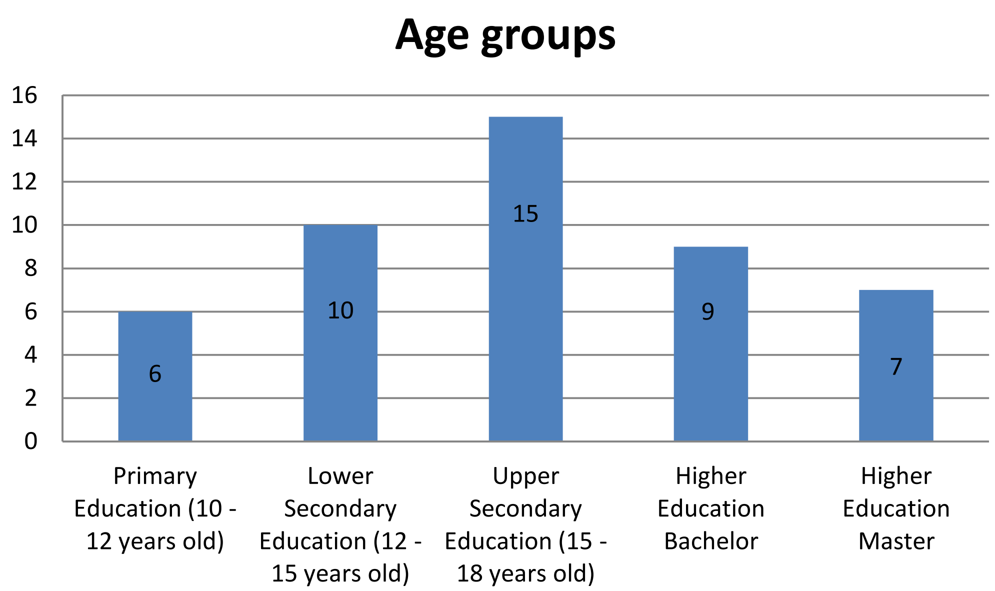

Figure 10. Labs by age group

In Table 3 below we show the available labs in each age group and category.

Table 3. Labs by age and type

Level, Age	Type	Name
Primary Education (10 -12 years old)	Remote Labs (2)	DSpace WebLab-DEUSTO Aquarium
	Virtual Labs (2)	CERNland LearnIT 3D Games Based Go Lab Simulations
	Data Sets/Analysis Tools (2)	Sun4All SalsaJ
Lower Secondary Education (12 -15 years old)	Remote Labs (4)	DSpace Faulkes VISIR WebLab-DEUSTO Aquarium
	Virtual Labs (4)	International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations

		LHC Game Many cratered Worlds
	Data Sets/Analysis Tools (2)	Sun4All SalsaJ
Upper Secondary Education (15 -18 years old)	Remote Labs (7)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CPLD Lab DSpace ELVIS / OP – AMP Labs Faulkes Microcontroller platform in robolabor.ee VISIR
	Virtual Labs (4)	International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Matlab Simulations Galaxy Crash
	Data Sets/Analysis Tools (4)	HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) MINERVA Sun4All SalsaJ
Higher Education Bachelor	Remote Labs (5)	CPLD Lab DSpace ELVIS / OP – AMP Labs Microcontroller platform in robolabor.ee VISIR
	Virtual Labs (1)	Matlab Simulations
	Data Sets/Analysis Tools (3)	HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) MINERVA Sun4All
Higher Education Master	Remote Labs (5)	CPLD Lab DSpace ELVIS / OP – AMP Labs Microcontroller platform in robolabor.ee VISIR
	Virtual Labs (1)	Matlab Simulations
	Data Sets/Analysis Tools (1)	Sun4All

5.3 Lab Domains

Most of the labs are multidisciplinary. In fact just six of them (30%) are only focused on one specific subject sub-domain. Overall, fourteen sub-domains are covered by a varying number of labs (Figure 10). The complete list of labs for each sub-domain can be found in Table 19 in the Annex.

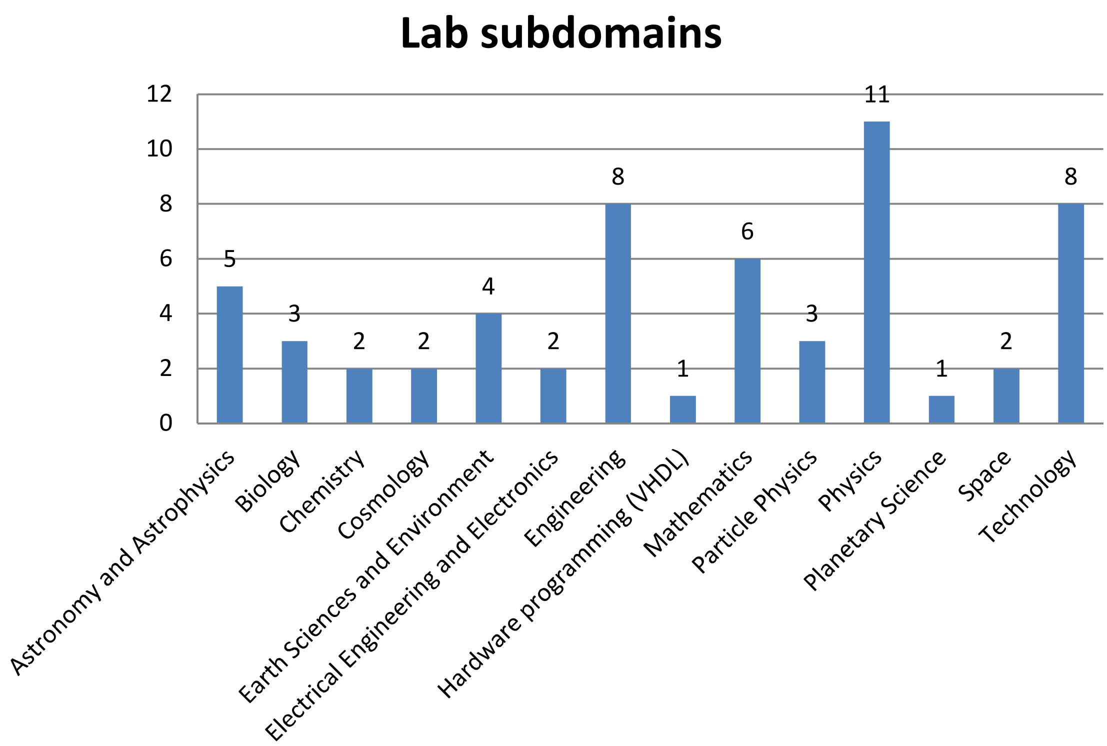

Figure 11. Lab sub-domains

Because of the large number of domains and the uneven number of sub-domains that were stated by the lab authors we have also classified all labs under the STEM (Science, Technology, Engineering, and Math) system (Figure 11). Here we see that a large number of labs fall under the science category, something that is to be expected given the large number of science sub-domains that are covered. We must also note that several labs remain multidisciplinary even after this aggregation. A prime example is Matlab Simulations which exists in all of the four aggregated categories.

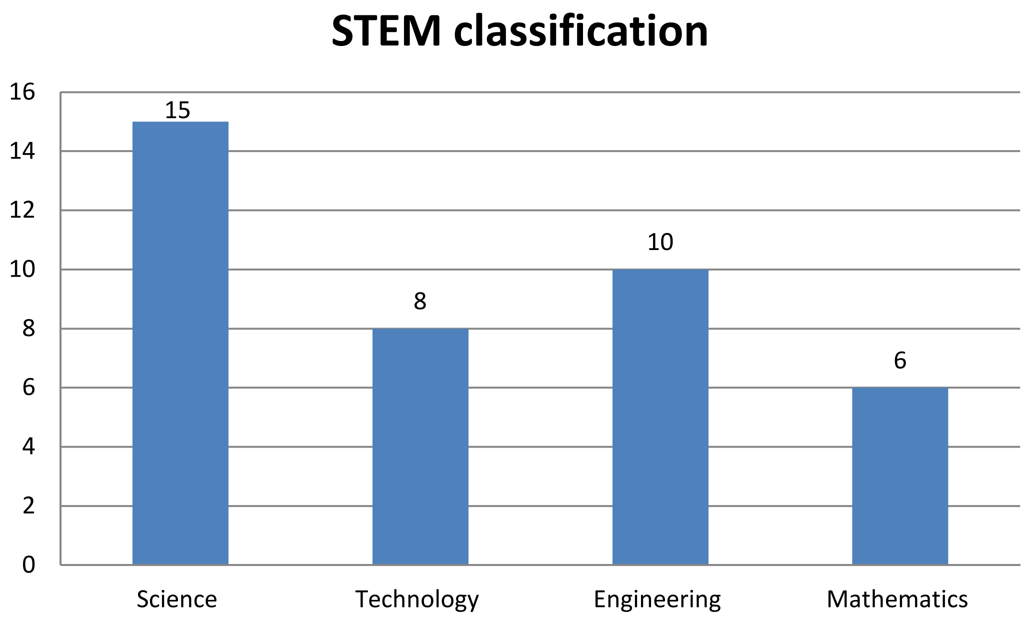

Figure 12. STEM classification

Below (Table 4) we show the complete list of labs by STEM and by type. We see that Remote Labs and Virtual Labs are covered by at least one lab in all four categories whereas Data Sets/Analysis Tools only cover Science and Mathematics.

Table 4. STEM Lab Classification

Domain	Type	Name
Science (15)	Remote Labs (3)	DSpace
		Faulkes
		WebLab-DEUSTO Aquarium
	Virtual Lab (8)	CERNland
		International Space Station 3D teaching tool
		Galaxy Crash
		LearnIT 3D Games Based Go Lab Simulations
		LHC Game
		Many cratered Worlds
		Matlab Simulations
		VISIR
	Data Sets/Analysis Tools (4)	HYPATIA(**Hy**brid **P**upil's **A**nalysis **T**ool for **I**nteractions in **A**tlas)
		MINERVA
		Sun4all
		SalsaJ

Technology (8)	Remote Lab (3)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CPLD Lab Microcontroller platform in robolabor.ee
	Virtual Lab (5)	CERNland International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Many cratered Worlds Matlab Simulations
	Data Sets/Analysis Tools (0)	
Engineering (10)	Remote Lab (5)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CPLD Lab ELVIS / OP – AMP Labs Microcontroller platform in robolabor.ee VISIR
	Virtual Lab (5)	CERNland International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Matlab Simulations SimQuest Elektro
	Data Sets/Analysis Tools (0)	
Mathematics (6)	Remote Lab (1)	DSpace
	Virtual Lab (3)	International Space Station 3D teaching tool Many cratered Worlds Matlab Simulations
	Data Sets/Analysis Tools (2)	Sun4all SalsaJ

5.4 Languages

Almost all of the labs are available in English, with the exception of Matlab Simulations, and most of them are multi language. In total nineteen languages are available in at least one lab. In the chart below (Figure 12) we present the European languages that are supported by at least one lab. We see that in addition to English which is predictably the most popular language, all major European languages are supported.

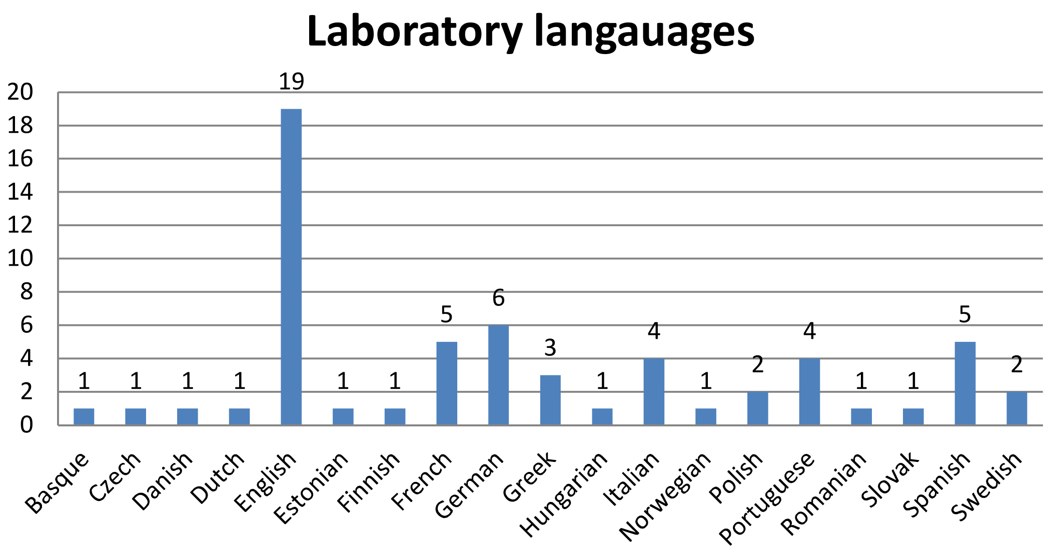

Figure 13. Available Languages

The complete list of labs that are available in each language can be found in Table 20 in the Annex.

5.5 Learning activities

The majority of the available online labs offer some learning activities. These vary in number, complexity, length and subjects covered. In Table 5 below we present a brief description of the available material. The comments are the based on the author's statements about the material offered as well as the inquiry made during the analysis.

Table 5. Learning activities

#	Name / URL	Comment
1.	HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) http://hypatia.phys.uoa.gr/applet	HYPATIA offers complete scenarios with the appropriate events. Instructions for the tool and explanations of relevant physics principles are also provided. In the home page of the lab there are 5 complete educational activities. Additionally, more activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/
2.	The Faulkes Telescopes Project http://www.faulkes-telescope.com/	The Faulkes Telescopes Project has a wide range of activities and projects, as well as information to help students make the best use of the telescopes. http://resources.faulkes-telescope.com/. Additionally, more activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/
3.	WebLab-DEUSTO Aquarium	Learning activities and supportive materials are to be developed.

	http://www.weblab.deusto.es/weblab/	
4.	Galaxy Crash http://burro.cwru.edu/JavaLab/GalCrashWeb/	Students are asked to make predictions on how galaxies form and evolve in the Universe using the 'Galaxy Crash' tool to simulate the evolution of 2 disc galaxies over time. In the "Lab" section of the homepage several learning activities are available. Activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/
5.	CERNland http://www.cern.ch/cernland and http://www.cernland.net	CERNland offers a variety of games, multimedia applications and interactive tools complete with instructions. They are all integrated in the lab.
6.	LHC Game http://education.web.cern.ch/education/Chapter2/Teaching/games/LHCGame	The LHC Game has been included in various inquiry-based teaching scenarios targeting students at primary and lower secondary level who are either visiting CERN or engage in learning activities associated with understanding Big-Science infrastructures for the experimental study of particle physics. Some of the are available in in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/
7.	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS http://boole-deusto.sourceforge.net/ For the latest version e-mail to zubia@deusto.es	The lab offers different pedagogical scenarios. Students' materials and training courses (in numerous languages) can be accessed at http://www.olarex.eu/web/index.php/en/products
8.	ELVIS / OP – AMP Labs http://ilabs.cti.ac.at/iLabServiceBroker/	Learning activities and supportive materials are to be developed.
9.	VISIR http://ilabs.cti.ac.at/iLabServiceBroker/	Learning activities and supportive materials are to be developed.
10.	CPLD Lab http://ilabs.cti.ac.at/iLabServiceBroker/	Learning activities and supportive materials are to be developed.
11.	MINERVA http://atlas-minerva.web.cern.ch/atlas-minerva/	MINERVA offers complete exercises with explanations about the physical processes that are used and the tool itself. These exercises are available in the "Masterclass – Resources" section of the lab's homepage. Additionally, more activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/

12.	Many cratered Worlds http://cosmoquest.org	The Many cratered Worlds lab offers a variety of scenarios where the users analyse and process images from Solar System bodies, taken from different space exploration missions. Educational activities are available through the homepage of the lab in the "Do Science" section.
13.	Sun4all http://www.mat.uc.pt/sun4all/index.php/en/	The data set offers a very large number of solar images that can be used in a number of different analysis paths. Several activities are available in the activities section of the lab's homepage. Additionally, more activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/
14.	The Discovery Space Portal http://www.discoveryspace.net/	Scenarios of use are available in the webpage of the portal http://www.discoveryspace.net/index.asp?Cat_id=581 as well as in the "Discover the Cosmos" educational repository http://www.discoverthecosmos.eu.
15.	Microcontroller platform in robolabor.ee http://distance.roboticlab.eu/lab/view/8	Courses and modules are available in the webpage of the lab. Example projects and some practical examples are available in http://home.roboticlab.eu/.
16.	SimQuest Elektro http://www.simquest.nl/	This lab allows users to conduct experiments in the domain of electrical circuits. Assignments and guidelines are integrated in the lab.
17.	Matlab Simulations http://sim01.cti.ac.at/	Learning activities and supportive materials are to be developed.
18.	LearnIT 3D Games Based Go Lab Simulations	All guidance in built in to the simulations. Additional supportive materials are to be developed.
19.	International Space Station 3D teaching tool http://www.esa.int/esaHS/SEM3TFYO4HD_education_0.html	A large variety of tasks are available organized by age range, mission or subject. ESA offers a wide range of additional resources that may facilitate not only multiple activities which include ESA's labs but also astronomy activities in in general. Some of these resources are listed below: ESA Kids — http://www.esa.int/kids Ariane 5 for Kids — http://www.esa.int/Education/Ariane_5_for_kids ESA 3D models of ESA spacecraft — http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=34999 Science @ ESA Vodcasts — http://sci.esa.int/science-e/www/object/index.cfm?fobj

			ectid=44686
		Astrobiology lectures	http://wsn.spaceflight.esa.int/?pg=page&id=11
		SEOS tutorials	http://wsn.spaceflight.esa.int/?pg=page&id=11
		IMPRESS	http://www.spaceflight.esa.int/impress/text/education/index.html
		International Space Station DVD series	http://www.esa.int/esaHS/SEMZTFYO4HD_education_0.html
		Space in Bytes video lessons	http://www.esa.int/SPECIALS/Space_In_Bytes/index.html
		ESA Lessons Online	http://www.esa.int/SPECIALS/Lessons_online/index.html
20.	SalsaJ http://www.euhou.net/index.php/salsaj-software-mainmenu-9	A large collection of activities have been developed within the EU-HOU, GHOU and GTTP collaborations. http://www.euhou.net/index.php/exercises-mainmenu-1 Additionally, more activities (in numerous languages) can also be found in the "Discover the Cosmos" educational repository. http://portal.discoverthecosmos.eu/	

5.6 *Inquiry Cycle*

The phases of the complete inquiry cycle that was used in the initial analysis are as follows:

- Orientation
- Questioning
- Hypothesis
- Experiment planning
- Observing
- Analysing
- Conclusion
- Evaluation
- Reflection

As mentioned above the Go-Lab inquiry cycle was finalized after the completion of the initial template by the lab owners. Thus this element was changed respectively in the second version of the template for describing the Go-Lab labs that was distributed to the lab owners of the 13 labs that are included in the first version of the Go-Lab inventory.

Many of the available labs follow some, or all, of those phases. In the graph below (Figure 13) the number of labs that support each of those phases is presented. A lab can be considered to follow the inquiry cycle as long as it follows at least three of the basic phases mentioned above. Table 21 in the Annex shows the inquiry cycle phases that each of the labs follows.

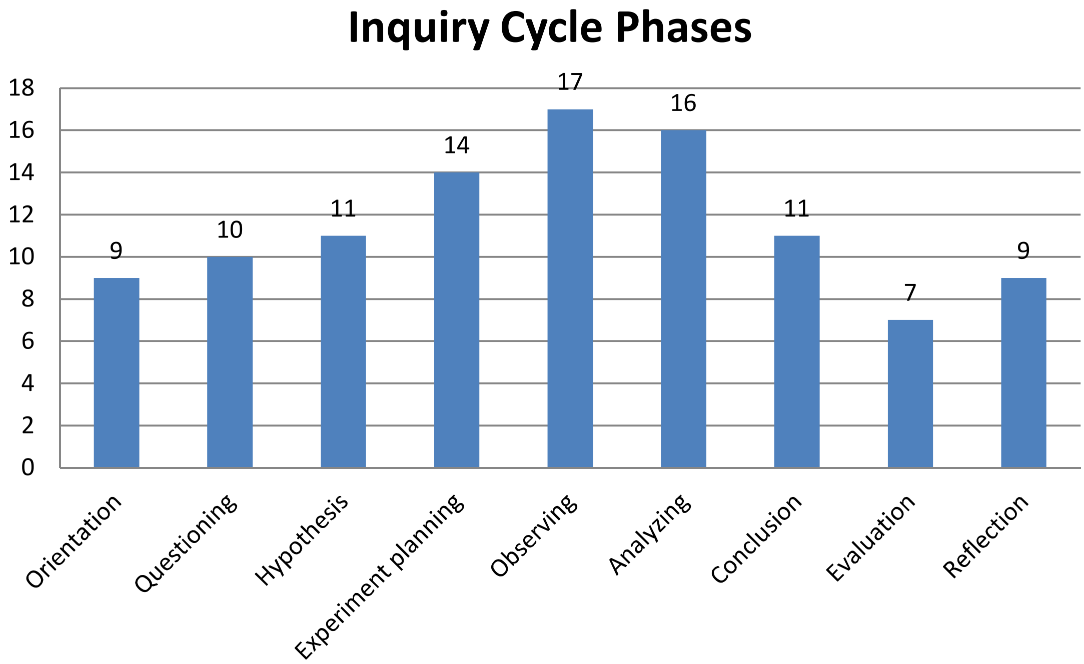

Figure 14. Inquiry Cycle

5.7 Guidance tools and Scaffolds

Guidance tools and scaffolds aid in inquiry learning by supporting the students through the inquiry process. This is especially important for students unfamiliar with the process. Scaffolds can exist in a number of ways, like tools that help formulate a hypothesis or interact with the experimental data. As can be seen in Figure 14, six (30%) of the available labs make use of guidance tools in some way. In our preliminary analysis we have referred to the terms “guidance tools and scaffolds” as any kind of support tool that may help students through the inquiry process. Based on the analysis of the templates provided, six labs (HYPATIA, WebLab DEUSTO Aquarium, Boole DEUSTO, LHC Game, CERNLand and the Discovery Space Portal) appear to have such tools or have guidance incorporated in the lab.

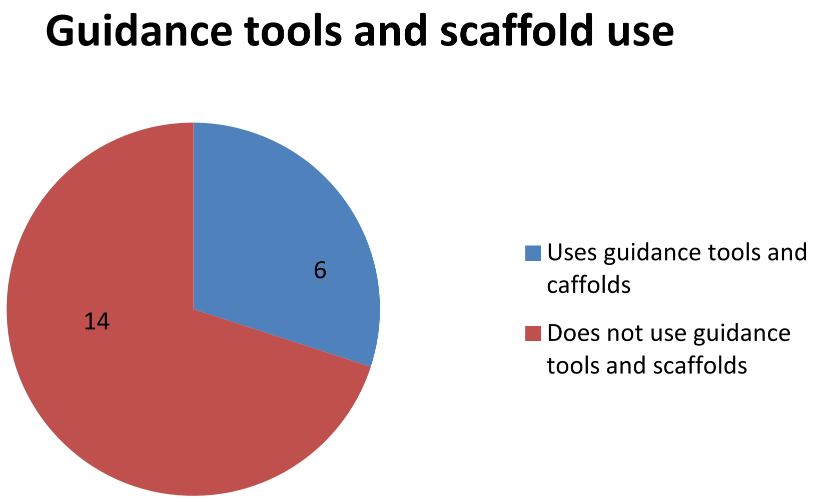

Figure 15. Use of guidance tools and scaffolds

However, in all six cases the tools provided are mainly for guidelines, processing data and analysis tools, and they do not facilitate students in overcoming problems they may face during the inquiry process (for example, a scaffold to allow them to make well-structured hypotheses). Thus, none of the labs include any kinds of guidance consistent with the definition provided in the deliverable D1.1 "Go-Lab learning spaces specification" (which was defined after the initial template had been distributed to the lab owners),

> *"Scaffolds are tools that help students perform a learning process by supporting the dynamics of the activities involved. Scaffolds often provide students with the components of the process and thus structure the process. Scaffolds are appropriate when students do not have the proficiency to perform a process themselves or when the process is too complicated to be performed from memory (Marschner et al., 2012). An example of a scaffold is a hypothesis scratchpad (van Joolingen & de Jong, 1991) but also a modelling tool or an experiment design tool can be regarded as scaffolds (Jackson et al., 1996)".*

Conclusively, the design of guidance tools, for example a Hypothesis tool, a concept map or an experimental design tool, is essential in facilitating students effectively, not only in processing data during the inquiry process, but also in completing successfully each phase of the inquiry cycle, from making effective testable hypotheses to putting together a meaningful report of their findings.

6 From Small to Big Ideas of Science

The aim of this section is to propose a classification scheme for the Go-Lab online labs that reflect the big ideas of science, expressed in ways appropriate for learners at various stages of their cognitive development. In the following analysis we aimed to define a set of big ideas of science and integrate them in the Go-Lab Methodology for Organizing Online Labs (presented in Section 9). Our analysis starts with a brief review of past initiatives and the presentation of different sets of big ideas and goes on into defining the Go-Lab big ideas of science. The next step was to study the set of big ideas produced and connect them with a thorough science and curriculum vocabulary developed by the ODS Project[1] (ODS Project – D4.2), which was also adopted by the Go-Lab Project. This was performed in order to validate whether our set of big ideas covers sufficiently all science curriculum subjects, as defined by the aforementioned science curriculum vocabulary. The last part of this section includes the integration of the proposed set of big ideas of science to the Go-Lab Methodology for Organizing Online Labs.

6.1 Big Ideas of Science: Definition

In order to help young students in learning science there are several aspects teachers should take into consideration. One of those aspects is the fact that students appear to miss the connection between what they are being taught at school and the world around them. It is often the case that although students learn about fundamental principles they fail to understand the connection between them as well as their connection to our life and to the world. These gaps in students' cognition often appear due to the fact that certain ideas are too abstract and thus difficult for them to grasp. Additionally, the fact that students often engage in several activities which are isolated and do not follow a meaningful sequence which would allow them to build on the experience acquired by previous activities, acts as one more drawback into helping students understand the fundamental principles of our world.

Consequently, in order to achieve in helping students understand such fundamental ideas it is necessary to create concrete learning experiences that are close to their everyday life and that are interconnected and presented within a common context. This way, students have the opportunity to build on them and ultimately develop a better understanding of fundamental principles by identifying the connections between different natural phenomena. The common context behind a set of learning episodes could be a fundamental concept that can be deployed to explain different phenomena under investigation. Such concepts are usually interdisciplinary and are often referred to as "Big ideas" of science. Big ideas of science can enable learners as individuals to understand aspects of the world around them, both the natural environment and that created through application of science (Harlen, 2010).

The term "Big Ideas of Science" has several similar definitions. For example, Harlen (2010) defines big ideas as: "ideas that can be used to explain and make predictions about a range of related phenomena in the natural world". The term "Big Idea" also refers to a statement that summarizes the core knowledge in a discipline that we would like students to understand (Wiggins & McTighe, 2005).

In this analysis we refer to "Big Ideas" as "a set of cross-cutting scientific concepts that describe the world around us and allow us to conceive the connection between different natural phenomena". A "Big Idea" is a concept that connects different subject domains of science and is

[1] *ODS Project is a major European Initiative referred to as: "Open Discovery Space: A socially-powered and multilingual open learning infrastructure to boost the adoption of eLearning Resources". The Open Discovery Space Project (http://www.opendiscoveryspace.eu/) aims to build a federated infrastructure for a super-repository on top of existing Learning Object Repositories in Europe and support the adoption of open educational resources (OERs) from European Schools.*

the common denominator of different natural phenomena. For example, the fact that "Objects can affect other objects at a distance" is the big idea behind the movement of celestial objects but also explains why magnets can attract iron objects. Thus, big ideas contribute in changing students' view of science and allow them to learn coherent concepts rather than a set of disconnected concepts and facts.

In the Go-Lab project we aimed to define a set of big ideas of science based on existing sets of big ideas and we to integrate them into the Go-Lab federation of online labs. This way each online lab of the Go-Lab federation will be accompanied by the big idea(s) that it aims to demonstrate. Thus, by working with multiple online labs which have common big ideas behind them, students will be able to better understand certain concepts and the connection between different principles and phenomena which at first sight might appear to be non existent.

6.2 Existing Sets of Big Ideas of Science

The introduction of big ideas of science is present in the science curriculum of European countries starting from the 5th and 6th grade (around the age of 10). In order to teach any subject, a general context is first introduced and then comes the teaching of specific principles and phenomena. For example, if a teacher wishes to teach the students about acceleration and how it is achieved, he/she would first need to introduce the concept that "Changing the movement of an object requires a net force to be acting on it" (Harlen, 2010). Thus in order to better organize and define the subjects taught in the school curriculum, it is important to outline the set of big ideas that stand behind each subject domain.

Different sets of big ideas have been developed over time either for different domains of science or for science as a whole. The most popular set of big ideas of science have been introduced by Harlen (2010) and they are presented below:

1. All material in the Universe is made of very small particles.
2. Objects can affect other objects at a distance.
3. Changing the movement of an object requires a net force to be acting on it.
4. The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.
5. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.
6. The solar system is a very small part of one of billions of galaxies in the Universe.
7. Organisms are organized on a cellular basis.
8. Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.
9. Genetic information is passed down from one generation of organisms to another.
10. The diversity of organisms, living and extinct, is the result of evolution.

The aforementioned set of big ideas is about science education as a whole and covers multiple subject domains. However other attempts have also been made in order to produce set of big ideas on specific subjects. Such sets are presented below:

- **Big Ideas in Nano Scale Science and Engineering (Stevens and Krajcik, 2009):**
    1. Size & Scale: Factors relating to size and scale (e.g., size, scale, scaling, shape, proportionality, dimensionality) help describe matter and predict its behaviour.

2. Structure of matter: All matter is composed of atoms that are in constant motion. Atoms interact with each other to form molecules. The next higher level of organization involves atoms, molecules or nanoscale structures interacting with each other to form nanoscale assemblies.
3. Size-Dependent Properties: The properties of matter can change with scale. In particular, as the size of material transitions from the bulk to atomic scale, it often exhibits unexpected properties that lead to new functionality.
4. Forces and Interactions: All interactions can be described by multiple types of forces, but the relative impact of these forces changes with scale. On the nanoscale, a range of electrical forces with varying strengths tends to dominate the interactions between objects.
5. Quantum Effects: Scientists may choose to use different models to help explain and predict the behaviour of matter depending on the scale and conditions of the system. In particular, as the size or mass of an object becomes smaller and approaches the nanoscale, quantum mechanics becomes necessary to explain its behaviour.
6. Self-Assembly: Under specific conditions, some materials can spontaneously assemble into organized structures. This process provides a useful means for manipulating matter at the nanoscale.
7. Tools & Instrumentation: Development of new tools and instruments helps drive scientific progress. The recent development of specialized tools has led to new levels of understanding of matter by helping scientists detect, manipulate, isolate, measure, fabricate, and investigate nanoscale matter with unprecedented precision and accuracy.
8. Models & Simulations: Scientists use models and simulations to help them visualize, explain and make predictions and hypotheses about the structure, properties and behaviour of objects, processes, systems and phenomena. The complexity and extremely small size of nanoscale targets make models and simulations useful for the study and design of nanoscale materials and phenomena.
9. Science, Technology and Society: The advancement of science involves developing explanations for how and why things work, and technology applies that knowledge to meet objectives, solve practical problems or answer questions of interest. At each step, people make decisions that affect scientific progress and its effects on society and the environment. Because nanotechnology is an emergent science, it provides an opportunity to witness and actively participate in scientific progress and the decisions about how to use the new technologies.

- **Big Ideas in Physics (Denver Public Schools, 2009):**

1. Motion can be measured and described using a variety of methods.
2. Forces and energy are essential to understanding motion.
3. Collisions can be described using forces, energy, and momentum.
4. Energy and its conservation are essential in describing and analysing motion.
5. The properties of sound and light demonstrate wave behaviour.
6. Electricity is caused by the movement and energy transfer of electrons.
7. Electric fields and magnetic fields are related and can be used for mechanical energy output (motor) or electrical energy generation (generator).

8. The nature of atoms cannot be directly observed but can be described through models.

- **Big Ideas in Chemistry (Talanquer, 2013):**
  1. Atoms, molecules, and ions are the basic components of matter.
  2. Chemical bonds are formed by electrostatic attractions between positively charged cores and negatively charged valence electrons.
  3. Atoms in molecules and crystals arrange in particular geometries.
  4. Atoms and molecules are in constant motion.
  5. Atoms in molecules and crystals can reorganize to form new molecules and crystals.
  6. Reactions occur when the disorder of the Universe is increased.
- **Big Ideas in Biology (Wood, 2009):**
  1. Evolution as the basis for both the diversity and the unity of life
  2. Biological systems and their properties, including energy use, molecular components, growth, reproduction, and homeostasis.
  3. Information: how organisms store it, retrieve and use it, transmit, and respond to it.
  4. Interaction of systems components and the emergent properties of the resulting entities, from DNA molecules to cells to organisms to ecosystems
- **Big Ideas in Earth Science (Ross and Duggan-Haas, 2010):**
  1. The Earth is a system of systems.
  2. The flow of energy drives the cycling of matter.
  3. Life, including human life, influences and is influenced by the environment.
  4. Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system.
  5. To understand (deep) time and the scale of space, models and maps are necessary.

6.3 The Go-Lab Set of Big Ideas of Science

Throughout our analysis on the sets presented in Section 6.2, Task 2.2 partners have concluded that certain aspects seemed to be missing or are in need of further refinement. After reviewing and studying the sets of big ideas presented above, we decided that we would not adopt Harlen’s set (or a combination of the other four sets) as it is. Instead, we produced the Go-Lab set of big ideas based on what has been presented. Thus our final set is produced by adopting, combining and extending the existing sets while taking into consideration some adaptations that are presented below.

One aspect that seems to be absent and needs to be introduced is that there are certain ideas like the universal application of fundamental principles that can be applied to all subject-domains of science. Such an idea is even more generic than all the ideas presented above. Thus we have come to the conclusion that in the Go-Lab set of Big Ideas there would be two distinct levels of big ideas. The first would be the “General Level” which will consist of big ideas that are completely generic and apply to all fields of science. These general ideas will be broken down into more focused ones in the second level, the “Specific Level” that will reflect the principle ideas of our world and that to their total will cover all different subject-domains of science. Conclusively, the big ideas of the general level are wider compared to those in the specific level. This set of ideas, as a whole, can be considered to be the background context for every single idea in the specific level. Respectively, every idea of the specific level targets particular concepts (e.g., evolution, energy, fundamental forces) while it is still a component of all of the ideas in the general level.

Additionally, in Harlen's set, some ideas can be parts of even bigger ones. For example, ideas #2 and #3 ("Objects can affect other objects at a distance" and "Changing the movement of an object requires a net force to be acting on it") are both derivatives of the same bigger idea of fundamental forces and how they act on objects. So by reviewing the sets presented above there is the possibility of merging a number of them into even bigger ones. Consequently, a part of our work focused on reviewing and comparing ideas from different or from within the same set that have similar meanings. This comparison led to the merging of some ideas and transforming them into bigger ones.

Another factor that considered was the fact that some ideas were in need of further elaboration so as to make them more complete and easier for learners to understand at various stages of their learning development. For example, big idea #7 from Harlen's set ("Organisms are organised on a cellular basis") could be more complete by pointing out the fact that there is one common key component for all life forms on the planet. Likewise in the set of big ideas on Physics for example, big idea #5 ("the properties of sound and light demonstrate wave behaviour") could be extended as just like sound and light all matter and radiation can demonstrate wave behaviour. Thus, part of our work focused into further elaborating the existing big ideas so as to make them more complete. A more descriptive presentation of each big idea would also make them more comprehensible to students and allow them to identify connections between them more easily.

Overall, after reviewing the sets of big ideas presented in the previous section and working on them based on the adaptations mentioned above, we have produced the Go-Lab set of big ideas of science. As mentioned above the Go-Lab set has two levels; one that includes General Ideas that apply to all fields of science and a Specific Level which includes a set of cross-cutting ideas that as a total could describe our world in a nutshell. The total set is presented below:

Table 6. The set of the Go-Lab Big Ideas of Science

<table>
<tr><th>General Big Ideas</th><th>Specific Big Ideas</th></tr>
<tr><td rowspan="8">A. Physical and chemical principles are unchanging and drive both gradual and rapid changes in all systems throughout all scales of the Universe.

B. The Universe and the world around us, is not only composed of what we see around us. There are entities and phenomena that humans cannot grasp directly with their senses and yet they can be investigated and described using models and proper equipment.</td><td>1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.</td></tr>
<tr><td>2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.</td></tr>
<tr><td>3. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.</td></tr>
<tr><td>4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.</td></tr>
<tr><td>5. All matter and radiation exhibit both wave and particle properties.</td></tr>
<tr><td>6. Evolution is the basis for both the unity of life and the biodiversity of organisms (living and extinct). Organisms pass on genetic information from one generation to another.</td></tr>
<tr><td>7. Organisms are organized on a cellular basis and require a supply of energy and materials. All life forms on our planet are based on a common key component.</td></tr>
<tr><td>8. Earth is a system of systems which influences and is influenced by life on the planet. The processes occurring within this system shapes the climate and the surface of the planet.</td></tr>
</table>

6.4 Connecting a Science Curriculum Vocabulary with the Go-Lab Set of Big Ideas of Science

The Go-Lab set of big ideas aims to cover all subject areas of science curriculum. In order to investigate if it does cover all these subject areas we have studied the connection between the Go-Lab set of big ideas and a science curriculum vocabulary which includes terms that cover all subjects taught in science education.

Given that big ideas are considered to be interdisciplinary, each term from the science curriculum vocabulary (and consequently the online labs and the activities that can be characterized with this term) will correspond to one or more big ideas. This matching of big ideas and the terms of the science vocabulary will provide us with a clear idea of how to organize the online labs following a set of big ideas in such a way that will clearly demonstrate the connection between different subject areas and interconnections among labs. This type of organization will give the opportunity to teachers to identify connections between different online labs and thus be able to select them not only in order to carry out isolated activities but also to pre-define a group of online labs that if used in sequence may provide their students with a coherent set of activities which will allow them to acquire a better perspective on the connection between different natural phenomena. To this end, the organization of labs using big ideas could be used as a recommendation system. Once teachers retrieve a lab from the Go-Lab federation, the system will also provide them with a list of recommended labs based on the big ideas they correspond to. For example if a teacher selects a lab aiming to teach about the properties of light, based on the organization following the big ideas of science the system will recommend to the teacher the use of other labs that are related not only to light but also to the demonstration of wave properties in general so as to allow him/her to further extend the subject under investigation. Thus, teachers will have at their disposal a recommendation system which will offer them a set of related labs that will help them teach more efficiently different subjects by connecting them to each other and allowing students to understand the common principles behind them.

In order to make the connection between science subject areas and the Go-Lab set of big ideas, we have used the primary terms of the science curriculum vocabulary that has been developed by the ODS Project (ODS Project – D4.2). The ODS science curriculum vocabulary provides a controlled vocabulary of terms used in European schools. This vocabulary is in line with science curriculum vocabularies used by two major educational resources repositories, the Learning Resource Exchange (LRE) and TES Resources. This vocabulary has also been adopted for the purposes of the Go-Lab and the primary terms used for connecting them with the proposed set of big ideas of science are presented in Table 6, whereas the complete vocabulary terms are presented in Annex.

Table 7: The Primary Terms of Science Curriculum Vocabulary

Astronomy	Astronomy
Biology	Anatomy Botany Ecology Humans and animals Life Processes Variation, Inheritance and evolution
Chemistry	Analytical Chemistry Chemical Reaction Inorganic Chemistry Physical Chemistry Organic Chemistry
Environmental Education	Climate Energy Environmental

	Environmental Protection Natural Resources
Geography and Earth Science	Geography Earth Science
Physics	Electricity and magnetism Energy Fields Forces and motion History of Science and Technology
	High Energy Physics Light Obtaining and using materials Radioactivity Solids, liquids and gases Sound Technological applications Tools for Science Useful materials and products Waves

In the analysis below we present the connection between each vocabulary term to each of the Go-Lab big ideas. As these big ideas are cross-cutting scientific concepts it is expected that each big idea will involve several terms and that many terms may correspond to more than one big ideas.

A. Physical and chemical principles are unchanging and drive both gradual and rapid changes in all systems throughout all scales of the Universe. **B. The Universe and the world around us, is not only composed of what we see around us. There are entities and phenomena that humans cannot grasp directly with their senses and yet they can be investigated and described using models and proper equipment.**
History of science and technology
Technological applications
Tools for science

As it is also mentioned above, Big Ideas A and B are considered to be general and 'omnipresent' so all science curriculum vocabulary terms given in Table 7 match these. However, it is difficult to match three of the terms from Table 7 (History of Science and

Technology, technological applications and Tools for science) to the more focused ideas given below (numbered 1 to 8). We consider these four terms to address all fields of science, just as big ideas A and B do.

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
Astronomy
Energy
Chemical reactions
Forces and motion
High energy physics
Light
Life processes
Sound

The online labs that focus on the investigation of different motions and of phenomena that involve the transformation of energy from one form to another are included in this set. Such labs can cover subject areas like mechanics (free fall motion, springs, etc.), thermodynamics (internal energy, entropy and pressure), quantum mechanics and nuclear physics (binding energy, quantum models, ionization) as well as wave motions.

2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance causing a change in motion or in the state of matter. Forces can act through a respective physical field causing a change in motion or in the state of matter.
Astronomy
Electricity and magnetism
Energy
Fields
Forces and motion
High Energy Physics
Light
Radioactivity

Online labs that cover the investigation of all kinds of interactions can be included in this set. These labs can investigate interactions in all scales of the Universe, from particle interactions and radioactivity to the orbits of the planets and the formation of galaxies. Labs that investigate phenomena are due to the electromagnetic force, like the movements of charged particles or light are also included in this category.

3. The Universe is comprised of billions of galaxies each if which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.
Astronomy
High energy physics
Light
Life processes
Forces and motion

Labs that cover the investigation of large scale phenomena occurring in our Universe belong in this set. Such labs can involve the observation of the motion of celestial objects, the investigation of their making and others.

4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.
Analytical chemistry
Chemical reactions
Energy
Forces and motion
Inorganic chemistry
Obtaining and using materials
Organic chemistry
Physical chemistry
High energy physics
Radioactivity
Solids, liquids and gases

Any kind of lab that studies the structure of matter fits in this category. For example, labs of high energy physics that study elementary particles or any kind of chemistry lab that studies the structure of atoms, molecules and ions as well as the interactions between them.

5. All matter and radiation exhibit both wave and particle properties.
Energy
Forces and Motion
High energy physics
Light

Radioactivity
Sound
Waves

This section is closely connected to the second set and covers all labs that are connected with waves and wave behaviour. All labs connected to optics, the properties of light and sound, as well as labs that study oscillations are included in this set.

6. Evolution is the basis for both the unity of life and the biodiversity of organisms (living and extinct). Organisms pass on genetic information from one generation to another.
Anatomy
Botany
Ecology
Humans and animals
Life processes
Variation, inheritance and evolution

Biology labs connected to the study of life processes, the evolution of living organisms and the study of DNA are included in this category.

7. Organisms are organized on a cellular basis and require a supply of energy and materials. All life forms on our planet are based on a common key component.
Anatomy
Botany
Humans and animals
Life processes
Organic chemistry
Physical chemistry

This section involves labs that cover the anatomy of living organisms and the different functions of cells. Chemistry labs connected to the chemical reactions that take please within living organisms are also included.

8. Earth is a system of systems which influences and is influenced by life on the planet. The processes occurring within this system shapes the climate and the surface of the planet.
Botany
Climate

Earth science
Ecology
Environment
Environmental protection
Geography
Natural resources
Obtaining and using materials
Radioactivity
Solids, liquids and gases
Useful materials and products

This set covers a wide a range of labs. The labs included are connected with the investigation of processes occurring on Earth. Labs that simulate the effect of human activities on our environment, environmental pollution and the investigation of our climate (like meteorological satellites data sets) are included in this set. Other labs that investigate the surface and the underground of the planet as well as the materials obtained are also included in this section.

As it can be seen from the categorization presented above, all subject domains of the science curriculum vocabulary correspond to one or more big ideas of science thus confirming that the Go-Lab set of big ideas covers all subject areas on the science curriculum. The fact that each big idea involves more than one subject domains verifies the fact that they are cross-subject concepts that allow the interconnection between different fields of science and place them within the same context.

6.5 Integrating the Go-Lab Set of Big Ideas of Science to the Go-Lab Methodology for Organizing Online Labs

In order to organize online labs it is essential to ensure that they are interconnected so that they can constitute a set of meaningful entities which complement each other. Focusing on the fact that we understand something if we see how it is related or connected to other things we know and that the degree of understanding is determined by the number and strength of the connections (Hiebert & Carpenter, 1992). We can assume that the use of online labs within the school classroom can be more beneficial if it is carried out within a broader common framework which allows students to identify the connections behind the phenomena under investigation. Providing this common framework can be achieved by deploying the big ideas of science in order to characterize and organize the online labs. Such an organization would be useful as it would allow them to be interconnected and demonstrate a natural progression and escalation of the subjects taught which would allow students to see the connections between them and gradually move from grasping small isolated principles and phenomena to understanding the big ideas of science that briefly outline the world we live in.

Based on current practices the educational objectives set on an educational activity are very targeted and directly related to it so that students may be able to achieve them by just completing this specific activity. This set of educational objectives could be referred to as the “Small Ideas” of science education as they are concepts that aim to explain or present only a narrow set of phenomena without placing them into a wider context. Thus online labs can serve multiple educational objectives based on the context of use and the activity in which there are included. For example if students use an online lab to study the free fall motion, an educational objective (which could be referred to as a “Small Idea” of science education) could be “the gravitational force acting on a body forces it to accelerate while falling”.

Additionally, the educator may also set one or more educational objectives that are more abstract and which are meant to introduce to the students more general concepts within a longer-term period after the completion of a group of related activities using different online labs. These more general educational objectives may involve the introduction of concepts that can be deployed to explain several different phenomena that at a first glance may seem unrelated. These concepts are the “Big Ideas” of science as they are described in the previous sections.

The use of a single online lab may not be enough to help the students comprehend a big idea; it can however be a part of a bigger group of online labs which in total can facilitate the students grasping this big idea. In the framework of one isolated activity, the principles and laws that are deployed in order to explain the phenomena under investigation may appear to students as isolated stand-alone entities that are in position to only explain only a few of phenomena. As however students use more and more online labs to perform experiments that demonstrate the application of the same laws, and principles within different contexts they start to understand that they are parts of bigger concepts that can be applied to explain a wider range of phenomena. So, starting with one activity at a time students get to conceive several “Small Ideas” which become bigger and bigger as students are involved in the use of more online labs and eventually transform into the “Big Ideas” of Science.

In the example mentioned above, the big idea related to the free fall activity would be the second from Table 6, namely “There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance causing a change in motion or in the state of matter. Forces can act through a respective physical field causing a change in motion or in the state of matter”

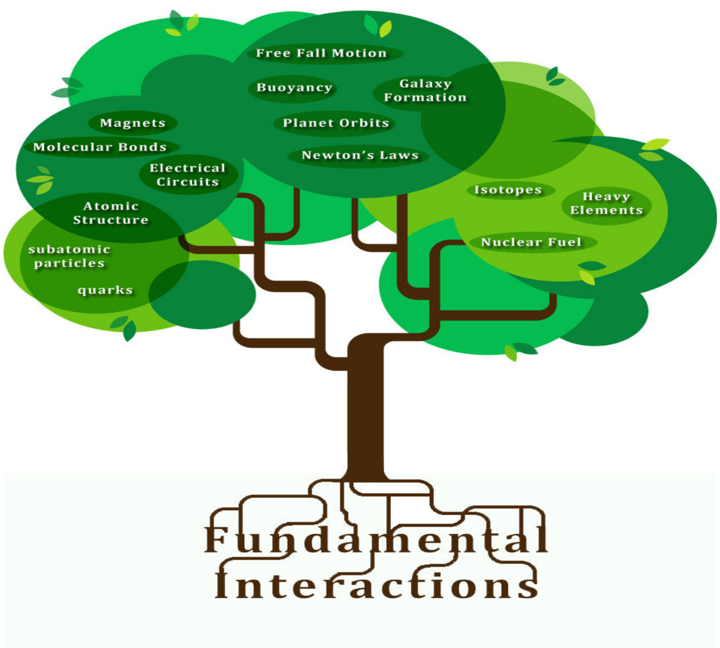

Figure 16. Several phenomena that at a first glance may seem unrelated may be part of the same bigger concept

Each lab of the Go-Lab federation can be characterized by one or more big ideas of science. The characterization of a lab with big ideas means that this lab promotes these ideas and that its use can contribute in helping students to grasp them. The promotion of big ideas of science through the use of different online labs will allow the students to comprehend the interrelationships between different phenomena and natural processes and understand that they occur due to the same set of principles and laws.

Conclusively, based on the above analysis and on the definition given to the big ideas of science as a set of cross-cutting scientific concepts that describe the world around us and allow us to conceive the connection between different natural phenomena, we aim to integrate the big ideas of science in the Go-Lab methodology for organizing online labs as a form of classification next to the classification based on the science curriculum vocabulary (presented in Annex A.**Error! Reference source not found.**). This classification could also be deployed as a recommendation system for the online labs. When it comes to educational activities that deploy the use of one or more online labs, the big ideas of science will also play a complementary role next to the educational objectives set. Contrary to online labs that can be used to serve several educational objectives depending on their use, the educational activities are organized learning plans which have specific educational objectives. To this end, when it comes to characterizing educational activities, we aim to deploy a taxonomy which will allow users to further characterize them. More specifically, we aim to deploy Bloom's revised taxonomy (see Section 7.2) for setting educational objectives in order to further characterize educational activities. By presenting the big ideas of science behind the labs that are deployed for each educational activity as well as the activity's educational objectives, the connection between the small and big ideas of science will be more transparent.

7 Characteristics of Go-Lab Online Labs

The aim of this section is to present and propose vocabularies for specific characteristics of the Go-Lab online labs that are related with the Go-Lab approach and they can be considered of major importance for the Go-Lab methodology for organizing online labs. In particular these characteristics as described also in Go-Lab DoW, Part A, pp.12 are: (a) the connection of an online lab with the different phases of the Go-Lab inquiry cycle, as defined in deliverable D1.1 (Go-Lab Project – D1.1), (b) the educational objectives addressed by online labs and (c) the ICT competence level that a teacher should possess for the effective use of an online lab.

7.1 The Go-Lab Inquiry Cycle

In the framework of the Go-Lab Project the identification of online labs that support the implementation of the different phases of the inquiry cycle is of major importance. This means that it is essential to characterize whether an online lab can support the different phases of the inquiry cycle. This will enable teachers to search and retrieve online labs from the Go-Lab Repository based on the phases of the inquiry cycle that these online labs can support. In particular, we adopt the phases of the inquiry cycle that have been defined in deliverable D1.1 (Go-Lab Project – D1.1) to be used for characterizing the Go-Lab online labs. Table 8 presents the Go-Lab inquiry phases, which consist of five (5) phases and seven (7) sub-phases.

Table 8: The Go-Lab Inquiry Phases (Go-Lab Project – D1.1)

General phases	Definition	Sub-phases	Definition
Orientation	A process of stimulating curiosity about a topic and addressing a learning challenge through a problem statement.		
Conceptualisation	A process of stating questions and/or hypotheses.	Question	A process of generating research questions based on the stated problem.
		Hypothesis	A process of generating hypotheses to the stated problem based on theoretical justification.
Investigation	A process of planning, exploration or experimentation, collecting, and analysing data based on the experimental design or exploration.	Exploration	A process of systematic and planned data generation on the basis of a research question.
		Experimentation	A process of designing and conducting an experiment in order to test a hypothesis. In experimenting students also make a prediction of the expected outcome of an experiment.
		Data interpretation	A process of making meaning out of collected data and synthesizing new knowledge.
Conclusion	A process of making conclusions out of the data. Comparing inferences based on data with hypotheses or research questions.		

Discussion	A process representing findings by communicating to others and controlling the whole learning process by using reflecting activities.	Communication	A process of presenting results of an inquiry phase or of the whole inquiry cycle to others and collecting feedback from them.
		Reflection	A process of describing, critiquing, evaluating and discussing on the whole inquiry process or on a specific phase.

7.2 Educational Objectives

In science teaching there are different types of educational objectives that aim to set learning goals on multiple levels and not just on students' cognition. Each lab within the Go-Lab federation can serve specific educational objectives and intend not only to demonstrate to students certain principles and laws but also to help them develop certain skills like being observant or making accurate measurements. In each case, while experimenting with the labs, students explore and observe different phenomena; they attempt to explain them and ultimately achieve the educational objectives that have been set.

One of the most popular taxonomies is the one proposed by Bloom (1956) in order to promote higher levels of learning. Bloom's Taxonomy of Educational Objectives (Bloom, 1956) had many subsequent revisions and extensions (Harrow, 1972; Simpson, 1972; Krathwohl, Bloom, & Masia, 1973; Dave, 1975; Anderson et al, 2001; Fisher, 2005) but the most widely used revised Bloom's taxonomy has been proposed by Anderson et al (2001).

According to Bloom (1956) educational objectives are usually divided in three categories: cognitive, affective, and psychomotor. Cognitive objectives deal with intellectual results, knowledge, concepts and understanding. Affective objectives include the feelings, interests, attitudes and appreciations that may result from science instruction. The psychomotor domain includes objectives that stress motor development, muscular coordination and physical skills (Trowbridge et al, 2000).

Within the framework of the OSR project[2], there has been defined a taxonomy of educational objectives based on revised Bloom's taxonomy, in order to characterize educational scenarios (OSR Project – D2.1). This taxonomy is also adopted for the Go-Lab Project and it is presented in Table 9, Table 10, Table 11 and Table 12 . For each vocabulary term of the taxonomy presented below it has been foreseen the provision of a free-text field where the teachers will be able to define how the specific general educational objective is addressed with the use of a specific lab.

Table 9. Cognitive Objectives: Types of Knowledge (Anderson et al, 2001)

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc
Meta-cognitive	Knowledge and awareness of cognition, e.g., of learning strategies, cognitive tasks, one's own strengths, weaknesses and knowledge level, etc

[2] http://www.osrportal.eu/

Table 10. Cognitive Objectives: Processes

Revised Bloom taxonomy (Anderson et al, 2001)		Go-Lab taxonomy	
Process	**Description**	**Process**	**Description**
To remember	To help the learner recognize or recall information	To remember	To help the learner recognize or recall information
To understand	To help the learner organize and arrange information mentally	To understand	To help the learner organize and arrange information mentally
To apply	To help the learner apply information to reach an answer	To apply	To help the learner apply information to reach an answer
To analyse	To help the learner think critically on causes and results	To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas
To evaluate	To help the learner make judgments and decisions based on reflection and assessment		
To create	To help the learner think originally, predict, and create new ideas		

Note. This classification of cognitive educational objectives should be read as a 'scale': a gradual move towards higher-order thinking (from simple remembering through to transforming information and creating new ideas). Each level builds on and subsumes the previous levels.

Table 11. Affective Objectives

Bloom's taxonomy (Krathwohl et al., 1973)		Go-Lab Taxonomy	
Process	**Description**	**Process**	**Description**
To receive	To help the learner focus and pay attention to stimuli (passively)	To pay attention	To help the learner focus and pay attention to stimuli, passively
To respond	To help the learner react to stimuli and actively participate in the learning process	To respond and participate	To help the learner react to stimuli and actively participate in the learning process
To value	To help the learner attach values to stimuli and commit themselves to the learning process	To recognize values	To help the learner attach values to stimuli
To organize a value system	To help the learner build an internally consistent system of values, a philosophy of life	To form and follow a system of values	To help the learner build a consistent system of values and behave accordingly
To internalize a value system	To help the learner develop behaviour characteristics that are consistently formed by a system of values		

Note. This classification of affective educational objectives should be read as a 'scale': a gradual move towards higher-order thinking (from simple reception of stimuli to value-based behaviour). Each level builds on and subsumes the previous levels.

Table 12. Psychomotor Objectives

<table>
<tr><th colspan="2">Simpson taxonomy (Simpson, 1972)</th><th>Dave taxonomy (Dave, 1975)</th><th colspan="2">Go-Lab Taxonomy</th></tr>
<tr><th>Process</th><th>Description</th><th>Process</th><th>Process</th><th>Description</th></tr>
<tr><td>Perception</td><td>To help the learner use sensory cues to guide motor activity</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>Set</td><td>To help the learner get ready to act according to their mental, physical, and emotional dispositions (mindsets)</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>Guided response</td><td>To help the learner achieve the early stages in learning a complex skill through imitation, trial and error</td><td>Imitation</td><td>To imitate and try</td><td>To help the learner perform certain actions by following instructions and practicing; reproduce activity from instruction or memory</td></tr>
<tr><td>Mechanism</td><td>To help the learner reach the intermediate stage in learning a complex skill, through habitual responses and confident movements</td><td>Manipulation</td><td>To perform confidently following instructions</td><td>To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help</td></tr>
<tr><td>Complex overt response</td><td>To help the learner reach proficiency and skilful performance of motor acts which involve complex movement patterns</td><td>Precision</td><td>To perform independently, skilfully, and precisely</td><td>To help the learner coordinate a series of actions, achieving harmony and internal consistency; adapt and integrate expertise to satisfy a non-standard objective</td></tr>
<tr><td>Adaptation</td><td>Skills are well developed and the individual can modify movement patterns to fit special requirements</td><td>Articulation</td><td rowspan="2">To adapt and perform creatively</td><td rowspan="2">To help the learner achieve high level performance and become natural, without needing to think much about it; automated, unconscious mastery of activity and related skills at strategic level</td></tr>
<tr><td>Origination</td><td>Creating new movement patterns to fit a particular situation or specific problem.</td><td>Naturalization</td></tr>
</table>

Note. This classification of psychomotor educational objectives should be read as a 'scale': a gradual move from the simplest behaviour to the most complex behaviour. Each level builds on and subsumes the previous levels.

7.3 Teachers' ICT Competences

Teachers' presence in online labs is more critical, complex and challenging than traditional lab environments due to characteristics of the technology (de Jong et al., 2013). They have to make decisions among the expanded choices and opportunities that online labs provide them. Moreover, teachers have to overcome potential barriers caused by technology, time and place. As a result, the effective use of online labs by the teachers requires appropriate ICT competences. This means that characterizing an online lab with the ICT competence level that is required by a teacher to use this lab with his/her students, it can significantly facilitate teachers to select more effectively online labs that match their competence profile.

Teachers' competences can be modelled by existing teachers' competence frameworks that have been designed and developed over the past years. A well known framework that describes the kinds of knowledge needed by a teacher for effective pedagogical practice in a technology enhanced learning environment is the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler & Mishra, 2009). Significant parts of TPACK framework are covered by the dominant competence framework for modelling teachers' competences, which is the UNESCO ICT Competency Framework for Teachers (UNESCO, 2011). The goal of the UNESCO ICT Competency Framework for Teachers (ICT-CFT) is to outline the competences that teachers need to integrate ICT into their professional practice. ICT-CFT is organized around three successive stages of teacher's development, as follows: (a) technology literacy, enabling students to use ICT in order to learn more efficiently, (b) knowledge deepening, enabling students to acquire in-depth knowledge of their school subjects and apply it to complex real-world problems and (c) knowledge creation, enabling students, citizens and the workforce they become, to create the new knowledge required for more harmonious, fulfilling and prosperous societies. Moreover, ICT-CFT addresses six different categories of teacher's work, namely: (a) understanding ICT in education, (b) curriculum and assessment, (c) pedagogy, (d) ICT, (e) organization and administration and (f) teacher professional learning. By crossing these six categories with the three stages of teacher's development creates a matrix which forms the UNESCO ICT-CFT (Figure 17). The cells of this matrix are the ICT competence levels of the framework for each category of teacher's work and they can be used for characterizing an online lab, so as to denote the ICT competence level that is required by a teacher for effectively use this online lab with his/her students.

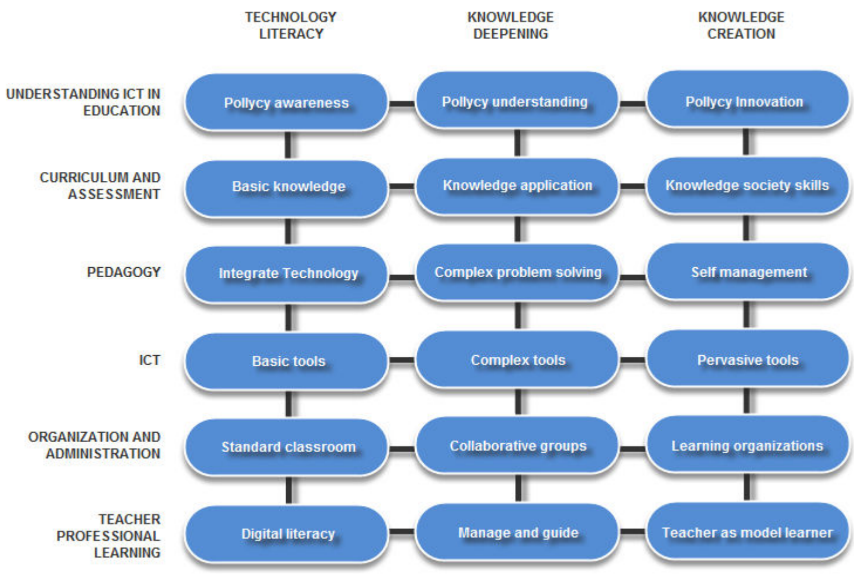

Figure 17. The stages of teacher's development and the categories of teacher's work as proposed by UNESCO ICT-CFT

8 Review of Metadata Elements of Existing Repositories and Federations of Online Labs

The aim of this section is to review metadata elements used by existing repositories and federations of online labs for describing their labs. An overall set of thirteen (13) repositories and federations of online labs have been assembled throughout research in related publications and Internet sources. Each repository or federation of online labs has been visited and thoroughly analyzed, according to the following process:

- **Step 1:** The **searching/browsing mechanism** of each repository or federation of online labs was analyzed and the searching elements were identified. This step aims at identifying common searching elements used in existing repositories and federations of online labs towards providing suggestions for the Go-Lab Inventory, as well as for the Go-Lab Portal.
- **Step 2:** The **metadata elements** used by each repository or federation of online labs were analyzed and they were classified in two categories: (a) lab owner metadata, which are the metadata added by the owners of the online labs and (b) social metadata, which are the metadata added by the end-users of the online labs and includes social tags, ratings and comments. This step aims at identifying common lab owner and social metadata, which could be adopted by the Go-Lab Methodology for Organizing Online Labs.
- **Step 3:** For each repository or federation of online labs, the **types of additional resources and apps** connected to the online labs were analyzed. More precisely, the additional resources and apps were classified in three categories: (a) student's materials, which include materials that can be used by the students before, during or after the execution of an experiment with an online lab, (b) teacher's materials, which include materials that can be used by the teacher to develop educational activities supported by online labs and (c) supportive apps, which include apps that can support students during the execution of an experiment with an online lab. This step aims at identifying common types of additional resources and supporting apps offered by existing repositories and federations, which could be adopted by the Go-Lab Methodology for Organizing Online Labs.

The detailed analysis of the 13 thirteen (13) repositories and federations of online labs is presented in Appendix 1

8.1 *Existing Repositories and Federations of Online Labs*

In this section, an overview of the repositories and federations of online labs that were presented in Appendix 1 is provided. Table 13 presents the categories of the labs that these repositories and federations include, as well as the number of virtual and/or remote labs that include.

Table 13. Overview of Existing Repositories of Online Labs

No	Name	Repository/ Federation URL	Lab Categories		Number of Labs	
			Virtual Labs	Remote Labs	Virtual Labs	Remote Labs
1	PhET	http://phet.colorado.edu	√	-	125	-

2	Library of Labs	https://www.library-of-labs.org/	√	-	274	-
3	Labshare	http://www.labshare.edu.au/	-	√	-	11
4	Open Sources Physics	http://www.compadre.org/osp	√	-	100	-
5	Smart Science	http://www.smartscience.net/	-	√	-	164
6	Molecular Workbench	http://mw.concord.org/	√	-	946	-
7	Explore Learning	http://www.explorelearning.com	√	-	450	-
8	ChemCollective	http://www.chemcollective.org/	√	-	40	-
9	Remotely Controlled Laboratories (RCL)	http://rcl-munich.informatik.unibw-muenchen.de	-	√	-	17
10	Skoool	http://skoool.com	√	-	4.950	-
11	iLabCentral	http://ilabcentral.org	-	√	-	21
12	Lab2Go	http://www.lab2go.net	√	√	157	51
13	WebLab Deusto	https://www.weblab.deusto.es/weblab	-	√	-	15
Total Number of Labs					**7.042**	**279**

As we can notice from Table 13, concerning the lab categories, 8 out of 13 of the examined repositories and federations include virtual labs, 4 out of 13 of the examined repositories and federations include remote labs and only 1 of examined repositories and federations includes the both virtual and remote labs. Additionally, concerning the number of labs, the number of remote labs included in these repositories and federations is quite limited in comparison with the number of virtual labs. This is reasonable because remote labs are based on actual experimental devices, which might be very expensive and require high maintenance costs. On the other hand, virtual labs are computer programs, which can simulate a science experiment and they can be developed more easily.

In the next section, we present a detailed comparative analysis of the repositories and federations that are presented in Table 13.

8.2 Comparative Analysis

8.2.1 Searching/Browsing Mechanisms

In this paragraph, we provide an overview of the number of searching/browsing elements used to the repositories and federations of online labs that were reviewed in Section 8.1. Figure 18 presents the number of searching/browsing elements used at each repository or federation of online labs.

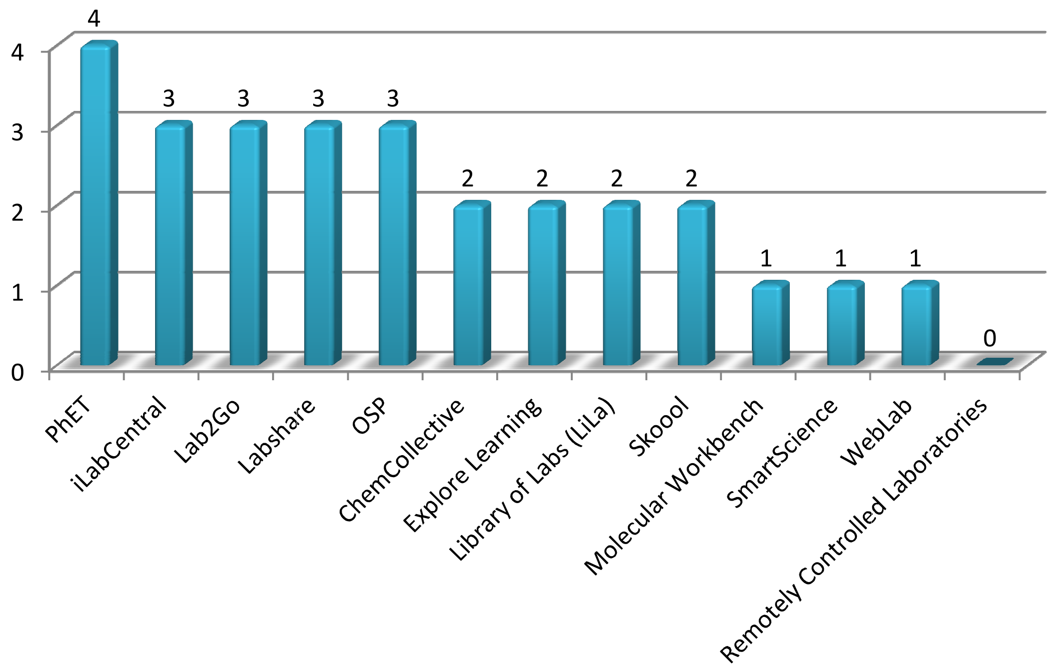

Figure 18. Number of Searching/Browsing Elements per Repository or Federation of Online Labs

As we can notice from Figure 18 the number of searching/browsing elements may range from 1 element to 4 elements (if we exclude RCL federation, which does not provide a searching/browsing mechanism and the searching elements are zero). Moreover, the average number of searching/browsing elements based on the reviewed repositories and federations of online labs is between **2 and 3 searching/browsing elements.** This outcome could be also useful for the searching/browsing interface of the Go-Lab Portal.

Next, we present the frequency of searching/browsing elements used by the searching/browsing mechanisms of the repositories and federations of online labs that were analysed. Figure 19 present the most frequent and the less frequent searching/browsing elements.

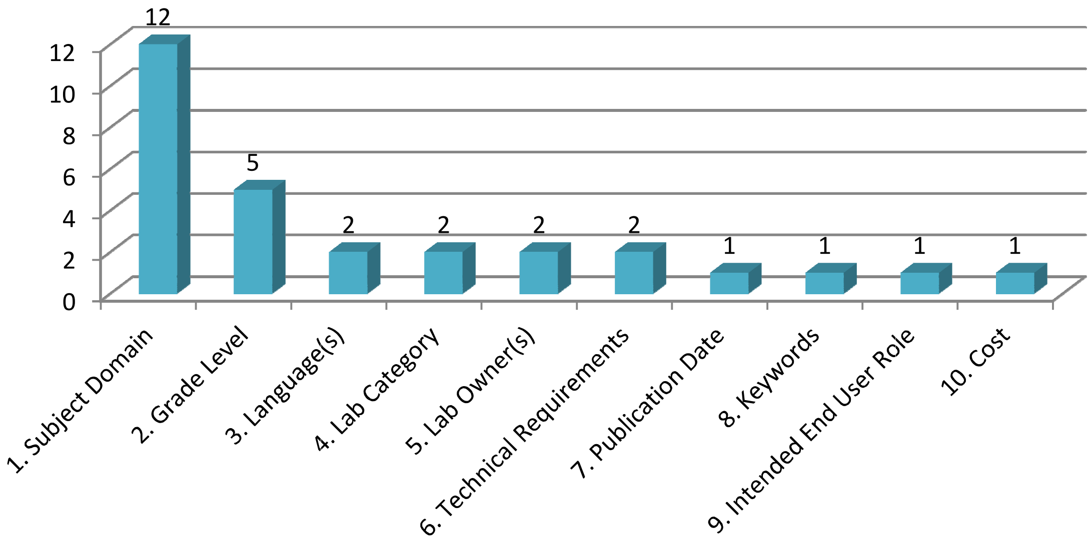

Figure 19. Frequency of Metadata Elements used by Searching/Browsing Mechanisms of Existing Repositories and Federations of Online Labs

As we can notice from Figure 19, ten (10) searching/browsing elements are used by the reviewed searching/browsing mechanisms of the existing repositories and federations of online labs. The most frequent searching/browsing element is the **Subject Domain,** which is used in all searching/browsing mechanisms (except RCL, which does not provide a searching/browsing mechanism). Moreover, **Grade Level** is also frequently used. These elements could also be used for organizing the Go-Lab Inventory.

8.2.2 Metadata Elements

8.2.2.1 Lab Owner Metadata

The aim of this section is to identify commonly used lab owner metadata elements, which could be adopted by the Go-Lab Methodology for Organizing Online Labs. In order to achieve that we need to harmonize the metadata elements used by the repositories and federations on online labs reviewed in Section 8.1. Table 14 presents main lab owner metadata elements identified from Section 8.1, as well as metadata elements that store similar information with the main metadata elements. All elements have been divided into three main categories, namely general, pedagogical and technical following the categorization that has been proposed in Section 3.

Table 14. Harmonization of Lab Owner Metadata Elements

No.	Main Metadata Element	Similar Metadata Element(s)	Description
General Category (15 Elements)			
1	**Lab Title**	Alternative Title	This metadata element presents the name given to a lab.
2	**Lab Description**	-	This metadata element provides a textual description of the lab.
3	**Contributor(s)**	Administrator	This metadata element refers to the entities that have contributed to the current state of the lab.
		Hosted By	
		Rig Concept	
		Rig Designer	
4	**Lifecycle Dates**	Date Created	This metadata element refers to critical dates related to the lab's lifecycle.
		Publication Date	
		Last Modified	
5	**Keywords**	-	This metadata element refers to a set of terms that characterize the content of the lab.
6	**Language(s)**	-	This metadata element refers to the languages that the lab is available.
7	**Access Rights**	-	This metadata element refers to the lab's access permissions (i.e., free or registration etc.).
8	**Cost**	-	This metadata element refers to any payment

No.	Main Metadata Element	Similar Metadata Element(s)	Description
			required for using the lab (i.e., free or payment).
9	**Lab Owner**	Provider Creator	This metadata element provides information about the provider of the lab.
10	**Lab Category**	-	This metadata element refers to the specific kind of the lab (i.e., virtual or remote lab)
11	**Contact Details**	-	This metadata element provides information about contact details of the person or the organization responsible for the lab.
12	**License**	-	This metadata element provides information about copyrights and restrictions applied to the use of the lab.
13	**Rights Holder(s)**	-	This metadata element refers to those entities that hold the lab's copyrights.
14	**Status**	-	This metadata element provides information about the availability status of the lab (i.e., available, offline, online, etc.).
15	**Version**	**-**	This metadata element provides information about the current version of the lab.
Pedagogical Category (5 Elements)			
16	**Subject Domain**	-	This metadata element refers to the lab's subject domain (i.e., physics, chemistry, biology etc.).
17	**Grade Level**	-	This metadata element refers to the grade level for which the lab can be used.
18	**Educational Objective(s)**	-	This metadata element refers to the educational objectives that the lab addresses.
19	**Difficulty**	-	This metadata element refers to the level of difficulty of the lab.
20	**Intended End User Role**	-	This metadata element refers to the principal users for whom the lab was designed.
Technical Category (3 Elements)			
21	**Lab URL**	-	This metadata element provides a URL for accessing the lab.
22	**Technical Requirements**	Client Requirement(s)	This metadata element refers to the technical requirements that are needed for using the lab.
23	**Technical Format**	**-**	This metadata element refers to lab's technical format.

As we can notice from Table 14, **twenty three (23)** lab owner metadata elements can be used for describing online labs based on the review performed for the existing repositories and federations of online labs in Section 8.1. These metadata elements are going to be exploited by the Go-Lab Methodology for Organizing Online Labs in Section 9.

Next, we present the frequency of the lab owner metadata elements as identified from Table 14. Figure 20 present the most frequent and the less frequent lab owner metadata elements.

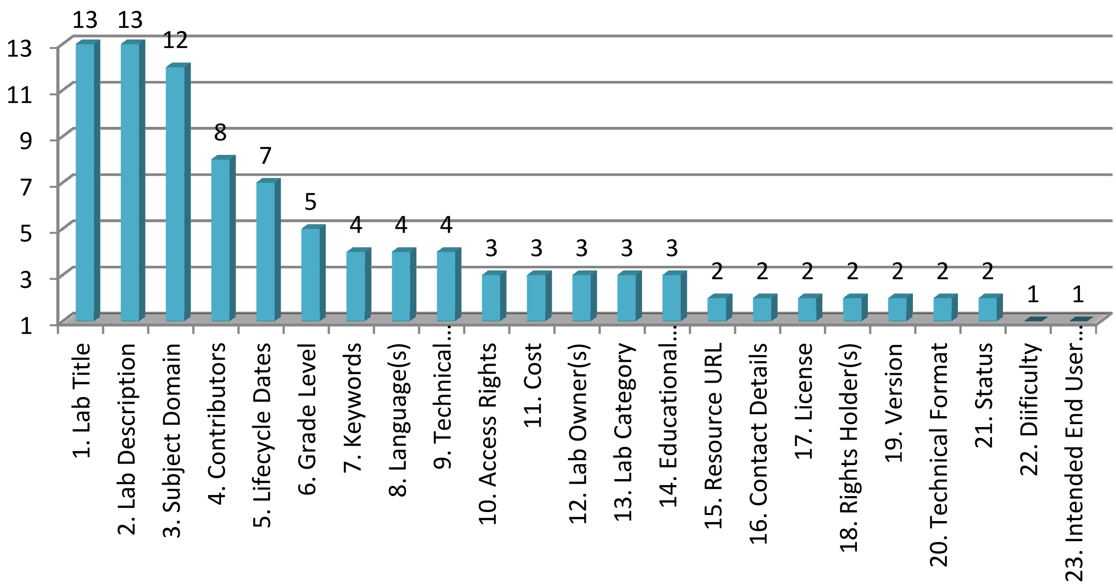

Figure 20. Frequency of Lab Owner Metadata Elements used by Existing Repositories and Federations of Online Labs

As we can notice from Figure 20, the frequently used lab owner metadata elements are the following: (i) **Title**, (ii) **Description**, (iii) **Subject Domain**, (iv) **Contributor(s),** (v) **Lifecycle Dates.** Except from these elements that seem to be important for the existing repositories and federation of online labs, we can identify also additional elements that have been recognized as important elements especially for the Go-Lab Project. These are: (vi) the **Big Ideas of Science** (as proposed in Section 6.3), (vii) the **Educational Objectives** (as proposed in Section 7.2), (viii) the connection with **Go-Lab Inquiry Cycle** (as proposed in Section 7.1), (ix) the Teacher ICT Competence Level (as proposed in Section 7.3), (x) the **Language(s)** (as proposed in Section 8.2.1). The aforementioned 10 metadata elements could be considered used for creating a condensed/quick view of lab owner metadata, as they will be presented to the end-users of the Go-Lab Repository during the searching process, whereas all lab owner metadata elements could be also presented in a new page with a detailed view of the metadata elements.

8.2.2.2 Social Metadata

The aim of this section is to identify commonly used social metadata options, which could be also adopted by the Go-Lab Repository. Table 15 provides an overview of the social metadata options provided by the repositories and federations of online labs that were reviewed in Section 8.1.

Table 15. Overview of Social Metadata Options provided by Existing Repositories and Federations of Online Labs

No	Repository / Federation Name	Social Tags	Ratings	User's Comments

No	Repository / Federation Name	Social Tags	Ratings	User's Comments
1	PhET	No	No	No
2	Library of Labs (LiLa)	No	Yes (Like Ratings)	Yes
3	Labshare	No	No	No
4	Open Source Physics (OSP)	No	Yes (1-5 Star Rating)	Yes
5	Smart Science	No	No	No
6	Molecular Workbench	No	No	No
7	Explore Learning	No	No	No
8	ChemCollective	No	No	No
9	Remotely Controlled Laboratories (RCL)	No	No	No
10	Skoool	No	No	No
11	iLabCentral	No	No	No
12	Lab2Go	No	Yes (1-5 Star Rating)	No
13	WebLab Deusto	No	No	No

As we can notice from Table 15, the majority of the repositories and federations of online labs do not offer the opportunity to the end-users to participate in the characterization of online labs. More specifically, concerning social tags, none of the examined repositories and federations of online labs provide a social tagging system. Moreover, we can notice limited usage of users' comments and ratings. These options are offered by only 3 (23%) of the examined repositories and federations of online labs.

The overall absence of social tags and limited usage of users' comments and ratings to the examined repositories and federations of online labs provide us evidence that most of the repositories and federations of online labs were developed on the basis of a sharp distinction between lab owners and end-users (namely, teachers and learners). While the former are the only responsible for the development and characterization of an online lab, the latter is mostly assigned to the role of a passive user. In this respect, the majority of the examined repositories and federations of online labs end up to be web-based digital repositories since they provide typical functionalities of digital repositories to their end-users for search and retrieval of online labs through the use of lab owner metadata. The limitation of this approach is that end-users are given limited opportunities to provide their feedback and experiences about the use of online labs that are stored in these repositories and federations, as well as end-users interactions are not facilitated and creation of users' communities is not supported.

As a result, it is important to consider for the Go-Lab Methodology the aforementioned social metadata options, namely social tags, ratings and user's comments. These options could significantly facilitate towards the empowerment of the end-users and their active participation and interaction with the online labs offered by the Go-Lab Portal.

8.2.3 Additional Resources and Apps

The aim of this section is to identify common types of additional resources and apps, which are connected with the online labs offered by existing repositories and federations. These types of additional resources and apps could also be adopted by the Go-Lab Methodology for Organising Online Labs. Table 16 provides an overview of additional resources and apps options that are connected with the online labs provided by the examined repositories and federations in Section 8.1.

Table 16. Overview of Additional Resources and Apps Options connected with the online labs provided by Existing Repositories and Federations of Online Labs

No	Repository / Federation Name	Additional Resources		Supportive Apps
		Student's Materials	Teacher's Materials	
1	PhET	No	Yes (Lesson Plan)	No
2	Library of Labs (LiLa)	Yes (Student's Guide, Assignment Sheet)	Yes (Lesson Plan)	No
3	Labshare	No	Yes (Lesson Plan)	No
4	Open Source Physics (OSP)	Yes (Student's Guide)	Yes (Lesson Plan)	No
5	Smart Science	Yes (Glossary, Student's Guide, Tutorial)	Yes (Lesson Plan)	Yes
6	Molecular Workbench	No	Yes (Lesson Plan)	Yes
7	Explore Learning	Yes (Assignment Sheet, Glossary)	Yes (Lesson Plan)	No
8	ChemCollective	Yes (Assignment Sheet)	Yes (Lesson Plan)	No
9	Remotely Controlled Laboratories (RCL)	Yes (Student's Guide)	Yes (Lesson Plan)	No
10	Skoool	Yes (Assignment Sheet)	Yes (Lesson Plan)	No
11	iLabCentral	Yes (Assignment Sheet)	Yes (Lesson Plan)	No
12	Lab2Go	Yes (Student's Guide)	No	No
13	WebLab Deusto	Yes (Tutorial)	No	No

As we can notice from Table 16, 10 (77%) of the examined repositories and federations offer student's materials, which are linked with the online labs provided by these repositories and federations. These materials include: student's guides, assignment sheets, glossaries and tutorials. Moreover, 11 (85%) of the examined repositories and federations offer teacher's materials, which are linked with the online labs provided by these repositories and federations. These materials mainly include lesson plans for exploiting online labs in the context of educational activities to be conducted by their students. Finally, only 2 (15%) of the examined repositories and federations offers supportive apps that aim to facilitate students during the process of using the online labs. However, this kind of apps is very important in the inquiry process. Especially, in the Go-Lab approach the use of supportive apps such as apps that help students to formulate hypothesis or interact with experimental data are considered as an important part of the Go-Lab intervention.

As a result, it is important to adopt to the Go-Lab Methodology all aforementioned additional resources and apps options, namely student's materials (student's guides, assignment sheets, glossaries and tutorials), teacher's materials (lesson plans) and supportive apps. These options could significantly facilitate teachers when using online labs for designing educational activities for their students, as well as students when using the online in the context of these activities.

9 The Go-Lab Methodology for Organizing Online Labs

The aim of this section is to present the Go-Lab Methodology for Organizing Online Labs. This methodology reflects the conclusions from (a) Section 6.3, where the Go-Lab set of big ideas were developed, (b) Section 7, where the particular characteristics of the Go-Lab online labs were analyzed and appropriate vocabularies were developed and (c) Section 8, were recommendations were proposed based on the review of existing repositories and federations of online labs.

9.1 Starting Points

The first starting point for designing the Go-Lab Methodology reflects the conclusion from the analysis of the existing repositories and federations of online labs. From this analysis, it was identified that online labs can be described with: (a) lab owner metadata authored by the owners of the labs and (b) social metadata derived from the interaction of the end users with an online lab. Moreover, online labs are connected with different types of additional materials and apps used for supporting teachers and students during the process of using online labs.

Regarding the **lab owner metadata**, **thirty (30) metadata elements** were considered, as follows:

- **One (1) element** that stores information about the Go-Lab set of big ideas, as proposed in Section 6.3
- **Three (3) elements** that store information about the specific characteristics of the Go-Lab online labs, namely the connection with Go-Lab Inquiry Cycle (as proposed in Section 7.1), the educational objectives (as proposed in Section 7.2) and the teacher ICT competence level (as proposed in Section 7.3)
- **Twenty (22) elements** were considered based on the review of existing repositories and federations of online labs. The initial set of elements considered from the analysis of the existing repositories and federations of online labs was twenty three (23) but in these set of elements there were “the educational objectives” element, which has been already considered in our lab owner metadata set.
- **Four (4) elements** were considered based on the characterization scheme that was initially developed in Section 3, namely, engaging in scientific reasoning, supporting students with disabilities, level of interaction and booking required. It should be mentioned that the characterization scheme initially developed in Section 3 includes elements that have been already considered in our lab owner metadata set based on the analysis performed in Section 8. Moreover, it includes technical details about an online lab, which is beyond the scope of the Go-Lab Methodology for Organizing Online Labs.

Regarding the **social metadata, three (3) options** were considered, which reflects the conclusion from the analysis of the existing repositories and federations of online labs (as presented in Section 8.2.2.2).

Finally, regarding the **options for additional resources and apps** that could be connected to the online labs, **three (3) options** were considered, which reflect the conclusions from the analysis of the existing repositories and federations of online labs (as presented in Section 8.2.3).

9.2 Go-Lab Methodology Full Element Set

This section presents the full element set of the Go-Lab Methodology for Organising Online Labs. Based on this full element set, deliverable D5.2 “” has selected a subset these metadata elements that will be immediately used for the Go-Lab Repository. During the project lifetime, all metadata elements of the Go-Lab Methodology will be specified in the Go-Lab Repository (Go-Lab Project – D5.2).

For each element of the Go-Lab Methodology the following information is defined:

- **Element Name:** the title of the element as references by the Go-Lab Methodology
- **Description**: a short description explaining the information that the element can store
- **Datatype:** indicates whether the values of the element can be a character string or a vocabulary term
- **Value Space**: the set of allowed values for the element – typically in the form of a vocabulary or a reference to another standard.

Lab Owner Metadata

General Metadata (16 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
1	Lab Title	This metadata element refers to the title of the lab	Character String	-
2	Lab Description	This metadata element provides a textual description of the lab.	Character String	-
3	Keyword(s)	This metadata element refers to a set of terms that characterize the content of the lab.	Character String	-
4	Language(s)	This metadata element refers to the languages that the lab is available in.	Vocabulary Term	EN (English) EL (Greek) FR (French) CA (Catalan) CS (Czech) DE (German) ES (Spanish) HU (Hungarian) IT (Italian) PT (Portuguese) Other
5	Lab Category	This metadata element refers to the specific kind of the lab (i.e., virtual or remote lab).	Vocabulary Term	Remote lab Virtual Lab Data Set/Analysis Tools
6	Contributor(s)	This metadata element refers to the entities that have contributed to the current	Character String	Name of Contributor Email Organization *(if there are more than one contributors please add their information in the same way)*

General Metadata (16 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
		state of the lab.		
7	Lifecycle Dates	This metadata element refers to critical dates related to the lab's lifecycle.	Character String	Date Action Taken (*if there are more than one dates please add the information in the same way)*
8	Access Rights	This metadata element refers to the lab's access permissions	Vocabulary Term	Free access Restricted access
9	License	This metadata element provides information about copyrights and restrictions applied to the use of the lab.	Character String	CC – Zero (universal) - http://creativecommons.org/publicdomain/zero/1.0/ CC BY (v3.0 Unported) - http://creativecommons.org/licenses/by/3.0/ CC BY-SA http://creativecommons.org/licenses/by-sa/3.0/ CC BY-NC http://creativecommons.org/licenses/by-nc/3.0/ CC BY-NC-SA http://creativecommons.org/licenses/by-nc-sa/2.0/ CC BY-ND http://creativecommons.org/licenses/by-nd/2.0 CC BY-NC-ND http://creativecommons.org/licenses/by-nc-nd/1.0/ GNU General Public License http://www.gnu.org/licenses/gpl.html Commercial License Other (please specify)
10	Cost	This metadata element refers to any payment required for using the lab	Vocabulary Term	Yes No
11	Lab Owner(s)	This metadata element provides information about the provider(s) of the lab.	Character String	Name of provider Email Organization (*if there are more than one providers please add their information in the same way)*
12	Contact Details	This metadata element provides information about contact details of	Character String	Name Email Organization

General Metadata (16 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
		the person or the organization responsible for the lab.		*(if there are more than one contact persons please add their information in the same way)*
13	Rights Holder(s)	This metadata element refers to those entities that hold the lab's copyrights	Character String	Name Email Organization *(if there are more than one contact persons please add their information in the same way)*
14	Status	This metadata element provides information about the availability status of the lab.	Vocabulary Term	Available Online Offline Unavailable
15	Version	This metadata element provides information about the current version of the lab.	Character String	*(e.g., v1.0 or v2.0)*
16	Booking Required	This metadata element describes whether the use of the lab requires booking	Vocabulary Term	Yes No

Pedagogical Metadata (11 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
17	Big Ideas	This metadata element refers to the big ideas of science that the lab addresses	Vocabulary Term	See Section 6.3
18	Subject Domain	This metadata element refers to the lab's subject domain	Vocabulary Term	See Annex A: Science Curriculum Vocabulary
19	Grade Level	This metadata element refers to the grade level for which the lab can be used.	Vocabulary Term	Primary Education (10 - 12 years old) Lower Secondary Education (12 -15 years old) Upper Secondary Education (15 -18 years old) Higher Education Bachelor Higher Education

Pedagogical Metadata (11 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
				Master
20	Educational Objectives	This metadata element refers to the educational objectives that the lab addresses	Vocabulary Term	See Section 7.2
21	Engaging in Scientific Reasoning	This metadata element describes how the use of the lab can support students in manipulating, testing, exploring, predicting, questioning, observing, analyzing and making sense of the natural and physical world.	Character String	Manipulating Testing Exploring Predicting Questioning Observing Analysing Making sense of the natural and physical world.
22	Inquiry Cycle Phase	This metadata element describes which phases of the Go-Lab inquiry cycle the lab can support.	Vocabulary Term	See Section 7.1
23	Level of Difficulty	This metadata element refers to the level of difficulty of the lab.	Vocabulary Term	Easy Medium Advanced
24	Level of Interaction	This metadata element refers to the level of interaction the lab offers.	Vocabulary Term	Low Medium High
25	Intended End User Role	This metadata element refers to the principal users for whom the lab was designed.	Vocabulary Term	Learner Teacher Researcher Professional/Practitioner Administrator General Public Parent/Guardian Other
26	Teacher ICT Competence Level	This metadata element refers to the ICT competence level that a teacher should possess for the effective use of the lab.	Vocabulary Term	See Section 7.3
27	Supporting Students with Disabilities	This metadata element describes whether the lab can support students with disabilities.	Vocabulary Term	Physical impairments Visual impairments Hearing impairments Learning disabilities

Pedagogical Metadata (11 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
				No specific provisions

Technical Metadata (3 Elements)				
No	**Element Name**	**Description**	**Datatype**	**Value Space**
28	Resource URL	This metadata element provides a URL for accessing the lab.	Character String	-
29	Technical Requirements	This metadata element refers to the technical requirements that are needed for using the lab.	Vocabulary Term	***Operating System*** Window MacOS Linux iOS Android ***Additional Software*** Java Adobe Flash Player LabView Runtime Engine Other ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera Other
30	Technical Format	This metadata element refers to lab's technical format.	Vocabulary Term	application/java application/x-shockwave-flash application/javascript application/widget application/zip application/xhtml+xml Other

Additional Resources and Apps				
No	**Element Name**	**Description**	**Datatype**	**Value Space**

1	Type of Student's Materials	This metadata element refers to the type of student's material that is connected to the lab	Vocabulary Term	Student's guide Assignment Sheet Glossary Tutorial
2	Student's Material(s)	This metadata element provides the URL(s) for accessing any student's material(s) that is connected to the lab	Character String	-
3	Lesson Plan	This metadata element provides the URL(s) for accessing any lesson plans that can be used for exploiting the lab.	Character String	-
4	Supportive App(s)	This metadata element provides the URL(s) for accessing any supportive app(s) that are connected to the lab.	Character String	-

Social Metadata

No	Element Name	Description	Datatype	Value Space
1	Tag(s)	Free text describing the subject domain of an online lab and/or the big idea addressed.	Character String	-
2	User's Comment	Textual comments including feedback from the use of an online lab.	Character String	-
3	Rating	Ratings related to the quality of an online lab.	Vocabulary Term	One star Two stars Three stars Four stars Five stars

10 Populating the Go-Lab Inventory

To ensure that a maximum number of relevant online labs will be properly included in the Go-Lab portal, the project – according to the methodology described in the Go-Lab DoW, Part B, pp.10-11, implements a three-stage deployment cycle by populating the Go-Lab inventory with online labs.

Based on the proposed approach and during the first year of the project, Go-Lab was planning to adapt existing labs offered by large scientific organisations part of the project and already targeting primary and secondary school students.

According to the initial plan in a first stage (first year), Go-Lab large scientific organizations had to provide and adapt first the following labs:

- CERNland, LHC Game, MINERVA and AMELIA (CERN),
- HYPATIA (IASA),
- Meteosat and Gaia (ESA),
- The Faulkes Telescopes Project (UoG),
- Discovery Space Portal and Universe Quest/Learnit3D Lab (EA),
- SalsaJ, Sun for all, and CosmoQuest (NUCLIO).

During the initial period (following the kick-off meeting) of the project this issue was further discussed among the consortium members as the labs mentioned above are covering quite similar thematic areas (astronomy, space and high energy physics that is additionally a rather complex subject to be presented to students) it was decided to enrich the initial list with labs that are covering different curriculum areas as well as age groups (complexity) in order the consortium to be able to implement the project in a more effective way during the first implementation period. It was also clear from the numerous visionary workshops that were organized in the participating countries that there was a great interest on the availability of labs in additional thematic areas (Go-Lab Project - D3.1).

In this framework the Go-Lab consortium decided during the first months of the project life cycle to modify the initial list by adding a series of labs that were planned to be integrated during the second implementation phase and are covering more curriculum areas.

The variety of the thematic areas covered (curriculum coverage) was the most important parameter for the selection. Additionally the maturity of each lab (as well as the number of its current users) was considered for the selection process. It is very important the labs that will be offered to the school communities during the first implementation cycle to be used (and assessed) by numerous users, to offer high quality services and support materials (scenarios of use, tutorials, online support). Although the availability of the lab interface in different languages could be the most crucial parameter for the successful implementation of the project with the school communities, the majority of the labs are available only in English. This is an issue that the Go-Lab consortium has to take into account during the design of the support mechanism of the user communities. Finally the technical team had the opportunity to indicate some specific labs that offer significant technical challenges in the integration process. These cases (e.g., the Black-Body Radiation Lab) were treated like case studies by the technical team in order to assess the complexity of the integration process.

Table 17. Initial List of the Go-Lab Online Labs

Initial List of Go-Lab Online Labs			
No	**Go-Lab Online Labs for the First Implementation phase**	**Main Thematic Area and Type of Lab**	**Online Labs proposed for the First Implementation Phase (according tot the Go-Lab DoW, Part B, pp. 10-11)**
1	HY.P.A.T.I.A.	High Energy Physics - Analysis Tool (that can be used to analyse data from CERN)	HYPATIA, MINERVA and AMELIA
2	The Faulkes Telescopes Project	Astronomy - Remote Lab	The Faulkes Telescopes Project, Discovery Space Portal, Universe Quest/Learnit3D Lab
3	WebLab-DEUSTO Aquarium Aquarium	Buoyancy, Mechanics – Remote Lab	-
4	Galaxy Crash	Astronomy - Virtual Lab	SalsaJ, Sun for all, and CosmoQuest
5	CERNland	Particles Interactions - Virtual Lab	CERNland
6	LHC Game	Particles Interactions - Virtual Lab	LHC Game
7	Craters on Earth and Other Planets	Space - Virtual Lab	Meteosat and Gaia
8	Black-Body Radiation	Radiation – Remote Lab	-
9	Boole-Deusto + WebLab-Deusto	Digital Systems – Remote Lab	-
10	Electricity Lab	Electricity – Virtual Lab	-
11	ELVIS / OP – AMP Labs	Amplifiers, Electricity – Remote Lab	-
12	VISIR	Circuits, Electricity - Remote Lab	
13	Methyl Orange	Chemistry, Remote Lab	-

11 The Go-Lab Inventory of Online Labs

Below we present the thirteen (13) online labs that are included in the Go-Lab Inventory for the 1st year. Nine of these online labs are from the initial pool of twenty labs that was presented in Section 4. However, based on the selection criteria mentioned in Section 10 four new labs have also been added to the inventory. The labs have been described by following the methodology that was presented in Section 9.2. This will enable their storage with a common format to the Go-Lab Repository. Moreover, each lab has been described with additional elements that are highly needed for the technical integration of the labs to the Go-Lab Portal.

11.1 HY.P.A.T.I.A

11.1.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	HY.P.A.T.I.A. Hybrid Pupils' Analysis Tool for Interactions in ATLAS
2	Lab Description	HYPATIA is an event analysis tool for data collected by the ATLAS experiment of the LHC at CERN. Its goal is to allow high school and university students to visualize the complexity of the hadron - hadron interactions through the graphical representation of ATLAS event data and interact with them in order to study different aspects of the fundamental building blocks of nature.
3	Keyword(s)	High energy, ATLAS, CERN, LHC, elementary particles, bozon, electron, muon, positron, proton, neutron, neutrino, accelerator, hadron, collision, momentum
4	Language(s)	EN (English) EL (Greek) FR (French)
5	Lab Category	Data Set/Analysis Tools
6	Contributor(s)	Name of Contributor: Christine Kourkoumelis e-mail: hkourkou@phys.uoa.gr Organization: University of Athens/IASA Name of Contributor: Stelios Vourakis e-mail: s.vourakis@gmail.com Organization: University of Athens/IASA
7	Lifecycle Dates	-
8	Access Rights	Free Access
9	License	N/A
10	Cost	No

General Metadata (16 Elements)		
No	**Element Name**	**Value**
11	Lab Owner(s)	Name of provider: Christine Kourkoumelis e-mail: hkourkou@phys.uoa.gr Organization: University of Athens, department of Physics / Institute of Accelerating Systems and Applications (IASA)
12	Contact Details	Name of provider: Christine Kourkoumelis e-mail: hkourkou@phys.uoa.gr Organization: University of Athens, department of Physics / Institute of Accelerating Systems and Applications (IASA)
13	Rights Holder(s)	Name of provider: Christine Kourkoumelis e-mail: hkourkou@phys.uoa.gr Organization: University of Athens, department of Physics / Institute of Accelerating Systems and Applications (IASA)
14	Status	Online
15	Version	Not applicable
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	HYPATIA aims to show students how real high energy physic research is done. It provides the students with real data and an environment that closely resembles what actual researchers use, to give them the opportunity to conduct their own analysis and “discover” new particles.
B	Current number of lab users	300/month
C	Average time of use (per experiment/session)	Depending on the experiment. One hour is typical.

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.1.2
18	Subject Domain	**Electricity and magnetism** Electric charge – generally Electromagnetism – generally **Energy**

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Conservation and dissipation Internal Energy Kinetic energy Potential energy **Fields** Magnetic field Electric field Electromagnetic field Angular velocity **Forces and motion** Conservation of momentum Nuclear force Collision **Tools for science** Accelerators & beams Antimatter Calorimeters **High Energy Physics** Charged particle acceleration Dark matter Higgs particle Invariant mass Leptons QCD, jets & gluons Quarks & hadrons Standard model Supersymmetry
19	Grade Level	• Upper Secondary Education (15-18 years old) • Higher Education Bachelor • Higher Education Master
20	Educational Objectives	See Section 11.1.3
21	Engaging in Scientific Reasoning	Manipulating Analysis Making sense of the natural and physical world. *HYPATIA is designed so that the user can view real events as they are detected by the ATLAS experiment at CERN. The scenarios involving HYPATIA mimic the process used by actual researchers during their work on event analysis. Thus, the user can analyse real data using real methods and*

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		get a taste of what it feels like to be a particle physics researcher. *The user is given instructions on how to identify the various kinds of events that he will have to go through. Then every user (or pair) has to apply those criteria to the available events (which are different for every group of students) and identify then on his own. Then he has to study the histograms and reach a conclusion based on his analysis.*
22	Inquiry Cycle Phase	Orientation Conceptualization Investigation Data Interpretation Conclusion
23	Level of Difficulty	Medium
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.1.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No guidance tools and scaffold provided
B	Context of use	Flexible. Can be used by individual student or teacher as well as in an organized Masterclass.
C	User manual	Yes Manual Title: - Access URL: http://hypatia.iasa.gr/en/HYPATIA_Instructions_eng.pdf
D	Description of a use case	Students can examine real Z boson decays and calculate their mass through the use of the built-in invariant mass table. They can do the same with simulated Higgs boson decays. Then they create histograms that give them the invariant mass and width of the particle.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://hypatia.iasa.gr
29	Technical Requirements	***Operating System*** Windows MacOS Linux *Additional Software* Java ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/java

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s))	http://hypatia.iasa.gr
B	APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **Concurrent use by all** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How?

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
		http://portal.discoverthecosmos.eu
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	No

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Tutorial
2	Student's Material(s)	http://hypatia.iasa.gr/en/exercise.html
3	Lesson Plan	N/A
4	Supportive App(s)	Help page: http://hypatia.iasa.gr/en/help.html

11.1.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical

field causing a change in motion or in the state of matter.
4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.
5. All matter and radiation exhibit both wave and particle properties.

11.1.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform independently, skillfully, and precisely	To help the learner coordinate a series of actions, achieving harmony and internal consistency; adapt and integrate expertise to satisfy a non-standard objective

11.1.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	Policy Awareness	**Policy Understanding**	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills

Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	Basic Tools	**Complex Tools**	Pervasive Tools
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.2 The Faulkes Telescope Project (USW)

11.2.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Faulkes Telescope Project
2	Lab Description	The Faulkes Telescope Project is an education partner of Las Cumbres Observatory Global Telescope Network (LCOGTN). Our aim is to provide free access to robotic telescopes and a fully supported education programme to encourage teachers and students to engage in research-based science education. Access to our resources and those of our partners is provided at no charge to teachers and students. Robotic Telescopes. We provide access to the telescope for all schools in the UK and Ireland and limited access to telescope time for schools outside of this region. All users have unlimited access to the data and image archives, from where they can download data. LCOGTN operates a network of research class robotic telescopes. Currently there are two telescopes, one in Hawaii and the other in Australia. 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 and a team of educators and professional astronomers. http://www.faulkes-telescope.com/resources/videos/ft-lcogt_introduction
3	Keyword(s)	Astronomy, Robotic, Telescopes, Research, galaxy, star, nebula, cluster, observation
4	Language(s)	EN (English)

General Metadata (16 Elements)		
No	**Element Name**	**Value**
5	Lab Category	Remote Lab
6	Contributor(s)	Name of Contributor: Fraser Lewis e-mail: fraser.lewis@faulkes-telescope.com Organization: University of South Wales Name of Contributor: Paul Roche e-mail: paul.roche@faulkes-telescope.com Organization: University of South Wales Name of Contributor: Sarah Roberts e-mail: sarah.roberts@faulkes-telescope.com Organization: University of South Wales
7	Lifecycle Dates	N/A
8	Access Rights	Restricted Access
9	License	CC BY-NC – http://creativecommons.org/licenses/by-nc/3.0
10	Cost	No
11	Lab Owner(s)	Name of Contributor: Fraser Lewis e-mail: fraser.lewis@faulkes-telescope.com Organization: University of South Wales Name of Contributor: Paul Roche e-mail: paul.roche@faulkes-telescope.com Organization: University of South Wales Name of Contributor: Sarah Roberts e-mail: sarah.roberts@faulkes-telescope.com Organization: University of South Wales
12	Contact Details	Name: Professor Paul Roche e-mail : paul.roche@faulkes-telescope.com Organization: University of South Wales
13	Rights Holder(s)	Organization: LCOGT
14	Status	Online
15	Version	N/A
16	Booking Required	Yes

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	• Demonstrate how scientists work • Demonstrate how, through the use of telescopes, astronomers can draw conclusions on what they observe in the Universe

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
		• Demonstrate how a very complex scientific instrument works.
B	Current number of lab users	About 5,000 users (teachers and students)
C	Average time of use (per experiment/session)	1 hour

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value Space**
17	Big Ideas	See Section 11.2.2
18	Subject Domain	**Astronomy** Asteroid belt Asteroid Astrometry Binary stars Black holes Brown dwarfs Comets and meteors Co-ordinates Cosmology Eclipses Einstein ring Elliptical galaxy Extrasolar planets Formation Galaxies and dwarf galaxies Galaxy clusters Gamma-ray bursts Gas Giants Globular clusters Gravitational lenses HR diagram H II region

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value Space**
		Intergalactic medium Interstellar medium Irregular galaxy Jets Kuiper belt objects Light curve Main sequence Mass loss Microlensing effect Milky Way Near-Earth Objects Nebula Neutron stars Nucleosynthesis Open clusters Orbit Planetary nebula Planets Pulsars Quasars Redshift Solar System Spiral galaxy Star chart Stars Supernova Supernova remnants Variable stars **Fields** Gravitational field **Forces and motion** Gravitational force and gravity Circular motion Period Rotation Universal law of gravitation

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value Space**
		Light Colour Light sources Properties of light – generally Reflection **Tools for Science** Analysis tools Detectors Detectors: CCD camera Observatories Online laboratories Remote laboratories Sensors **Waves** EM spectrum Optics Visible light
19	Grade Level	• Primary Education (10-12 years old) • Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old)
20	Educational Objectives	See Section 11.2.3
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting Questioning Observing Analysis
22	Inquiry Cycle Phase	Orientation Conceptualization Investigation Conclusion Discussion
23	Level of Difficulty	Medium

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value Space**
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.2.4 Teachers will need to be competent in the following ICT areas: Searching the internet for information Accessing data from websites Using JAVA tools (simulation software) and navigating websites for further information which may aid in the use of the tools
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No Scaffold provided
B	Context of use	This lab is designed to be used in a computer lab during an approx. 1 hour lesson. However, many FT activities can take much more than this if required.
C	User manual	Yes Manual Title: Advice booklet Access URL: http://resources.faulkes-telescope.com/course/view.php?id=12
D	Description of a use case	There are numerous showcases available on the web site of the telescope http://www.faulkes-telescope.com/showcases/schools

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://www.faulkes-telescope.com
29	Technical Requirements	***Operating System*** Windows MacOS Linux

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
		iOS Android *Additional Software* Java Adobe Flash Player ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari
30	Technical Format	application/x-shockwave-flash 1application/javascript 1application/widget

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	N/A
B	APIs (server)	There is no API involved in this lab.
C	Alternative clients	There is a simulator/walkthrough of the Faulkes Telescopes http://lcogt.net/files/flash/rti-demo/index.html
D	Registration needed	Yes 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. By filling out the form and accepting the Las Cumbres Observatory terms and conditions you are registering your organization for telescope use. http://rti.faulkes-telescope.com/control/Register.isa
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **Access through booking** http://www.faulkes-telescope.com/information/registration Do you want to grant Go-Lab the right to make these conditions of use public? **Restricted use for pilot schools so not to be made public**

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
		Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **Discover the Cosmos – no restrictions** http://portal.discoverthecosmos.eu/
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	Yes
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Tutorial
2	Student's Material(s)	http://resources.faulkes-telescope.com
3	Lesson Plan	There are numerous showcases available on the web site of the telescope http://www.faulkes-telescope.com/showcases/schools
4	Supportive App(s)	**Multimedia Resources** **Web Applications** These applications are designed and built by the FT team and run in your internet browser. These applications go hand in hand with our educational projects but can also be used independently. **Interactive Animations** Have a look at our interactive animations which help explain scientific concepts

		and methods. These animations are fun to play with and good educational tools which aid our educational programmes. http://www.faulkes-telescope.com/multimedia **Google Sky** Add Faulkes Telescope images to Google Sky. These packs are constantly updated and could include images that you have taken. **Videos** Have a browse through our video library. These videos and podcasts are produced by members of the FT team and include topics from information about the Faulkes Telescope Project through to how stars are formed.

11.2.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
3. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.
5. All matter and radiation exhibit both wave and particle properties.

11.2.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.2.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	Basic Tools	**Complex Tools**	Pervasive Tools
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.3 WebLab-DEUSTO Aquarium (DEUSTO)

11.3.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	WebLab-DEUSTO Aquarium
2	Lab Description	The main learning objective is Archimedes' Principle. There is an aquarium with 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, etc.
3	Keyword(s)	Archimedes' Principle, density, aquarium, volume, mass, water, buoyancy, oil, alcohol, liquid
4	Language(s)	EN (English) FR (French) CS (Czech) DE (German) ES (Spanish) HU (Hungarian) PT (Portuguese) Other: Basque, Slovak, Romanian, Russian
5	Lab Category	Remote Lab
6	Contributor(s)	Name: webLab-Deusto team (Leader of group Javier Garcia-Zubia, zubia@deusto.es) e-mail: weblab@deusto.es Organization: Organization: University of Deusto
7	Lifecycle Dates	Date: January 2014 Action Taken: The design from the scratch of a new remote lab for the Archimedes Principle
8	Access Rights	Free Access
9	License	GNU General Public License http://www.gnu.org/licenses/gpl.html
10	Cost	No
11	Lab Owner(s)	Name of provider: Olga Dziabenko, Javier Garcia-Zubia email: olga.dziabenko@deusto.eszubia@deusto.es Organization: WebLab-Deusto, University of Deusto
12	Contact Details	Name of provider: Javier Garcia-Zubia e-mail: zubia@deusto.es Organization: WebLab-Deusto, University of Deusto
13	Rights	Organization: University of Deusto

General Metadata (16 Elements)		
No	**Element Name**	**Value**
	Holder(s)	
14	Status	Online (Available)
15	Version	V1.0
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**

A	Primary aims of the lab	• Demonstrate how scientists work
		• Explain the scientific process
		• Study the main principle of Archimedes:
		  ○ Density
		  ○ Sinking and floating
		  ○ Relative density
		  ○ Archimedes' principle - Water displacement: volume and mass
		An additional (or alternative) final cycle could also be:
		  ○ Archimedes' principle - Buoyant force

B	Current number of lab users	Around 200
C	Average time of use (per experiment/session)	One session can need more than one connection. The Go-Lab scenario will determine duration of a connection. We estimate that it will be around 3 minutes and depends on the pedagogical scenario.

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.3.2
18	Subject Domain	**Forces and motion** Pressure Weight **Solids, liquids and gases** Density Properties of materials

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Tools for science Laboratory measuring instruments, including sensors and meters **History of Science and Technology** Science: historical and contemporary examples
19	Grade Level	• Primary Education (10-12 years old) • Lower Secondary Education (12-15 years old)
20	Educational Objectives	See Section 11.3.3
21	Engaging in Scientific Reasoning	Manipulating Exploring Observing Making sense of the natural and physical world *The user can see the different behaviours of the ball filled with different liquids (different densities) in the water. After this experiment they can discuss why it happens. Finally, with the help of a teacher or a scaffold, they will connect this experience with Archimedes' Principle.*
22	Inquiry Cycle Phase	Conceptualization Hypothesis Investigation
23	Level of Difficulty	Easy
24	Level of Interaction	Low
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.3.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance	No specific scaffolds are given, but the remote lab offers different levels of analysis to a user:

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
	tools and scaffolds	In the first level a user can see the behaviour of the ball into the water using a web cam. In the second level a user can take pictures of the aquarium, and after this she/he can analyse the picture using software tools, e.g., Paint. In the third level the WebLab-Deusto offers to a user a possibility of processing the interface picture. Using this tool a user will obtain some data (volume, volume over the water….) ready to be used them to calculate the density or to conclude where is an oil, or an alcohol. The teacher will decide the scaffold that he needs to teach or to perform the experiment in the classroom. The technical data such as density of water and alcohol, volume of the balls, etc. is provided.
B	Context of use	The Archimedes' Principle is suitable for all these scenarios: school classrooms, at home, etc.
C	User manual	No
D	Description of a use case	In the classroom the teacher shows that identical balls but with different densities have different behaviour when they are in the water: sinking or floating.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://www.weblab.deusto.es/weblab
29	Technical Requirements	***Operating System*** Windows MacOS Linux iOS Android ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/widget

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s))	http://www.weblab.deusto.es/weblab/client/#page=experiment&exp.category=Aquatic%20experiments&exp.name=aquarium
B	APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? **Free at this moment** First in first served or access through booking? **First in first served (but with privileges) in WebLab-Deusto. It is also available in Graasp** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **This remote lab is not included in any repository.**
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	N/A

2	Student's Material(s)	There are no student's materials. To be designed through the Go-Lab project.
3	Lesson Plan	N/A
4	Supportive App(s)	N/A

11.3.2 Big Idea of Science

2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.

11.3.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc

Cognitive Objectives: Processes

Process	Description
To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To imitate and try	To help the learner perform certain actions by following instructions and practicing; reproduce activity from instruction or memory

11.3.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	**Basic Knowledge**	Knowledge Application	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	**Digital Literacy**	Manage and guide	Teacher as model learner

11.4 Galaxy Crash

11.4.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Galaxy Crash
2	Lab Description	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.
3	Keyword(s)	Galaxy, astronomy, stars, gravity, interactions, spiral, irregular, elliptical, velocity, distance
4	Language(s)	EN (English)
5	Lab Category	Virtual Lab
6	Contributor(s)	Name of Contributor: Chris Mihos e-mail: hos@burro.astr.cwru.edu Organization: Case Western Reserve University Name of Contributor:Greg Bothun e-mail:nuts@bigmoo.uoregon.edu Organization: University of Oregon Name of Contributor: Dave Caley Organization: University of Oregon Name of Contributor: Bob Vawter Organization: Case Western Reserve University Name of Contributor: Cameron McBride Organization: Case Western Reserve University
7	Lifecycle Dates	N/A
8	Access Rights	Free Access
9	License	N/A
10	Cost	No

General Metadata (16 Elements)		
No	**Element Name**	**Value**
11	Lab Owner(s)	Name of Contributor: Dr Fraser Lewis e-mail: fraser.lewis@southwales.ac.uk Organization: University of South Wales
12	Contact Details	Name of Contributor: Dr Fraser Lewis e-mail: fraser.lewis@southwales.ac.uk Organization: University of South Wales
13	Rights Holder(s)	Name of Contributor: Chris Mihos e-mail: hos@burro.astr.cwru.edu Organization: Case Western Reserve University
14	Status	Available
15	Version	N/A
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	• 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
B	Current number of lab users	N/A
C	Average time of use (per experiment/session)	1-2 hours

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.4.2
18	Subject Domain	**Astronomy** Elliptical galaxy Energy Formation Galactic wind Galaxies and Dwarf galaxies

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Galaxy clusters Irregular galaxy Spiral galaxy Stars Universe – generally **Energy** Kinetic energy Potential energy **Fields** Central field Gravitational field **Forces and motion** Acceleration Angular acceleration Angular velocity Centre of mass Collision Gravitational force and gravity Newton's laws Velocity
19	Grade Level	• Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old)
20	Educational Objectives	See Section 11.4.3
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting Questioning Observing Analysing Making sense of the natural and physical world *Through the use of galaxy simulation software, students can manipulate different scenarios on how galaxies form. They can change the parameters of the galaxies in the software, such as the mass, distance from each other, angle of inclination etc, and test any theories or hypotheses that they may have on how galaxies interact and evolve over time.* *By examining telescope observations of currently interacting galaxies, students will be encouraged to predict what will happen to these galaxies in the future – they can then test their predictions by running the simulation software until their*

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		simulated galaxies match the observations, and then run time forward to see what may happen to the galaxies. *By analyzing the results of the simulation software, students can estimate the likely time for galaxies of different masses, etc to interact and merge, or investigate what parameters affect whether galaxies merge or not, or how tidal tails are formed in interacting galaxies.*
22	Inquiry Cycle Phase	Orientation *Students will be encouraged to think about how galaxies form and evolve over time with such questions as: How do galaxies form? What types of galaxies are there in the Universe? How long does it take for galaxies to form? Do all galaxies merge together? What evidence is there for galaxy interactions?* Conceptualization Hypothesis *After thinking about the different types of galaxies, and how they form, students will come up with ideas on how galaxies may form, and how they can investigate this using simulations. They will be encouraged to predict how galaxies form.* Investigation Experimentation *After students have made their predictions, they will be guided through the 'Galaxy Crash' simulation software. This will give them the background knowledge which they will need for planning their experiment. After they have become familiar with the software, they will plan an experiment to investigate how galaxies form e.g., they will choose what parameters to change/keep constant in the simulations and see how this may affect their hypotheses.* Exploration *The students will observe the outputs of their simulated galaxy collisions and draw conclusions on what parameters affect a galaxy's evolution. They will also be asked to search the Faulkes Telescope data archive for evidence of galaxy interactions that have been imaged by the telescopes. They can then attempt to recreate these interactions using the simulation software, and observe how closely their simulations and observations match up.* Data Interpretation Conclusion *Students can draw conclusions based on their analysis e.g., which parameters best model the observed galaxy interaction? How long did it take for this interaction to reach the observed shape? Based on the simulation, what do they think will happen to these galaxies in the future?* *By comparing the observed galaxy images and the results of the simulations, students can investigate how the interactions may have taken place – they can look at what initial parameters the galaxies may have had, and what will happen to the 2 galaxies in the future* Discussion Communication Students can evaluate their findings by e.g., commenting on any shortcomings that the simulation software may have. They can discuss how they used the simulation software and what settings they adjusted, and compare how the simulation ran under different

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		initial parameters. Reflection By sharing their results with others in the class, students can communicate their explanations with each other, comment on any similarities/differences between their results and others in the class, and reflect on how they (individually) carried out the activity, and what they might change in future experiments which may affect their results.
23	Level of Difficulty	Medium
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher General Public Parent/Guardian
26	Teacher ICT Competence Level	See Section 11.4.4
27	Supporting Students with Disabilities	Visual impairments

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of scaffolds	No scaffold provided
B	Context of use	This lab is designed to be used in a computer lab during an approx. 1 to 2 hours lesson.
C	User manual	No
D	Description of a use case	This lab can be used to introduce the topic of simulation, and comparison with real observational data.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://burro.cwru.edu/JavaLab/GalCrashWeb
29	Technical	***Operating System***

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
	Requirements	Windows MacOS Linux Android *Additional Software:* Java - Version ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/java

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s))	http://burro.astr.cwru.edu/JavaLab
B	APIs (server)	N/A
C	Alternative clients	Galaxy Crash Simulation software: http://burro.cwru.edu/JavaLab/GalCrashWeb Data archive of Faulkes robotic telescopes: http://lcogt.net/observations/search
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free at this moment** First in first served or access through booking? **No booking needed** Do you want to grant Go-Lab the right to make these conditions of use public? The credit to this software states: All applets © 1999-2004 Chris Mihos. If desired, you may include these applets on your website via direct links, provided you also acknowledge the source via an accompanying link to the main page of the website (http://burro.astr.cwru.edu/JavaLab) Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How?

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	No

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Assignment Sheet Tutorial
2	Student's Material(s)	http://burro.cwru.edu/JavaLab/GalCrashWeb/labIntro.html
3	Lesson Plan	http://burro.cwru.edu/JavaLab/GalCrashWeb/labIntro.html
4	Supportive App(s)	N/A

11.4.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or

in the state of matter.

3. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.

11.4.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc

Cognitive Objectives: Processes

Process	Description
To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To adapt and perform creatively	To help the learner achieve high level performance and become natural, without needing to think much about it; automated, unconscious mastery of activity and related skills at strategic level

11.4.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	Integrate Technology	**Complex problem solving**	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools

	Terminology Literacy	**Knowledge Deepening**	**Knowledge Creation**
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.5 CERNland (CERN)

11.5.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	CERNland
2	Lab Description	CERNland contains games on all topics related to the CERN activity.
3	Keyword(s)	CERN, LHC, particle physics, ATLAS, detector, elementary particles, electron, photon, muon, quark, positron, proton, neutron, accelerator, energy, antimatter, powers of ten, ALICE
4	Language(s)	EN (English) FR (French) DE (German) ES (Spanish) IT (Italian) Other (Polish)
5	Lab Category	Virtual Lab
6	Contributor(s)	Name of Contributor: Antonella Del Rosso e-mail: Antonella.del.rosso@cern.ch Organization: CERN
7	Lifecycle Dates	N/A
8	Access Rights	Free access
9	License	Other: CERN Copyrights
10	Cost	No
11	Lab Owner(s)	Name of Contributor: Antonella Del Rosso e-mail: Antonella.del.rosso@cern.ch Organization: CERN
12	Contact Details	Name of Contributor: Antonella Del Rosso e-mail: Antonella.del.rosso@cern.ch Organization: CERN

General Metadata (16 Elements)		
No	**Element Name**	**Value**
13	Rights Holder(s)	Name of Contributor: Antonella Del Rosso e-mail: Antonella.del.rosso@cern.ch Organization: CERN
14	Status	Online
15	Latest Version	N/A
16	Booking Required	No

Additional General Information (3 elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	CERNland is the virtual theme park developed to bring the excitement of CERN's research to a young audience aged between 7 and 12. CERNland is designed to show children what we do at CERN and inspire them with some physics at the same time.
B	Current number of lab users	CERNland has an average number of daily visits around 270, (80% are new visitors and the rest is returning visitors)
C	Average time of use (per experiment/use)	N/A

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.5.2
18	Subject Domain	**Electricity and magnetism** Electric charge – generally Electric current Electrical quantities - generally Electromagnetism – generally Magnetic materials Magnetism – generally Voltage **Energy** Energy - using electricity Kinetic energy

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Potential energy **Fields** Central field Conservative force field Electric field Electromagnetic field Magnetic field **Forces and motion** Acceleration Circular motion Conservation of momentum Elastic collision Electric force Machines Magnetic force Velocity **Tools for science** Accelerators Fieldwork equipment **High Energy Physics** Accelerators & beams Antimatter Calorimeters Charged particle acceleration Higgs particle Invariant mass Leptons Particle beam parameters Particle detectors Particle dynamics Particle interactions with matter Physical constants QCD, jets & gluons Quarks & hadrons Weak interactions: electroweak Weak interactions: quarks & leptons
19	Grade Level	Primary Education (10 -12 years old)

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
20	Educational Objectives	See Section 11.5.3
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting Questioning Observing Analysing Making sense of the natural and physical world. *CERNland is designed to show children what we do at CERN and inspire them with some physics at the same time.* *Kids do not need any particle-physics expertise to enjoy CERNland but those who click on the information links will be better placed to answer the questions and improve their scores. As with many real theme parks there is no real age limit to enjoying CERNland: anyone can follow SuperBob round the LHC or try building atoms by collecting electrons, protons and neutrons.*
22	Inquiry Cycle Phase	Orientation Investigation
23	Level of Difficulty	Easy
24	Level of Interaction	High
25	Intended End User Role	Learner General Public
26	Teacher ICT Competence Level	See Section 11.5.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 elements)		
No	**Element Name**	**Value**
A	Use of guidance	No Scaffolds provided.

Additional Pedagogical Information (4 elements)		
No	**Element Name**	**Value**
	tools and scaffolds	
B	Context of use	School, Science Lab
C	User manual	Yes Help included in each game.
D	Description of a use case	CERNland, a virtual thematic park composed mainly of games but also videos and other multimedia material about CERN and its experiments, physics, cosmology and technology, can be used by primary school students individually or in groups during in-class and out-class activities, including visits to CERN and its associated travelling exhibitions. A typical case includes the use of CERNland following a family or school visit to CERN as described in inquiry-based learning scenarios available at the Discover the COSMOS Portal under the title "Visiting the CERN Mini Expo".

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://www.cern.ch/cernland http://www.cernland.net
29	Technical Requirements	**Operating System** Windows MacOS Linux iOS **Additional Software** Adobe Flash Player **Supported Browsers** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/x-shockwave-flash

Additional Technical Information (8 elements)		
A	Web client (link to client app(s)	N/A
B	APIs (server) APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **No booking required** Do you want to grant Go-Lab the right to make these conditions of use public? **YES** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? Discover the COSMOS portal http://portal.discoverthecosmos.eu
F	Additional software/hardware needed?	Yes Flash Player
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	No

Additional Resources and Apps

No	Element Name	Value
31	Type of Student's Materials	-

No	Element Name	Value
32	Student's Material(s)	They are all integrated in the lab.
33	Lesson Plan	CERNland is included as a follow-up activity in structured inquiry-based teaching scenarios supporting parents and primary school teachers to organize better their visits with their young pupils to CERN permanent and travelling exhibitions. These scenarios are available at the Open Science Resources (OSR) Portal as well as the Discover the COSMOS Portal and have been used extensively by parents and teachers in the framework of the CERN mini-expo tours in Greece and Spain over the last two years.
34	Supportive App(s)	-

11.5.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.
5. All matter and radiation exhibit both wave and particle properties.

11.5.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To apply	To help the learner apply information to reach an answer

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To imitate and try	To help the learner perform certain actions by following instructions and practicing; reproduce activity from instruction or memory

11.5.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	**Basic knowledge**	Knowledge Application	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex tools	Pervasive tools
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	**Digital literacy**	Manage and guide	Teacher as model learner

11.6 LHC Game (CERN)

11.6.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	LHC Game
2	Lab Description	A computer interactive developed for the Microcosm exhibition at CERN introducing the workings of a particle accelerator like the Large Hadron Collider. Users of the interactive discover how, for example, protons are accelerated using electromagnetic fields. They then put their knowledge to the test as they are asked to regulate the accelerating field to accelerate a proton before passing to the next stage. On successful completion of the 3 steps (acceleration, bending and focusing) collisions occur and data taking can commence.
3	Keyword(s)	CERN, LHC, particle physics, detectors, elementary particles, charged particles, electron, photon, quark, positron, proton, neutron, accelerator, energy, quadrupole magnets
4	Language(s)	EN (English) FR (French) DE (German) IT (Italian)
5	Lab Category	Virtual Lab
6	Contributor(s)	Name of Contributor: Emma Sanders e-mail: emma.sanders@cern.ch Organization: CERN
7	Lifecycle Dates	N/A
8	Access Rights	Free access
9	License	Other: CERN Copyrights
10	Cost	No
11	Lab Owner(s)	Name of Contributor: Emma Sanders e-mail: emma.sanders@cern.ch Organization: CERN
12	Contact Details	Name of Contributor: Emma Sanders e-mail: emma.sanders@cern.ch Organization: CERN
13	Rights Holder(s)	Name of Contributor: Emma Sanders e-mail: emma.sanders@cern.ch

General Metadata (16 Elements)		
No	**Element Name**	**Value**
		Organization: CERN
14	Status	Online
15	Latest Version	v1.0
16	Booking Required	No

Additional General Information (3 elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	Introduce the principal elements of a particle accelerator such as the Large Hadron Collider at CERN.
B	Current number of lab users	N/A
C	Average time of use (per experiment/session)	N/A

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.6.2
18	Subject Domain	**Electricity and magnetism** Electric charge – generally Electric current Electrical quantities - generally Electromagnetism – generally Magnetic materials Magnetism – generally Voltage **Energy** Energy - using electricity Kinetic energy Potential energy **Fields**

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Central field Conservative force field Electric field Electromagnetic field Magnetic field **Forces and motion** Acceleration Circular motion Machines Magnetic force Velocity **Tools for science** Accelerators Fieldwork equipment **High Energy Physics** Accelerators & beams Antimatter Calorimeters Charged particle acceleration Higgs particle Invariant mass Leptons Particle beam parameters Particle detectors Particle dynamics Particle interactions with matter Physical constants QCD, jets & gluons Quarks & hadrons Weak interactions: electroweak Weak interactions: quarks & leptons
19	Grade Level	Lower Secondary Education (12 -15 years old)
20	Educational Objectives	See Section 11.6.3

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting Questioning *Students learn about the experiments performed at CERN and the equipment that is used. By interacting with the lab they gain an understanding on the work of the scientists.*
22	Inquiry Cycle Phase	Orientation Investigation Experimentation Exploration
23	Level of Difficulty	Easy
24	Level of Interaction	Medium
25	Intended End User Role	Learner General Public
26	Teacher ICT Competence Level	See Section 11.6.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No Scaffolds provided.
B	Context of use	School, science lab
C	User manual	No

D	Description of a use case	Students are prepared to visit CERN or CERN mini-expo in a nearby location. The teacher, before the visit, informs and encourages the students to explore about the LHC by watching the LHC video on YouTube and also to play the LHC Game at home in combination with similar games such as the Hunt for Higgs.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://education.web.cern.ch/education/Chapter2/Teaching/games/LHCGame/
29	Technical Requirements	**Operating System** Windows MacOS Linux **Additional Software** Adobe Flash Player **Supported Browsers** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/javascript

Additional Technical Information (8 elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	N/A
B	APIs (server) APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking?

		First in first served Do you want to grant Go-Lab the right to make these conditions of use public? **YES** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **Discover the COSMOS portal** http://portal.discoverthecosmos.eu
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	No

Additional Resources and Apps

No	Element Name	Value
31	Type of Student's Materials	None
32	Student's Material(s)	None; all materials are incorporated in the lab.
33	Lesson Plan	The LHC Game has been included in various inquiry-based teaching scenarios targeting students at primary and lower secondary level who are either visiting CERN or engage in learning activities associated with understanding Big-Science infrastructures for the experimental study of particle physics.
34	Supportive App(s)	-

11.6.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.

11.6.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To understand	To help the learner organize and arrange information mentally

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.6.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in	**Policy Awareness**	Policy Understanding	Policy innovation

Education			
Curriculum and Assessment	**Basic knowledge**	Knowledge Application	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex tools	Pervasive tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	**Digital literacy**	Manage and guide	Teacher as model learner

11.7 Craters on Earth and Other Planets

11.7.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Craters on Earth and Other Planets
2	Lab Description	In this lab, pupils can simulate the impact of an object (e.g., an asteroid) on the Earth, Moon or Mars. They can vary parameters such as the diameter, density and velocity of the projectile and see the characteristics of the resulting crater. They can also analyse satellite imagery of real craters on a number of planets and moons. Various related classroom exercises are included. The lab uses satellite data from European Space Agency missions. It was developed in partnership with Faulkes Telescope.
3	Keyword(s)	ESA, Space, Satellite, Rosetta, Cassini Huygens, Faulkes, Telescope, Astronomy, Crater, Impact, Asteroid, Comet, Meteor, Meteorite, Solar System, Planets, Earth, Moon, Mars, Titan
4	Language(s)	EN (English) EL (Greek) FR (French) CS (Czech) DE (German) ES (Spanish) IT (Italia) PT (Portuguese) Other: Dutch, Norwegian, Swedish, Danish, Finnish, Polish, Romanian
5	Lab Category	Virtual Lab
6	Contributor(s)	Name of Contributor: Helen Page e-mail: helen.page@esa.int

General Metadata (16 Elements)		
No	**Element Name**	**Value**
		Name of Contributor: Paul Roche e-mail: paul.roche@faulkes-telescope.com
7	Lifecycle Dates	N/A
8	Access Rights	Free Access
9	License	CC BY-NC http://creativecommons.org/licenses/by-nc/3.0
10	Cost	No
11	Lab Owner(s)	Name: Helen Page e-mail: Helen.Page@esa.int Organization: European Space Agency (ESA) Name: Professor Paul Roche e-mail : paul.roche@faulkes-telescope.com Organization: University of South Wales
12	Contact Details	Name of Contributor: Dr Fraser Lewis e-mail: fraser.lewis@southwales.ac.uk Organization: University of South Wales
13	Rights Holder(s)	Name: Helen Page e-mail: Helen.Page@esa.int Organization: European Space Agency (ESA) Name: Professor Paul Roche e-mail: paul.roche@faulkes-telescope.com Organization: University of South Wales
14	Status	Online
15	Version	v1.0
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	• Demonstrate one of the uses of satellite data. • Demonstrate, with the impact calculator and relevant satellite imagery, how observations of craters caused by comets and asteroids can give insight to the characteristics of the projectile and the impact conditions. • Explain the consequences of previous impacts on the Earth's formation process and the origin of life.
B	Current number of lab users	N/A

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
C	Average time of use (per experiment/session)	1hour

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.7.2
18	Subject Domain	**Astronomy** Asteroids Astrometry Atmospheres Comets and meteors Crater Earth Formation Kuiper belt objects Meteor Meteorite Moon Near-earth objects Origin and evolution of the universe Planets Satellites: natural satellites Satellites: artificial satellites Solar system **Environment** Geophysical environment **Geography** Physical processes Satellite images Surface **Earth science** Catastrophe Natural phenomenon **Energy** Conservation and dissipation

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Forces and motion Acceleration Collision Gravitational force and gravity Inelastic collision Velocity **Tools for science** Analysis Tools Detectors Observatories
19	Grade Level	• Primary Education (10 – 12 years old) • Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old)
20	Educational Objectives	See Section 11.7.3
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting Questioning Observing Analysing
22	Inquiry Cycle Phase	Orientation Conceptualization Investigation Conclusion Discussion
23	Level of Difficulty	Easy/ Medium
24	Level of Interaction	Medium/ High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.7.4
27	Supporting	No specific provisions

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
	Students with Disabilities	

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No scaffold provided
B	Context of use	This lab is designed to be used in a computer lab during an approx. 1 hour lesson. However, many activities can take much more than this if required.
C	User manual	No
D	Description of a use case	There are numerous showcases available on the web site of Down to Earth: http://education.down2earth.eu/activities/en And ESA imagery at: http://spaceinimages.esa.int/Directorates/Space_Science/(class)/image

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	Lab still under development. A prior version of the Impact Calculator is available at: http://education.down2earth.eu Craters imagery (365 items): http://spaceinimages.esa.int/content/search?SearchText=crater&img=1&SearchButton=Go
29	Technical Requirements	***Operating System*** Windows MacOS Linux Android ***Additional Software:*** Java Adobe Flash Player

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
		Supported Browsers Mozilla Firefox Internet Explorer Google Chrome Safari
30	Technical Format	application/x-shockwave-flash application/javascript application/widget

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	N/A
B	APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free**
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Assignment Sheet
2	Student's Material(s)	Not yet available
3	Lesson Plan	Not yet available online but available offline - to be updated in the future.
4	Supportive App(s)	**Multimedia Resources** **Imagery of Craters** ESA website Down to Earth website: http://education.down2earth.eu/impact_calculator **Interactive Animations** Some available at ESA (http://spaceinimages.esa.int) , some at FT: http://www.faulkes-telescope.com/multimedia **Videos** ESA video library. Includes videos and vodcasts are produced by ESA

11.7.2 Big Idea of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
3. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.
7. Organisms are organized on a cellular basis and require a supply of energy and materials. All life forms on our planet are based on a common key component.
8. Earth is a system of systems which influences and is influenced by life on the planet. The processes occurring within this system shapes the climate and the surface of the planet.

11.7.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To apply	To help the learner apply information to reach an answer

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.7.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	**Basic Knowledge**	Knowledge Application	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	**Digital Literacy**	Manage and guide	Teacher as model learner

11.8 Black-body Radiation (CUAS)

11.8.1 Lab Profile

Lab Owner Metadata		
General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Black-body Radiation
2	Lab Description	From the theory is known that the energy which is radiated outward radically in three-dimensional space from a source is inversely proportional with the square of the distance from the source. This process is known as the Inverse square law. In this lab the student can measure the power from the light sources with a given distance and a fix step size.
3	Keyword(s)	Black body, wavelength, radiation, light source, spectrum.
4	Language(s)	EN (English)
5	Lab Type	Remote Lab
6	Contributor(s)	Name of Contributor: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences Name of Contributor: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of Contributor: Ramona Oros e-mail: oros@fh-kaernten.at Organization: Carinthia University of Applied Sciences
7	Lifecycle Dates	N/A
8	Access Rights	Free access
9	License	GNU General Public License http://www.gnu.org/licenses/gpl.html
10	Cost	No
11	Lab Owner(s)	Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences
12	Contact Details	Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences

General Metadata (16 Elements)		
No	**Element Name**	**Value**
		Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences
13	Rights Holder(s)	Organization: Carinthia University of Applied Sciences
14	Status	Online
15	Version	Version 1
16	Booking Required	Yes

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	• Understand basic about light sources • Understand the behavior the radiation power of a light bulb • Understanding how the emitted power evolves over distance
B	Current number of lab users	20
C	Average time of use (per experiment/session)	20 minutes

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.8.2
18	Subject Domain	**Astronomy** Black holes Light curve Stars Sun **Energy** Radiation Radiation transfer Temperature and heat Work and power

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Electricity and magnetism Electromagnetism – generally **Light** Colour Light sources Properties of light – generally Reflection Refraction **Tools for science** Laboratory equipment – generally Laboratory measuring instruments, including sensors and meters Online Laboratories Remote Laboratories Sensors Thermometers **Waves** Doppler effect Electromagnetic spectrum Information transmission, analogue and digital signals Infrared Microwaves Ultraviolet Visible light Wave characteristics – generally Wavelength
19	Grade Level	• Lower Secondary Education(12-15 years old) • Upper Secondary Education (15-18 years old)
20	Educational Objectives	See Section 11.8.3
21	Engaging in Scientific Reasoning	Manipulating Observing Analysing
22	Inquiry Cycle Phase	Orientation Conceptualization Investigation Experimentation Exploration Conclusion

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
23	Level of Difficulty	Medium
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.8.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No scaffolds are provided.
B	Context of use	These remote labs can be accessed in the lab under teacher supervision or from home, typical following a specific lab assignment. No special guidance is mandatory during working with Blackbody Radiation.
C	User manual	No
D	Description of a use case	During a lecture teacher explains the difference between different light sources regarding their radiation and how is time dependent. After the theoretical part a lab assignment is given where students have to test different light sources and compare the way the radiation power behaves over time in case of certainness sources.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://ilabs.cti.ac.at/iLabServiceBroker306
29	Technical Requirements	***Operating System*** Window MacOS Android

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
		Additional Software LabView Runtime Engine ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome
30	Technical Format	application/LV Remote Panel

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	http://ilabs.cti.ac.at/iLabServiceBroker
B	APIs (server)	http://ilabs.cti.ac.at/iLabServiceBroker
C	Alternative clients	No simulation available
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **Booking** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **Yes, OLAREX project, Lab2go**
F	Additional software/hardware needed?	Yes
G	Does the lab stores experimental data (measurements performed by users, images collected,	Yes

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
	etc.)?	
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Tutorial
2	Student's Material(s)	Not available
3	Lesson Plan	Not available
4	Supportive App(s)	Not available

11.8.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
3. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe.
4. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.
5. All matter and radiation exhibit both wave and particle properties.

11.8.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of	Description

knowledge	
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc

Cognitive Objectives: Processes

Process	Description
To understand	To help the learner organize and arrange information mentally

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.8.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	**Digital Literacy**	Manage and guide	Teacher as model learner

11.9 Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS (DEUSTO)

11.9.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value Space**
1	Lab Title	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS
2	Lab Description	Digital systems are everywhere. For instance, a computer is a digital system. This experiment shows the principles of digital systems and devices. This remote lab is not about science, it is about engineering (and technology): design, implementation and analysis of digital systems. The Boole-WebLab experiment has two steps: design (Boole-Deusto) and implementation (WebLab-Deusto). In this case a user uses a combination of a designing tool (Boole-Deusto) and a remote lab (WebLab-Deusto). A student designs the behaviour of a digital system using a truth table in Boole-Deusto designing tool. After design stage student can check the evolution of his design on an electronic board. The tool configures the electronic board automatically. When the reconfiguration is completed, the student can test the design – digital circuits – using switches, buttons and leds. For example, if the student has implemented a calculator, he will introduce two binary numbers with the switches and he will see the result in the leds. The system provides a rapid prototype environment for digital systems. From a didactical point of view, the Boole-WebLab-Deusto forces the student to design cycle: design – implement – analysis – design…
3	Keyword(s)	digital electronics, design cycle
4	Language(s)	EN (English) ES (Spanish)
5	Lab Category	Remote Lab
6	Contributor(s)	Name of Contributor: e-mail: zubia@deusto.es luis.rodriguez@deusto.es Organization: University of Deusto
7	Lifecycle Dates	Date:July 2013 Action Taken: v1.0 The new version establishes the connection between Boole and WebLab-Deusto
8	Access Rights	Restricted Access
9	License	GNU General Public License http://www.gnu.org/licenses/gpl.html
10	Cost	No
11	Lab Owner(s)	Name of provider: Javier Garcia-Zubia, Olga Dziabenko e-mail: olga.dziabenko@deusto.es Organization: WebLab-Deusto, University of Deusto
12	Contact Details	Name of provider: Javier Garcia-Zubia, Olga Dziabenko e-mail: olga.dziabenko@deusto.es

General Metadata (16 Elements)		
No	**Element Name**	**Value Space**
		Organization: WebLab-Deusto, University of Deusto
13	Rights Holder(s)	Organization: University of Deusto
14	Status	Online (Available)
15	Version	V 1.0
16	Booking Required	Yes The WebLab-Deusto uses a queue for the schedule. The maximum time is 200 seconds per connection; no restriction for quantity of the connection exists.

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	Design basic digital systems.
B	Current number of lab users	Around 100
C	Average time of use (per experiment/session)	The user has 200 seconds in each connection. Depends on the pedagogical scenario one lesson/session can need more than one connection.

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.9.2
18	Subject Domain	**Tools for science** Laboratory measuring instruments, including sensors and meters Analysis Tools Remote laboratories
19	Grade Level	• Upper Secondary Education (15-18 years old) • Higher Education Bachelor
20	Educational Objectives	See Section 11.9.3
21	Engaging in Scientific Reasoning	Testing Observing Analysing

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		The teacher can use the laboratory in the classroom to show students different examples of digital systems/circuits from basic to complex. *The Boole-Deusto helps a user to describe a digital system, and to follow the design process using Truth-Table, K-Map, minimization, Boolean expression and digital circuit. The implemented design shows how digital system runs in reality.*
22	Inquiry Cycle Phase	Orientation Investigation Conclusion
23	Level of Difficulty	Medium
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.9.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No scaffolds are provided.
B	Context of use	The system Boole-Deusto + WebLab-Deusto can be used by the teacher in many different scenarios that depend on educational objectives of the teacher. For example, (1) the teacher can teach the students what is a binary code, and after his explanation the students can design their own binary codes. (2) the teacher can explain the students the binary system and after this he (and the students) can implement an adder, calculator (3) the teacher can explain the students how to control a motor using a digital system. Based on this knowledge the students can design their own systems. Boole-Deusto is used (2001) more than 10 years (especially in Spain and Latin America). The connection with WebLab-Deusto has started this year.
C	User manual	Yes

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
		Manual Title: Boole-Deusto *Access URL:* http://paginaspersonales.deusto.es/zubia
D	Description of a use case	The teacher shows to the students how to design a digital circuit using the tool. After this, each student will design his own new circuit. This design will not be only in the computer, but also in an electronic board in the remote lab. So, the student can invent and explore the problem (digital or logical), design it, implement it and analyse it (in the remote lab). As a conclusion, he/she will decide if the design runs properly or if it needs to be refined.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	The remote lab is accessed directly from the Boole-Deusto software. http://boole-deusto.sourceforge.net/ E-mail to zubia@deusto.es to obtain the last version of Boole-Deusto
29	Technical Requirements	***Operating System*** Windows ***Supported Browsers*** Mozilla Firefox Internet Explorer (IE6<) Google Chrome Safari Opera
30	Technical Format	application/javascript application/zip application/exe

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s))	http://www.weblab.deusto.es/weblab/client/?locale=es#page=experiment&exp.category=FPGA%20experiments&exp.name=ud-fpga
B	APIs (server)	https://weblabdeusto.readthedocs.org/en/latest/remote_lab_development.html#client-side
C	Alternative clients	No simulation available

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **First in first served (but with privileges)** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **This remote lab is available on the OLAREX web page (www.olarex.eu). OLAREX is a KA3 European project.**
F	Additional software/hardware needed?	No The system can be extended by including new hardware, e.g., system with motors.
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	Yes The laboratory tracks login information (who, when, how much time, etc), input commands and their responses, and files sent by the user.

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Assignment Sheet
2	Student's Material(s)	http://www.olarex.eu/web/index.php/en/products
3	Lesson Plan	http://www.olarex.eu/web/index.php/en/products
4	Supportive App(s)	N/A

11.9.2 Big Ideas of Science

B. The Universe and the world around us, is not only composed of what we see around us. There are entities and phenomena that humans cannot grasp directly with their senses and yet they can be investigated and described using models and proper equipment.

11.9.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To apply	To help the learner apply information to reach an answer

Affective Objectives

Process	Description
To recognize values	To help the learner attach values to stimuli

Psychomotor Objectives

Process	Description
To perform independently, skillfully, and precisely	To help the learner coordinate a series of actions, achieving harmony and internal consistency; adapt and integrate expertise to satisfy a non-standard objective

11.9.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management
ICT	Basic Tools	**Complex Tools**	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations

Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.10 Electricity Lab (University of Twente)

11.10.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Electricity lab
2	Lab Description	Create electrical circuits and measure voltages and currents. The circuits are limited to static situations.
3	Keyword(s)	Electricity, circuit, voltage, current, resistor, light bulb, switch, capacitor
4	Language(s)	EN (English)
5	Lab Category	Virtual Lab
6	Contributor(s)	Name of Contributor: Jakob Sikken e-mail: j.sikken@utwente.nl Organization: University of Twente
7	Lifecycle Dates	N/A
8	Access Rights	Free Access
9	License	Other
10	Cost	No
11	Lab Owner(s)	Name of provider: Jakob Sikken e-mail: j.sikken@utwente.nl Organization: University of Twente
12	Contact Details	Name: Jakob Sikken e-mail: j.sikken@utwente.nl Organization: University of Twente
13	Rights Holder(s)	Name: Jakob Sikken e-mail: j.sikken@utwente.nl Organization: University of Twente
14	Status	Online (Available)
15	Version	V 0.9
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	The lab allows students to create and investigate static electrical circuits.
B	Current number of lab users	N/A
C	Average time of use (per experiment/session)	N/A

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.10.2
18	Subject Domain	**Electricity and magnetism** AC/DC Ampere's law Charge Circuits – generally Components in circuits: batteries, etc Coulomb law Electric charge - generally Electric current Electrical quantities - generally Electrical resistance/conductivity, Parallel circuits Series circuits Voltage **Energy** Energy - using electricity Energy resources **Forces and motion** Electric force **Tools for science** Laboratory measuring instruments, including sensors and meters
19	Grade Level	• Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old)
20	Educational	See Section 11.10.3

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
	Objectives	
21	Engaging in Scientific Reasoning	Manipulating Exploring Observing Analysis Making sense of the natural and physical world
22	Inquiry Cycle Phase	Investigation Experimentation Exploration
23	Level of Difficulty	Medium
24	Level of Interaction	High
25	Intended End User Role	Learner
26	Teacher ICT Competence Level	See Section 11.10.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	Not yet available
B	Context of use	School classroom
C	User manual	No
D	Description of a use case	Students learn the theory about building circuits and then they have hands-on activity where they practice on building their own circuits.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://go-lab.gw.utwente.nl/sources/ labs/ngElectricity/src/main/webapp/circuitSimulator.html
29	Technical Requirements	***Operating System*** Windows MacOS Linux iOS Android ***Supported Browsers*** Mozilla Firefox Internet Explorer (IE6<) Google Chrome Safari
30	Technical Format	application/javascript application/zip application/exe

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	http://go-lab.gw.utwente.nl/sources/labs/ngElectricity/src/main/webapp/circuitSimulator.html
B	APIs (server)	Not yet available
C	Alternative clients	Not applicable
D	Registration needed	No
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **Not applicable, unlimited concurrent access** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **No**
F	Additional software/har	No

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
	dware needed?	
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	Yes
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	-
2	Student's Material(s)	-
3	Lesson Plan	-
4	Supportive App(s)	-

11.10.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.

2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.

3. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.

11.10.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To apply	To help the learner apply information to reach an answer

Affective Objectives

Process	Description
To recognize values	To help the learner attach values to stimuli

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.10.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	**Basic Knowledge**	Knowledge Application	Knowledge society skills
Pedagogy	Integrate Technology	**Complex problem solving**	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.11 ELVIS/OP – AMP Labs (CUAS)

11.11.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	ELVIS / OP – AMP Labs
2	Lab Description	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 multi-meter)
3	Keyword(s)	Operational amplifier, oscilloscope, function generator, variable power supply, digital multi-meter
4	Language(s)	EN (English)
5	Lab Category	Remote Lab
6	Contributor(s)	Name of Contributor: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of Contributor: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences
7	Lifecycle Dates	-
8	Access Rights	Restricted Access
9	License	GNU General Public License http://www.gnu.org/licenses/gpl.html
10	Cost	No
11	Lab Owner(s)	Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences
12	Contact Details	Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at

General Metadata (16 Elements)		
No	**Element Name**	**Value**
		Organization: Carinthia University of Applied Sciences
13	Rights Holder(s)	Organization: Carinthia University of Applied Sciences
14	Status	Online (Available)
15	Version	v2
16	Booking Required	No

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	Demonstrate how operational amplifiers work, measure Op-Amp gain and compare with calculated values
B	Current number of lab users	20
C	Average time of use (per experiment/session)	20-30 minutes

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.11.2
18	Subject Domain	**Electricity and magnetism** AC/DC Ampere's law Charge Circuits – generally Components in circuits: batteries, etc Coulomb law Electric charge - generally Electric current Electrical quantities - generally Electrical resistance/conductivity, Parallel circuits Series circuits Voltage

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Energy Energy - using electricity Energy resources **Forces and motion** Electric force **Tools for science** Analysis Tools Laboratory equipment – generally Laboratory measuring instruments, including sensors and meters Lifecycle of products Telecommunications
19	Grade Level	• Upper Secondary Education (15-18 years old) • Higher Education Bachelor
20	Educational Objectives	See Section 11.11.3
21	Engaging in Scientific Reasoning	Manipulating Testing Analysis
22	Inquiry Cycle Phase	Orientation Investigation Conclusion
23	Level of Difficulty	Easy
24	Level of Interaction	Low
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.11.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No Scaffold provided
B	Context of use	These remote labs can be accessed in the lab under teacher supervision or from home. This depends on the way that the teacher wants to organize the course. No special guidance is mandatory during working with the system.
C	User manual	No
D	Description of a use case	During a lecture a teacher explains the relationship between the resistors in a non-inverting amplifier circuit and its gain. After the theoretical part a lab assignment is given where students have to test different combinations of resistors, measure the gain of the amplifier and finally compare with the calculated results.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://ilabs.cti.ac.at/iLabServiceBroker
29	Technical Requirements	***Operating System*** Windows MacOS Linux *Additional Software* Java ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/java

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client	http://ilabs.cti.ac.at/ilabServiceBroker

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
	app(s)	
B	APIs (server)	http://ilabs.cti.ac.at/ilabServiceBroker
C	Alternative clients	N/A
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **First in first served** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **Yes**
F	Additional software/hardware needed?	No
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	Yes
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Not available
2	Student's Material(s)	No other material connected. Teachers should prepare assignment sheet or any other material.
3	Lesson Plan	No lesson plan active

4	Supportive App(s)	Not available

11.11.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
5. All matter and radiation exhibit both wave and particle properties.

11.11.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc

Cognitive Objectives: Processes

Process	Description
To understand	To help the learner organize and arrange information mentally

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform independently, skillfully, and precisely	To help the learner coordinate a series of actions, achieving harmony and internal consistency; adapt and integrate expertise to satisfy a non-standard objective

11.11.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	**Integrate Technology**	Complex problem solving	Self-management

ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	**Digital Literacy**	Manage and guide	Teacher as model learner

11.12 VISIR (CUAS)

11.12.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	VISIR
2	Lab Description	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.
3	Keyword(s)	Electronic circuit, remote control, function generator, oscilloscope, flexibility
4	Language(s)	EN (English)
5	Lab Category	Remote Lab
6	Contributor(s)	Name of Contributor: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of Contributor: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences

General Metadata (16 Elements)		
No	**Element Name**	**Value**
		Name of Contributor: Ingvar Gustavsson e-mail: ingvar.gustavsson@bth.se Organization: BlekingeTekniskaHögskola Name of Contributor: Ramona Oros e-mail: oros@fh-kaernten.at Organization:Carinthia University of Applied Sciences
7	Lifecycle Dates	N/A
8	Access Rights	Restricted Access
9	License	GNU General Public License http://www.gnu.org/licenses/gpl.html
10	Cost	No
11	Lab Owner(s)	Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences
12	Contact Details	Name of provider: Christian Kreiter e-mail: Christian.Kreiter@edu.fh-kaernten.ac.at Organization: Carinthia University of Applied Sciences Name of provider: Danilo Garbi Zutin e-mail: d.garbizutin@fh-kaernten.at Organization: Carinthia University of Applied Sciences
13	Rights Holder(s)	Organization: Carinthia University of Applied Sciences
14	Status	Online
15	Version	v4.1
16	Booking Required	Yes

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
A	Primary aims of the lab	• Understand basic laws (ohm's and Kirchhoff's law) • Create simple electric circuits • Understand the behaviour of electronic components
B	Current number of lab	20

Additional General Information (3 Elements)		
No	**Element Name**	**Value**
	users	
C	Average time of use (per experiment/session)	No more than 20 minutes for a session

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.12.2
18	Subject Domain	**Electricity and magnetism** AC/DC Ampere's law Charge Circuits – generally Components in circuits: batteries, etc Coulomb law Electric charge - generally Electric current Electrical quantities - generally Electrical resistance/conductivity, Parallel circuits Series circuits Voltage **Energy** Energy - using electricity Energy resources **Forces and motion** Electric force **Tools for science** Laboratory measuring instruments, including sensors and meters Laboratory equipment – generally Industrial devices Lifecycle of products Telecommunications
19	Grade Level	• Lower Secondary Education (12-15 years old) • Upper Secondary Education (15-18 years old) • Higher Education Bachelor • Higher Education Master

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
20	Educational Objectives	See Section 11.12.3
21	Engaging in Scientific Reasoning	Manipulating Testing Predicting Observing Analysing Making sense of the natural and physical world *Using VISIR students can improve their knowledge in basic laws of electric circuits. They can study and analyze how electrical components are working and how they can create a circuit.* *Students can work on predefine circuits or design their own ones. For this they can use real laboratory equipment such as multimeter, direct current (DC) Power, Oscilloscope, and Function Generator into remote world.*
22	Inquiry Cycle Phase	Orientation Conceptualization Investigation Conclusion Discussion Reflection
23	Level of Difficulty	Advanced
24	Level of Interaction	High
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.12.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
A	Use of guidance tools and scaffolds	No Scaffold provided
B	Context of use	These remote labs can be accessed in the lab under teacher supervision or

Additional Pedagogical Information (4 Elements)		
No	**Element Name**	**Value**
		from home, typical following a specific lab assignment. Use of the remote lab is not mandatory, but optional for students to acquire understanding of the concepts presented during the theoretical lecture. No special guidance is mandatory during working with VISIR.
C	User manual	No
D	Description of a use case	During a lecture a teaches explains how resistor's combination in series and parallel works. After the theoretical part a lab assignment is given where students have to test different combinations of resistors, measure the equivalent resistance and compare with the calculated results.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://ilabs.cti.ac.at/iLabServiceBroker
29	Technical Requirements	***Operating System*** Windows MacOS Linux *Additional Software* Java ***Supported Browsers*** Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	application/x-shockwave-flash

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
A	Web client (link to client app(s)	http://ilabs.cti.ac.at/iLabServiceBroker
B	APIs (server)	http://ilabs.cti.ac.at/iLabServiceBroker
C	Alternative clients	N/A

Additional Technical Information (8 Elements)		
No	**Element Name**	**Value**
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? **Free** First in first served or access through booking? **Booking necessary** Do you want to grant Go-Lab the right to make these conditions of use public? **Yes** Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? **Yes, it is referenced in Lab2go (www.lab2go.net). This implies in no additional usage restrictions**
F	Additional software/hardware needed?	Yes
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	No
H	Does the lab tracks user interactions?	Yes

Additional Resources and Apps

No	**Element Name**	**Value**
1	Type of Student's Materials	Not available
2	Student's Material(s)	No other material connected. Teachers should prepare assignment sheet or any other material.
3	Lesson Plan	Not available

4	Supportive App(s)	Not available

11.12.2 Big Idea of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.
2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.
3. All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them.

11.12.3 Educational Objectives

Cognitive Objectives: Type of Knowledge

Type of knowledge	Description
Factual	Knowledge of basic elements, e.g., terminology, symbols, specific details, etc
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc

Cognitive Objectives: Processes

Process	Description
To understand	To help the learner organize and arrange information mentally

Affective Objectives

Process	Description
To respond and participate	To help the learner react to stimuli and actively participate in the learning process

Psychomotor Objectives

Process	Description
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.12.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and Assessment	Basic Knowledge	**Knowledge Application**	Knowledge society skills
Pedagogy	Integrate Technology	Complex problem solving	Self-management
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	**Standard Classroom**	Collaborative groups	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

11.13 Methyl Orange

11.13.1 Lab Profile

Lab Owner Metadata

General Metadata (16 Elements)		
No	**Element Name**	**Value**
1	Lab Title	Methyl Orange
2	Lab Description	Methyl orange is an orange, azoic dye and is used as pH-indicator, with a transition range from 3.1 to 4.4, as well as for dyeing and printing textiles. In this remote lab students can examine the synthesis of methyl orange.
3	Keyword(s)	Organic Chemistry, Amines/Ammonium UV-Vis Spectroscopy, ph indicator
4	Language(s)	EN (English)
5	Lab Category	Remote Lab
6	Contributor(s)	Name of Contributor: Hans van Dijk e-mail: a.j.van.dijk@vu.nl Organization: Free University Amsterdam
7	Lifecycle Dates	N/A
8	Access Rights	Restricted Access
9	License	N/A
10	Cost	No
11	Lab Owner(s)	Name of Contributor: Hans van Dijk e-mail: a.j.van.dijk@vu.nl Organization: Free University Amsterdam
12	Contact Details	Name of Contributor: Hans van Dijk e-mail: a.j.van.dijk@vu.nl Organization: Free University Amsterdam
13	Rights	N/A

General Metadata (16 Elements)		
No	**Element Name**	**Value**
	Holder(s)	
14	Status	Available
15	Version	N/A
16	Booking Required	Yes

Additional General Information (3 Elements)		
No	**Element Name**	**Value Space**
A	Primary aims of the lab	One of the aims of the project is to understand how to make fair' and accurate measurements. In this lab experiment students have to find out how 'fair' and accurate their inquiry was? Do students think their inquiry results are trustworthy? Are their conclusions valid? These are questions that students will answer by critically analysing the article written by the three student researchers. Following this student are expected– in a team of two – to perform a better inquiry.
B	Current number of lab users	N/A
C	Average time of use (per experiment/session)	N/A

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
17	Big Ideas	See Section 11.13.2
18	Subject Domain	**Analytical Chemistry** Bonding – generally Chromatography Ionic bonds Molecules – generally Other types of bonding **Chemical Reactions** Ph indicator Chemical changes Acids, alkalis and bases **Inorganic chemistry** Catalysts Compounds – generally **Tools for science** Laboratory equipment – generally Laboratory measuring instruments, including sensors and meters
19	Grade Level	Upper Secondary Education (15-18 years old)
20	Educational Objectives	See Section 11.13.3
21	Engaging in Scientific Reasoning	Manipulating Testing Exploring Predicting

Pedagogical Metadata (11 Elements)		
No	**Element Name**	**Value**
		Questioning Observing Analysing Making sense of the natural and physical world
22	Inquiry Cycle Phase	Orientation Conceptualization Hypothesis Investigation Experimentation Data Interpretation Conclusion Discussion
23	Level of Difficulty	Advanced
24	Level of Interaction	Medium
25	Intended End User Role	Learner Teacher
26	Teacher ICT Competence Level	See Section 11.13.4
27	Supporting Students with Disabilities	No specific provisions

Additional Pedagogical Information (4 elements)		
A	Use of guidance tools and scaffolds	Not available
B	Context of use	In the classroom, in the science lab
C	User manual	Yes http://www.chem.vu.nl/en/voor-het-vwo/online-scheikunde-experiment/index.asp
D	Description of a use case	In order to become familiar with the inquiry the teacher conducts a demonstration in class. Then the students do a guide experiment and analyze an inquiry done by Haenen, Van Harmelen & Oortwijn (2012). These three student researchers investigated optimal flow rates to produce methyl orange in a micro reactor. The students can improve this inquiry: student workbook and teacher's guide.

Technical Metadata (3 Elements)		
No	**Element Name**	**Value**
28	Lab URL	http://www.chem.vu.nl/en/voor-het-vwo/online-scheikunde-experiment/index.asp

29	Technical Requirements	***Operating System*** Windows MacOS Linux ***Additional Software*** None ***Supported Browsers*** *(please select all that apply)*Mozilla Firefox Internet Explorer Google Chrome Safari Opera
30	Technical Format	N/A

Additional Technical Information (8 elements)		
A	Web client (link to client app(s)	N/A
B	APIs (server) APIs (server)	N/A
C	Alternative clients	N/A
D	Registration needed	Yes
E	Conditions of use	Free, bartering paying? Free First in first served or access through booking? Booking Do you want to grant Go-Lab the right to make these conditions of use public? No Is the lab already referenced in an educational repository? (If yes, which?) Are there usage restrictions because of this? Can this repository be harvested? How? N/A

F	Additional software/hardware needed?	N/A
G	Does the lab stores experimental data (measurements performed by users, images collected, etc.)?	N/A
H	Does the lab tracks user interactions?	N/A

Additional Resources and Apps

No	Element Name	Value
1	Type of Student's Materials	Student's guide Assignment Sheet
2	Student's Material(s)	http://www.chem.vu.nl/en/Images/ Class%20activity_student%20workbook_tcm66-278726.pdf
3	Lesson Plan	http://www.chem.vu.nl/en/Images/ Methyl%20Orange_teacher%20guide_tcm66-278725.pdf
4	Supportive App(s)	Not available

11.13.2 Big Ideas of Science

1. Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion.

2. There are four fundamental interactions/forces in nature; gravitation, electromagnetism, strong-nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter.

3. All matter in the Universe is made of very small particles. They are in constant motion and

the bonds between them are formed by interactions between them.
4. All matter and radiation exhibit both wave and particle properties.
5. Organisms are organized on a cellular basis and require a supply of energy and materials. All life forms on our planet are based on a common key component.

11.13.3 Educational Objectives

Cognitive Objectives: Types of Knowledge

Type of knowledge	Description
Conceptual	Knowledge of interrelationships among the basic elements within a larger structure, e.g., classifications, principles, theories, etc
Procedural	Knowledge on how-to-do, methods, techniques, subject-specific skills and algorithms, etc
Meta-cognitive	Knowledge and awareness of cognition, e.g., of learning strategies, cognitive tasks, one's own strengths, weaknesses and knowledge level, etc

Cognitive Objectives: Processes

Process	Description
To think critically and creatively	To help the learner think on causes, predict, make judgments, create new ideas

Affective Objectives

Process	Description
To form and follow a system of values	To help the learner build a consistent system of values and behave accordingly

Psychomotor Objectives

Go-Lab Taxonomy	
Process	**Description**
To perform confidently following instructions	To help the learner refine performance and become more exact, with few errors; execute skill reliably, independent of help

11.13.4 Teachers' ICT Competences

	Terminology Literacy	Knowledge Deepening	Knowledge Creation
Understanding in Education	**Policy Awareness**	Policy Understanding	Policy innovation
Curriculum and	Basic Knowledge	**Knowledge Application**	Knowledge society skills

	Terminology Literacy	**Knowledge Deepening**	**Knowledge Creation**
Assessment			
Pedagogy	Integrate Technology	Complex problem solving	**Self-management**
ICT	**Basic Tools**	Complex Tools	Pervasive Tools
Organization and Administration	Standard Classroom	**Collaborative groups**	Learning Organizations
Teacher Professional Learning	Digital Literacy	**Manage and guide**	Teacher as model learner

12 Conclusions and Next Steps

This document presented the initial version of the Go-Lab Inventory, which includes thirteen (13) online labs for their further implementation and integration to the Go-Lab Portal. These labs were selected by considering aspects such as: the variety of the thematic areas covered (curriculum coverage) by each lab, the technical maturity of each lab, the number of its current users and the availability of the lab interface in different languages.

The online labs of the initial version of the Go-Lab Inventory were described by following a specific methodology for organizing online labs, namely the Go-Lab Methodology, which consists of the following dimensions: (a) lab owner metadata divided into three (3) categories (general metadata, pedagogical metadata and technical metadata) and (b) three (3) options for additional resources and apps, namely student's materials, teacher's materials and supporting apps. This approach will enable also the common and systematic description of these online labs towards their storage to the Go-Lab Repository. The proposed methodology has been created after considering different aspects. First, the metadata elements of existing repositories and federations of online labs were reviewed and appropriate metadata elements were selected. Then, a classification scheme based on big ideas of science was introduced along with aspects like the connection with inquiry cycle phases, the educational objectives addressed and the teachers' ICT competence level required for operating an online lab. Finally, the Go-Lab Methodology consists of a third dimension, namely, the social metadata, which will enable end-users of the Go-Lab Repository to organize the Go-Lab online labs based on their tags and feedback regarding the usage and the quality of these labs.

Next steps include further population of the Go-Lab Inventory with ten (10) additional labs for the 2nd Year of the project that will offered by Go-Lab partner universities. If necessary these online labs will be adapted for different age levels, so as to fit the school curriculum.

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Annex A: Science Curriculum Vocabulary

Astronomy	**Astronomy**	Asteroid belt
		Asteroids
		Astrobiology
		Astrometry
		Astronauts
		Atmospheres
		Aurora
		Big Bang
		Binary stars
		Black holes
		Brown dwarfs
		Comets and meteors
		Constellations
		Coordinates
		Cosmic background radiation
		Cosmic rays
		Cosmology
		Crater
		Dark energy
		Dark matter
		Density waves
		Dust
		Earth
		Eclipses
		Einstein ring
		Elliptical galaxy
		Escape velocity
		Extrasolar planets
		Extraterrestrial life
		Formation
		Galactic wind
		Galaxies and Dwarf galaxies
		Galaxy clusters
		Gamma ray bursts
		Gas
		Giants
		Globular clusters
		Gravitational lenses
		Halos

		Hertzsprung-Russell diagram
		HII region
		Hubble expansion
		Inflation
		Intergalactic medium
		Interstellar medium
		Irregular galaxy
		Jets
		Kuiper belt objects
		Light curve
		Lunar eclipse
		Main sequence
		Mass loss
		Meteor
		Meteorite
		Microlensing effect
		Milky Way
		Moon
		Near-earth objects
		Nebula
		Neutron stars
		Nucleosynthesis
		Open clusters
		Orbit
		Origin and evolution of the universe
		Phases
		Phases of the Moon
		Planetary nebula
		Planets
		Pulsars
		Quasars
		Redshift
		Rockets
		Rotation curve
		Satellites: natural satellites
		Satellites: artificial satellites
		Seasons
		Solar activity
		Solar eclipse
		Solar system

		Solar-terrestrial relations
		Space flight
		Space ships
		Space stations
		Spiral galaxy
		Star chart
		Stars
		Sun
		Sunspots
		Supernova
		Supernova remnants
		Theory of relativity
		Tides
		Universe – generally
		Variable stars
		Zodiac
		Zodiacal light
Biology	**Ecology**	Biomass
		Biosphere
		Carbon and nitrogen cycles
		Energy and ecosystems
		Food as fuel
		Food chains and webs
		Organic Agriculture
		Organic Biology
	Botany	Plants
		Flowering plants/parts of plants
		Flower
		Fruit
		Gardening
		Leaf
		Life cycle
		Parasite
		Photosynthesis
		Plant nutrition and growth
		Seeds
		Transport and water in plants
		Tree
	Anatomy	Brain
		Blood
		Blood vessels

		Cardiovascular
		Circulatory System
		Digestive System
		Endocrine System
		Heart
		Integumentary System
		Liver
		Muscles
		Nerve
		Nervous system
		Organs
		Pancreas
		Skeleton and muscles
		Stomach
		Reproductive system
		Teeth
		Tongue
	Humans and animals	Animal
		Amphibian
		Arachnid
		Bird
		Breeding
		Domestic animal
		Endangered species
		Fish
		Fishery
		Food chain
		Genetic engineering
		Genetics
		Genome
		Human health: smoking
		Human health: teeth
		Insulin
		Insect
		Invertebrate
		Mammal
		Menstrual cycle
		Microbiology
		Micro-organism
		Nutrition and digestion - generally
		Puberty/adolescence

		Reproduction
		Reptile
		Senses
		Stimulus and response
		Stomach acid and bile
		Transport of reactants/products
		Vertebrate
		wild animal
	Life processes	Biotechnology
		Cell processes - generally
		Cell structure
		Cell types - generally
		Cell types – other
		Chromosomes
		Epithelial
		Fertilisation
		Luminescent
		Meiosis
		Mitosis
		Ova
		Root hair
		Sperm
		Toxin
		Tissues
	Variation, inheritance and evolution	Asexual reproduction
		Classification/keys
		Cloning, selective breeding and genetic engineering
		Darwin
		Dinosaur
		DNA
		Environmental causes of variation
		Evolution - generally
		Extinction
		Fossil record
		Genetic causes of variation and mutation
		Inheritance - generally
		Inherited diseases
		Monohybrid inheritance
		Sex determination

		Taxonomy
		Variation – generally
Chemistry	**Physical chemistry**	Chemical Thermodynamics
		Chemical Kinetics
		Quantum Chemistry
		Statistical mechanics
		Electrochemistry
		Solid State Chemistry
		Material Science
		Plastics/polymers
	Analytical Chemistry	Atomic structure
		Atomic Absorption Spectroscopy
		Atoms – generally
		Bonding – generally
		Chromatography
		Covalent bonds
		Electrons – generally
		Ionic bonds
		Molecules – generally
		Nucleus: protons, neutrons
		Other types of bonding
		Role of electrons in reactions
	Chemical Reactions	Burning
		Chemical changes
		Physical changes
		Solubility
		Water cycle
		States of matter
		Acids, alkalis and bases
		Conservation of mass
		Displacement reactions
		Enzymes
		Equations and formulae
		Exo/endothermic
		Oxidation and reaction
		Patterns in reactions
		Ph indicator
		Reaction rates
		Reactions with metals
		Reactivity series
		Reversible reactions

		Thermal decomposition
	Inorganic chemistry	Alkali metals
		Catalysts
		Compounds - generally
		Distillation
		Extraction of metal from ore
		Elements
		Electrolysis
		Filtration
		Halogens
		Mixtures
		Minerals
		Metals – generally
		Metal complexes
		Useful substances from rocks & minerals
		Periodic table
		Separation - generally
		Separation - other
		Transition metals
	Organic chemistry	Aliphatic Compounds
		Aromatic Compounds
		Carbon
		Fossil resources - generally
		Fossil fuels
		Heterocyclic Compounds
		Hydrocarbons
		Organic Polymers
		Organic Reaction
Environmental Education	**Climate**	Climatic phenomenon
		Meteorology
	Energy	Electrical energy
		Electricity
		Hydroelectric power plant
		Nuclear energy
		Nuclear physics
		Nuclear power plant
		Renewable energy
		Natural resources
	Environment	Geophysical environment
		Desert
		Forest
		Forestry
		Wood
		Island

		Lake
		Meadow
		Mountain
		Ocean
		Sea
		Plain
		Sea
		Ocean
		Port
		Volcano
		Watercourse
		Port
		Water
		Ecosystem
		Biotope
		Environmental education
		Environmental protection
		Landscape
		Garden
		Natural resources
	Environmental protection	Ecology
		Education for sustainable development
		Endangered species
		Botany
		Zoology
		Environmental education
		National park
		Pollution
		Acid rain
		Ecology
		Greenhouse effect
		Noise
		Sound
		Waste management
		Recycling
	Natural resources	Gas
		Oil
		Water
		Drinking water
		Watercourse

		Environment
		Mining
		Renewable energy
Geography and Earth Science	**Geography**	Africa
		Antarctica
		Asia
		Atlases
		Biomes
		Changes in distribution of economic activity & their impact
		Cape
		Classifications of economic activity
		Climate
		Climatic influences on ecosystems
		Coasts
		Conflicting demands on environments
		Deposition
		Development & quality of life
		Differences in development between countries
		Differences in development within countries
		Dynamic Shape
		Earthquakes
		Ecosystems
		Effects of resource use
		Environmental issues
		Erosion
		European countries outside the European Union
		European Union
		Factors influencing development
		Geographical distribution of economic activity
		Geographical variations in weather & climate
		Geomorphological processes - general information
		GIS
		Global distribution of tectonic activity

		Global scale
		Globes
		Goods & services
		Hazards/geomorphological
		Hazards & human responses
		Human influences on ecosystems
		Human patterns
		Human processes
		Internal Structure
		International scale
		Land use
		Landforms
		Less economically developed countries
		Local scale
		Location of settlements
		Maps & plans
		Migration
		More economically developed countries
		Mountain
		National scale
		Natural population change
		North America
		Oceania
		Other geomorphological processes
		Other influences on ecosystems
		Patterns in general
		Physical patterns
		Physical processes
		Planning & management of resources
		Population & resources
		Population change
		Population distribution
		Processes in general
		Projection
		Regional scale
		Rivers
		Rock types
		Rural settlements

		Satellite images
		Settlements: change
		Settlements: size/character/function
		Soil influences on ecosystems
		Sources of resources
		South & Central America
		Space-Time Information
		Spatial information
		Spatial properties
		Spatial interactions
		Spatial interpolation
		Spatial transformations
		Supply of resources
		Surface
		Tectonic hazards & human responses
		Tectonic processes
		Topical geographical issues
		Types of economic activity
		Urban settlements
		Volcanoes
		Water
		Water cycle
		Water, landscapes & people - general information
		Weather
		Weathering
	Earth science	acid rain
		air
		atmospheric phenomenon
		cartography
		Catastrophe
		climate
		Climate
		Climatic phenomenon
		exploration of the earth
		Explorer
		fossil
		geological phenomenon
		Geological phenomenon
		geology

		geomorphologic phenomenon
		Geomorphologic phenomenon
		Greenhouse effect
		Mass
		Meteorology
		Mineral
		Mineralogy
		Natural phenomenon
		Palaeontology
		Reference Frame
		regional geography
		regional language
		seismology
		social geography
		Spatial heterogeneity
		Stratum
Physics	**Electricity and magnetism**	AC/DC
		Ampere's law
		Charge
		Circuits - generally
		Components in circuits: batteries, etc
		Coulomb law
		Domestic appliances
		Electric charge - generally
		Electric current
		Electric motors
		Electrical heating and costs
		Electrical quantities - generally
		Electrical resistance/conductivity
		Electricity generation/National Grid
		Electromagnetism - generally
		Electrostatic forces
		Electrostatic phenomena and uses
		Generators and transformers
		Magnetic materials
		Magnetism - generally
		Mains electricity - generally
		Mains electricity safety
		Maxwell's equations

		Parallel circuits
		Series circuits
		Voltage
	Energy	Conduction, convection and evaporation
		Conservation and dissipation
		Energy - using electricity
		Energy resources
		Energy transfer and storage
		Internal Energy
		Kinetic energy
		Potential energy
		Radiation
		Radiation transfer
		Temperature and heat
		Thermodynamics
		Work and power
	Fields	Central field
		Conservative force field
		Electric field
		Electromagnetic field
		Gravitational field
		Magnetic field
		Potential
	Forces and motion	Acceleration
		Air resistance
		Atmospheric Pressure
		Angular acceleration
		Angular velocity
		Centre of mass
		Circular motion
		Collision
		Combining forces
		Conservation of momentum
		Elastic collision
		Electric force
		Escape velocity
		Foucault pendulum
		Friction
		Gravitational force and gravity
		Horizontal throw

		Impulse
		Inelastic collision
		Inertia
		Kepler's laws
		Lorentz force
		Machines
		Magnetic force
		Mass
		Moment of inertia
		Moments
		Newton's laws
		Nuclear force
		Oscillations
		Pendulum
		Period
		Phase
		Pressure
		Rectilinear motion
		Rigid body
		Rotation
		Universal law of gravitation
		Velocity
		Vertical throw
		Weight
	Light	Colour
		Light sources
		Properties of light - generally
		Reflection
		Refraction
		Refraction index
		Vision
	Obtaining and using materials	Electrolysis
		Extraction of metal from ore
		Fossil fuels
		Fossil resources - generally
		Hydrocarbons
		Metals - generally
		Nitrogenous fertilizers
		Plastics/polymers
		Useful substances from rocks and minerals
	Radioactivity	Alpha radiation
		Background radiation
		Beta radiation
		Gamma radiation

		Half-life
		Nuclear decay
		Nuclear fission
		Nuclear fusion
		Uses of radioactivity, including radioactive dating
	Solids, liquids and gases	Adiabatic
		Changes of state
		Density
		Entropy
		Isovolumetric
		Isothermal
		Laws of Thermodynamics
		Gas pressure and diffusion
		Grouping materials
		Melting/boiling points
		Particle theory
		Properties of materials
		Thermodynamic Cycle
	Sound	Audible ranges
		Hearing - generally
		Hearing: noise
		Loudness
		Pitch
		Properties of sound - generally
		Sound sources
		Speed in media
		The ear
		Ultrasound
	Tools for science	Accelerometers
		Accelerators
		Analysis Tools
		Detectors
		Detectors: CCD camera
		Dynamometers
		Fieldwork equipment
		Laboratory equipment – generally
		Laboratory glassware
		Laboratory measuring instruments, including sensors and meters
		Microscope
		Observatories
		Online Laboratories
		Remote Laboratories
		Sensors
		Thermometers
	Useful materials and products	Everyday materials
	Waves	Diffraction
		Doppler effect
		Electromagnetic spectrum
		Gamma rays

		Information transmission, analogue and digital signals
		Infrared
		Longitudinal waves
		Microwaves
		Optics
		Radio waves
		Reflection
		Refraction
		Seismic waves
		Transverse waves
		Ultraviolet
		Visible light
		Wave amplitude
		Wave characteristics - generally
		Wave frequency
		Wave speed
		Wavelength
		X-rays
	Technological applications	Horology
		Industrial devices
		Lifecycle of products
		Energy production and energy resources research
		Musical instruments
		Nanotechnology
		Photography and cinematography
		Robotics
		Sound techniques
		Telecommunications
		Transport (air, water and ground)
		Writing ad press
		Metal processing
		Paper production
		Textiles
		Pharmaceutics
		Mining
		Nautical tools
		Glass production
		Ceramics production
		Wood production
	History of Science and Technology	Scientists and inventors
		First scientific revolution
		Second scientific revolution
		Science: historical and contemporary examples
	High Energy Physics	Accelerators & beams
		Antimatter
		Calorimeters
		Charged particle acceleration
		Coupled Motion dynamics
		Dark matter
		Free electron lasers

		Grand unification
		Higgs particle
		Invariant mass
		Leptons
		Particle beam parameters
		Particle cosmology
		Particle detectors
		Particle dynamics
		Particle interactions with matter
		Physical constants
		QCD, jets & gluons
		Quarks & hadrons
		Space-time symmetries
		Standard model
		Supersymmetry
		Synchrontron radiation
		Weak interactions: electroweak
		Unification
		Weak interactions: quarks & leptons

Annex B: Analysis of Go-Lab Online Labs Characteristics

B.1 Labs' Details

Table 18. Laboratory Details

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
1	HYPATIA http://hypatia.phys.uoa.gr/applet			X	• Upper secondary education (15 -18 years old), • Higher Education Bachelor	English, Greek	Particle Physics	X	-	High	Medium	-	-	300 /month	Java browser plugin
2	The Faulkes Telescopes Project http://www.faulkes-telescope.com/	X			• Lower Secondary Education (12 -15 years old), • Upper Secondary Education (15 -18 years old)	English	Astronomy and Astrophysics, Cosmology, Physics, Space	-	X	High	Medium	X	X	N/A	-

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
3	WebLab-DEUSTO Aquarium http://www.weblab.deusto.es/weblab/	X			• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old)	English, Spanish, Basque, French, German, Czech, Slovak, Portuguese, Romanian, Hungarian	Physics	-	X	Low	Easy	X	X	200	-
4	Galaxy Crash http://burro.cwru.edu/JavaLab/GalCrashWeb/		X		Upper Secondary Education (15-18 years old)	English	Astronomy, Physics	X	-	High	Medium	-	-	N/A	Java browser plugin
5	CERNLand http://www.cern.ch/cernland http://www.cernland.net		X		Primary education (7-12)	English, Polish, Spanish, Italian, German, French	Particle Physics, Technology, Engineering, Cosmology	X	-	High	Easy	-	-	270 per day	Flash

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
6	LHC Game http://education.web.cern.ch/education/Chapter2/Teaching/games/LHCGame/		X		Lower Secondary Education (12 -15 years old)	English, Italian, French, German	Physics	-	-	Medium	Medium	-	-	N/A	Flash
7	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS E-mail to zubia@deusto.es	X			Upper Secondary Education (15 -18 years old)	English, Spanish	Technology, Engineering	X	X	High	Medium	-	-	100	-
8	ELVIS / OP – AMP Labs http://ilabs.cti.ac.at/iLabServiceBroker/	X			• Upper Secondary Education (15 -18 years old), • Higher Education Bachelor, • Higher Education Master	English	Engineering	X	-	Low	Easy	-	X	20	Java
9	VISIR http://ilabs.cti.ac.at/iLa	X			• Lower Secondary Education	English	Physics, Electronics	X	-	High	Depends	X	X	20	Flash

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
	bServiceBroker/				(12 -15 years old) • Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master										
10	CPLD Lab http://ilabs.cti.ac.at/iLabServiceBroker/	X			• Upper Secondary Education (15 -18 years old), • Higher Education Bachelor, • Higher Education Master	English	Technology, Engineering, Hardware programming (VHDL)	X	-	Medium	Medium	-	X	20	LabView Virtual Machine
11	MINERVA http://atlas-minerva.web.cern.ch/a			X	• Upper secondary Education (15 -18	English	Particle Physics	X	X	Medium	Medium	-	-	N/A	Java

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
	tlas-minerva/				years old) • Higher education Bachelor										
12	Many cratered Worlds http://cosmoquest.org		X		Lower Secondary Education (12 -15 years old)	English	Earth Sciences and Environment, Technology, Mathematics, Planetary Science	X	-	Medium	Medium	-	X	N/A (In development)	Basic knowledge of ICT
13	Sun4All http://www.mat.uc.pt/sun4all/index.php/en/			X	All levels (10 years old and upwards)	English, Portuguese	Physics, Mathematics, Astronomy and Astrophysics	X	X	Medium	Medium	-	-	Thousands	Depending on the task you might need access to a spreadsheet and image analysis tool.
14	The Discovery Space Portal (DSpace) http://www.discoverysp	X			• Primary Education (10 -12	English	Physics, Mathematics, Astronomy	X	X	High	Medium	X	X	1,100 register	For the analysis of the images

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
	ace.net/				years old) • Lower Secondary Education (12 -15 years old) • Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master									ed users	LTImage and Salsaj analysis tools are recommended.
15	Microcontroller platform in robolabor.ee http://distance.roboticlab.eu/lab/view/8	X			• Upper Secondary Education (15 -18 years old), • Higher Education Bachelor, • Higher Education Master	English	Technology, Engineering	-	-	High	Easy, Medium	X	X	30	Basic, programming

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
16	SimQuest Elektro http://sim01.cti.ac.at/		X		• Upper Secondary Education (15 -18 years old) • Higher Education Bachelor • Higher Education Master	German	Electrical Engineering	X	-	-	-	-	-	1	-
17	Matlab Simulations http://sim01.cti.ac.at/		X		• Upper Secondary Education (15 -18 years old), • Higher Education Bachelor, • Higher Education Master	German	Chemistry, Physics, Earth Sciences and Environment, Technology, Engineering, Mathematics	X	-	Low	Medium	-	-	20	Java
18	LearnIT 3D Games Based Go Lab Simulations http://www.learnit3d.co		X		• Primary education, • (10-12 years old), Lower Secondary	English	Biology, Physics, Earth Sciences and Environment, Technology,	X	X	Medium	Easy	-	-	N/A	PC With minimum spec Windows XP SP2

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
	m/				Education (12 -15 years old), • Upper Secondary Education (15 -18 years old)		Engineering								or above 500mb of hard disk space 1gb of RAM •Net framework 2.0 DirectX 9.0 Modern graphics card with latest drivers, 64mb of RAM and Direct3D support.
19	International Space Station 3D teaching tool http://www.esa.int/esaHS/SEM3TFYO4HD_e		X		• Lower Secondary Education (12 -15 years old) • Upper Secondary	English, French, German, Spanish, Italian, Dutch, Portugues	Chemistry Biology Physics Earth Sciences and Environment Technology Engineering	-	-	Low	Easy	-	-	N/A	-

#	Name/ Website	Remote Lab	Virtual Lab	Data Set/Analysis Tools	Level/ Age	Languages	Domains	Has Learning Activities	Uses Scaffolds	Interactivity Level	Difficulty	Booking Required	Registration Required	Current number of users	Other Requirements
	ducation_0.html				Education (15 -18 years old)	e, Danish, Swedish, Finnish, Norwegian, Greek	Mathematics Space								
20	SalsaJ http://www.euhou.net/index.php/salsaj-software-mainmenu-9			X	• Primary Education (10 -12 years old) • Lower Secondary Education (12 -15 years old) Upper Secondary Education (15 -18 years old)	English, French, Spanish, Italian, Polish, Greek, Portuguese, Swedish, Northern Sami, Arabic, Chinese.	Biology Physics Mathematics Astronomy	X	-	High	Medium	-	-	10.000	-

B.2 Domain Classification

Table 19. Domain Classification

Domain	Name
Astronomy and Astrophysics (5)	DSpace Faulkes Galaxy Crash Sun4all SalsaJ
Biology (3)	International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations SalsaJ
Chemistry (2)	International Space Station 3D teaching tool Matlab Simulations
Cosmology (2)	CERNland Faulkes
Earth Sciences, and Environment (4)	International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Many cratered Worlds Matlab Simulations
Electrical Engineering and Electronics (2)	SimQuest Elektro VISIR
Engineering (8)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CERNland CPLD Lab ELVIS / OP – AMP Labs International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Matlab Simulations Microcontroller platform in robolabor.ee
Hardware programming (VHDL) (1)	CPLD Lab
Mathematics (6)	DSpace International Space Station 3D teaching tool Many cratered Worlds Matlab Simulations Sun4all SalsaJ
Particle Physics (3)	CERNland HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) MINERVA

Domain	Name
Physics (11)	DSpace Faulkes International Space Station 3D teaching tool Galaxy CrashLearnIT 3D Games Based Go Lab Simulations LHC Game Matlab Simulations Sun4all VISIR WebLab-DEUSTO Aquarium SalsaJ
Planetary Science (1)	Many cratered Worlds
Space (2)	Faulkes International Space Station 3D teaching tool
Technology (8)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CERNland CPLD Lab International Space Station 3D teaching tool LearnIT 3D Games Based Go Lab Simulations Many cratered Worlds Matlab Simulations Microcontroller platform in robolabor.ee

B.3 Language Classification

Table 20. Language classification

Language	Name
Basque (1)	WebLab-DEUSTO Aquarium
Czech (1)	WebLab-DEUSTO Aquarium
Danish (1)	International Space Station 3D teaching tool
Dutch (1)	International Space Station 3D teaching tool
English (19)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS CERNland CPLD Lab DSpace ELVIS / OP – AMP Labs Faulkes HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) International Space Station 3D teaching tool

Language	Name
	Galaxy Crash LearnIT 3D Games Based Go Lab Simulations LHC Game Many cratered Worlds Microcontroller platform in robolabor.ee MINERVA SimQuest Elektro Sun4all VISIR WebLab-DEUSTO Aquarium SalsaJ
Finnish (1)	International Space Station 3D teaching tool
French (5)	CERNland International Space Station 3D teaching tool LHC Game WebLab-DEUSTO Aquarium SalsaJ
German (5)	CERNland International Space Station 3D teaching tool LHC Game Matlab Simulations WebLab-DEUSTO Aquarium
Greek (3)	HYPATIA(Hybrid Pupil's Analysis Tool for Interactions in Atlas) International Space Station 3D teaching tool SalsaJ
Hungarian (1)	WebLab-DEUSTO Aquarium
Italian (4)	CERNland International Space Station 3D teaching tool LHC Game SalsaJ
Norwegian (1)	International Space Station 3D teaching tool
Polish (2)	CERNland SalsaJ
Portuguese (4)	International Space Station 3D teaching tool Sun4all WebLab-DEUSTO Aquarium SalsaJ
Romanian (1)	WebLab-DEUSTO Aquarium
Slovak (1)	WebLab-DEUSTO Aquarium
Spanish (5)	Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS

Language	Name
	CERNland International Space Station 3D teaching tool WebLab-DEUSTO Aquarium SalsaJ
Swedish (2)	International Space Station 3D teaching tool SalsaJ

B.4 Inquiry Cycle Phases

Table 21. Inquiry Cycle Phases

#	Name	Orientation	Questioning	Hypothesis	Experiment planning	Observing	Analysing	Conclusion	Evaluation	Reflection
1	HY.P.A.T.I.A.	X	X	X			X	X	X	
2	The Faulkes Telescopes Project					X				
3	WebLab-DEUSTO Aquarium			X	X	X	X			
4	Galaxy Crash	X	X	X	X	X	X	X	X	X
5	CERNland				X	X	X			
6	LHC Game					X	X			
7	Boole-Deusto + WebLab-Deusto				X	X	X			
8	ELVIS / OP – AMP Labs	X			X	X	X	X		X
9	VISIR	X	X	X	X	X	X	X	X	X
10	CPLD Lab	X	X	X	X	X	X	X		X
11	MINERVA				X	X	X	X		
12	Many Cratered Worlds					X	X	X	X	X
13	Sun4All	X	X	X	X	X	X	X	X	X
14	The Discovery Space Portal (Dspace)					X				

#	Name	Orientation	Questioning	Hypothesis	Experiment planning	Observing	Analysing	Conclusion	Evaluation	Reflection
15	Microcontroller platform in robolabor.ee	X	X	X	X	X	X	X	X	X
16	SimQuest Elektro		X	X	X	X				
17	Matlab Simulations			X	X	X	X	X		X
18	LearnIT 3D Games Based Go Lab Simulations	X	X	X	X	X	X	X	X	X
19	International Space Station 3D teaching tool	X	X							
20	SalsaJ		X	X	X		X			
	TOTAL	**9**	**10**	**11**	**14**	**17**	**16**	**11**	**7**	**9**