Go-Lab

Global Online Science Labs for Inquiry Learning at School

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The Go-Lab Inventory and Integration of Online Labs – Labs Offered by Universities

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Executive Summary

This document is the outcome of the work done during the 2nd year of the project in task *"T2.2 - Organizing Online Labs for the Go-Lab Federation: from Small to Big Ideas of Science",* in task "*T2.3 – The Go-lab Inventory of Online Labs*" and Task "*T2.4 – Populating the Go-Lab inventory"*. The document describes (a) the process of populating the Go-Lab Inventory for year 2, (b) the main characteristics of the new online labs (including quality, diversity, multilingualism) and (c) explains in detail the steps towards the development of a federated ecosystem of online labs and educational resources (inquiry learning activities that are making use of a lab – or a series of labs) that could be available to the users (namely science teachers) through an effective search mechanism. Overall the Go-Lab inventory includes currently **48 online labs** (the initial indicator was to have 45 online labs at the end of the project) out of which 13 were integrated during the 1st year of the project and 35 during the 2nd year. The consortium has already set in place a mechanism to populate the Go-Lab Repository with more online labs from the initial planned sample to support the large scale validation work. The consortium has already established cooperation with similar efforts across the globe. Following the remarks of the reviewers the main concepts of the proposed approach (Big Ideas of Science, online lab metadata model[1]) were validated with real users (namely, science teachers and teachers' trainers) in the framework of specific workshops and activities. The data were analysed and the results are presented. About **341 potential users** were involved in the validation exercises. In particular, **108 users** participated in the validation of the metadata elements set for online labs and **233 users** were involved in the validation of the Go-Lab set on the "Big Ideas of Science".

[1] We should clarify that it is beyond the scope of the present deliverable to present and discuss technical features of the online lab metadata (such as indexing, interoperability and data export formats). This is part of WP4 and WP5 deliverables.

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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 initial aim of tasks *"T2.2 - Organizing Online Labs for the Go-Lab Federation: from Small to Big Ideas of Science"* and *"T2.3 – The Go-lab Inventory of Online Labs*" is to design a methodology for organizing online labs. This methodology was initially described in deliverable "*D2.1 - The Go-Lab Inventory and Integration of Online Labs – Labs Offered by Large Scientific Organisations*" (Go-Lab Project – D2.1).

The main scope of this deliverable is to present the extension of the Go-Lab inventory by adding more labs that mostly come from Universities. Apart from increasing the number of labs special attention was paid to adding labs of high quality that meet the needs of the school communities. In addition the labs introduced in this second version of the inventory were also selected so as to extend the coverage of the curriculum in more subject areas. In particular, as during the first year of the inventory the labs added were mostly focused on physics, in this second round we aimed to extend more towards the subject area of biology. Likewise, in the next versions of our inventory we will focus more on the remaining subject areas so as to make sure that by the end of the integrating progress we will have an inventory of labs that cover widely and uniformly all subject areas.

In addition to the extension of the Go-Lab inventory, the scope of this deliverable is also to present the progress on the work that is taking place in the framework of WP2 while also taking into account the comments made by the reviewers during the first review of the project. In this framework, this document also presents:

- The process of establishing the Go-Lab federation of online labs
- The work done on validating the Go-Lab set of the "Big Ideas of Science" and checking its consequences with teachers and teachers' trainers.
- The work done in validating the metadata elements with teachers and lab owners, so as to ensure that these metadata elements are useful for them during the process of adding online labs to the Go-Lab repository (lab owners) and searching and retrieving online labs for the Go-Lab repository (teachers)

Finally in order to support the creation of the Go-Lab ecosystem, WP2 team presents an initial metadata model for the characterization of the Go-Lab Inquiry Learning Spaces (ILSs) that describe learning activities that are based on the use of the online labs of the Go-Lab Repository.

1.2 Audience

This document targets the Go-Lab partners, so that they can be aware of (a) the current status of the Go-Lab inventory and the labs that are included; (b) the updated set of the Go-Lab set of the "Big Ideas of Science"; (c) the updated methodology for organizing the Go-Lab online labs; and (d) the initial metadata model for characterizing Inquiry Learning Spaces towards the large scale implementation phase that will start in the 3rd year of the project's life cycle.

The results of this work will be of particular interest for (a) WP5 for developing the Go-Lab Repository and (b) WP1 in order to support the work of pedagogical team for designing relevant ILSs and characterizing them with appropriate metadata.

2 Populating the Go-Lab Inventory (Year 2)

2.1 Preparing the Large Scale Pilots

According to the methodology described in the Go-Lab DoW, Part B, pp.10-11, the project implements a three-stage deployment cycle by populating the Go-Lab Inventory with online labs. Based on the proposed approach, the first stage of deployment cycle was described in Deliverable D2.1 (Go-Lab Project – D2.1) and included the description and the categorization of the first 13 online labs. Following this approach, in the second year of the project, Go-Lab has adapted existing labs offered by Go-Lab partner universities (mainly departments of science, technology and applied sciences) and additional labs that were offered by external partners and consortia.

According to the initial plan in the second stage (second year), Go-Lab partner universities had to provide and adapt the following labs:

- Solar Lab, Conductance Measurement Lab, VISIR Lab, Matlab Web Lab, and Helmholtz Coils Lab (CUAS),
- WebLab Portal, including Robot, Aquarium and Energy Labs (UD),
- SimQuest Elektro (UT),
- Labs from the Invention Space, the Teaching Bridge, and the Roberta Center (EPFL).

Taking into account that the Go-Lab repository is expected to be used in about 500 schools in different European countries our team had to find ways to increase the diversity of the existing sample of labs (both in the subject areas and the age groups). This was also clear from feedback 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 - D6.4).

The variety of the thematic areas covered (curriculum coverage) was the most important parameter for the selection. Additionally the maturity of each lab, the number of its current users and its popularity among teachers were also considered for the selection process. The level of difficulty (targeting medium level of difficulty) and the level of interaction (targeting high level of interaction) were also taken into consideration. Finally, it is very important the labs that will be offered to the school communities during the second implementation cycle to be used (and assessed) by a high number of school teachers, to offer high quality services and support materials (scenarios of use, tutorials, online support).

The project team has set in place a plan to attract the interest of potential lab owners in order to increase the sample of the available labs. An effective dissemination cycle was organised including a variety of events focusing on online lab owners and providers. The technical team (WP4 & WP5) has managed to develop prototypes and set up a series of proof of concept experiments that could easily demonstrate the benefits of the integrated approach. Additionally this was a unique opportunity to present the plug and play capabilities of the system under development. This work is described in detail in Deliverable D4.3 (WP4) where the integration of selected online labs from two repositories PHET (http://phet.colorado.edu/) and VISH (http://vishub.org/) is discussed on pages 37 and 38. Figure 1 presents the Acid-Based Solutions Virtual Lab (from PHET repository) integrated to the Go-Lab repository following the description of the Lab with the necessary metadata. The specific lab was integrated in the framework of the discussions between Go-Lab and PHET consortia for the development of a common repository of online labs.

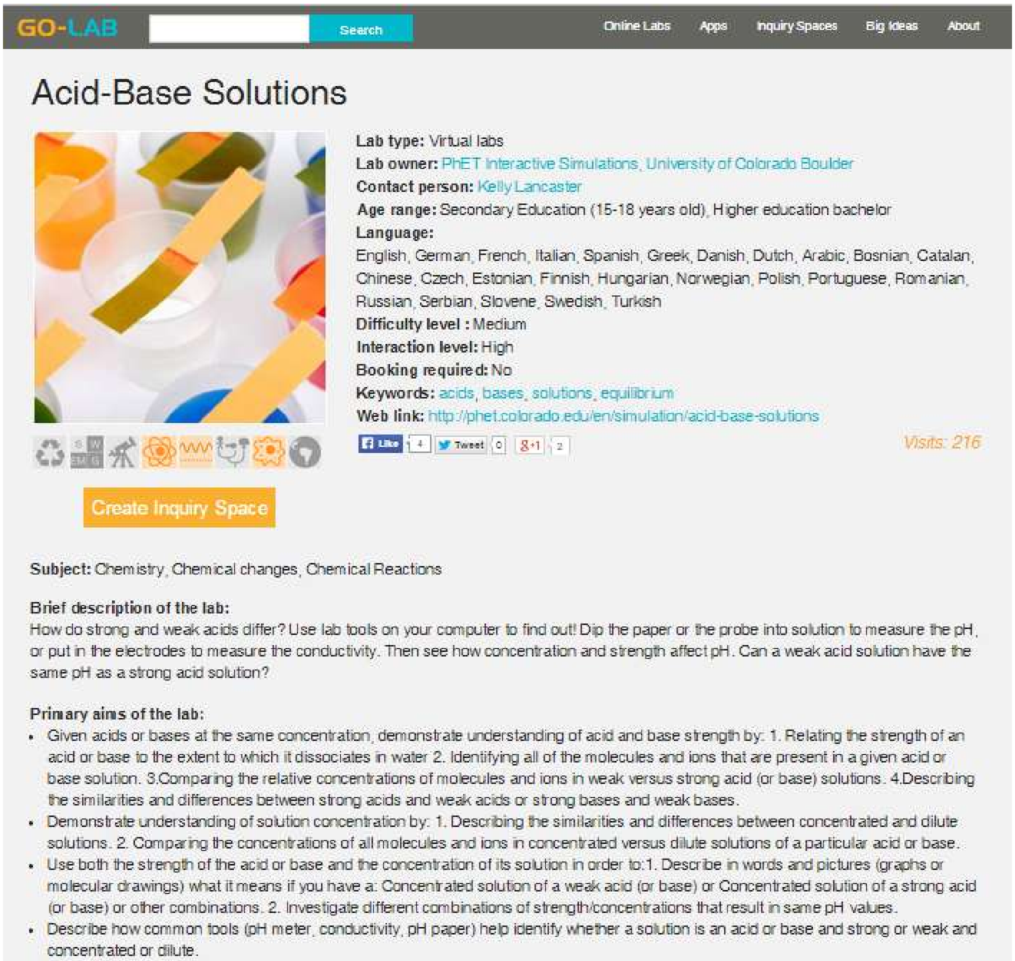


Figure 1. The Acid-Based Solutions Virtual Lab is included in the collection of the federated system. The specific lab was integrated in the framework of the discussions between Go-Lab and PHET consortia for the development of a common repository of online labs.

2.2 Lab Owners'/Providers' Level - The Go-Lab Affiliation Process

The establishment of a common process of attracting and affiliating interested lab providers that would like to offer their online labs for use in the context of the Go-Lab project activities is the first step towards the enrichment of the Go-Lab inventory. The lab owners/providers need to ensure that their online labs comply with the definition of the term "online lab" as defined by the Go-Lab consortium. The following sections focus on this process of integrating and affiliating new labs online labs to the Go-Lab collection.

2.2.1 Participation and Benefits

For a lab provider, the expected benefits to be received from the participation to the Go-Lab federation of online labs could be summarized as follows:

- Increase the visibility and attraction of its online labs.
- Receive feedback and recommendations on improvements for its online labs from the schools participating in the Go-Lab pilots according to their needs and experience.

- Further support the use of the online lab through the development of educational activities designed based on the specific online labs by teachers across Europe, in multiple languages.
- Enrichment of the online lab with a set of scaffolds facilitating students to perform online experiments more efficiently. Moreover, they can make use of Go-Lab add-on services such as the booking service and the learning analytics.
- Assessment from a community of teachers of the lab functionalities in real settings. The Go-Lab tutoring platform (Go-Lab Project - D4.4) could be a place where online lab providers will be in contact with the users of their labs and they will have the opportunity to get first hand feedback from classroom use.

Figure 2. The added value of the Go-Lab services: integration and contextualisation of labs with educational resources, scaffolds and wide scale use from numerous teachers and students across Europe that provides a large scale validation exercise.

2.2.2 Lab Provider Affiliation Process

2.2.1.1 Roles and Responsibilities

During the process of affiliating a new lab provider that will be part of the Go-Lab federation the following roles can be identified:

- **Lab Provider Representative**: a person, not necessarily with a technical background, that legally represents the online lab and can take decisions on its behalf. These decisions include the definition of policies for accessing the lab, quality criteria, as well as metadata formats to be supported.

- **Lab Provider Technical Team:** a person or a group, who decides, coordinates and supervises all technical tasks related with the online lab such as adaptations to comply with Go-Lab smart device/smart gateway. Moreover, this team is responsible for describing the online lab with metadata for inclusion to the Go-Lab repository (http://www.golabz.eu/).
- **Go-Lab Lab Board**: a group, who decides about the quality of new online labs, to be approached and plugged in the federation, tracks the joining process to Go-Lab and supervises the integration on the Go-Lab side. This group is composed by the WP2 partners, which are responsible for establishing the Go-Lab federation of online labs.
- **Go-Lab Integration Team:** a group whose work consists on carrying out and coordinating all technical activities for the successful integration of online labs to the Go-Lab federation and the Go-Lab Repository (http://www.golabz.eu/). This group is composed by the WP4 partners.
- **Go-Lab Liaison Representative:** a person, who contacts the lab provider on behalf of the Go-Lab consortium and informs him about the Go-Lab project and the potential benefits for joining the Go-Lab federation. This person could be any Go-Lab Partner.

2.2.1.2 Workflow

The proposed workflow to be followed for affiliating a lab provider and integrating his online labs to the Go-Lab federation is summarized to the steps below:

Step 1 - Reaching Consensus about New Online Labs: during this step each Go-Lab liaison representative informs the Go-Lab lab board about new online labs to be approached for possible integration to the Go-Lab federation. The Go-Lab lab board discusses and decides about the lab providers to be contacted.

Step 2 – Contact Lab Providers: during this step each Go-Lab liaison representative communicates with lab providers to inform them about the Go-Lab project and to invite them to participate to the Go-Lab federation. A template letter for contacting lab providers is presented in Annex A.

Step 3 – Gaining Understanding: during this step a lab provider might want to understand what it means to provide their online labs to the Go-Lab federation. This breaks down to both responsibilities as well as benefits. Initially, these are explained through conversations between the Go-Lab liaison representative and the lab provider. However, more information might be needed to be offered by the Go-Lab integration team.

Step 4 – Provision of Lab Profile Details: during this step and considering that the lab provider has agreed to join the Go-Lab federation**,** the Go-Lab liaison representative asks the lab provider technical team to provide details about the lab profile by using the form here: https://docs.google.com/forms/d/1U1YzifV1m7QLJ4YG7DDgoRpUcaYi9wBnold7yK_U3oE/edit#

Step 5 – Integrate the Lab: during this step the Go-Lab integration team adds the online labs of the lab provider to the Go-Lab repository based on the filled lab profile form(s). Moreover, the Go-Lab integration team communicates with the Lab Provider technical team, so as to fully integrate the online labs of the lab provider to the Go-Lab technical infrastructure.

Step 6 – Reward the Lab Provider: during this step the Go-Lab dissemination and exploitation leader prepares a certificate in order to express the appreciation of the Go-Lab consortium to the lab provider for joining the Go-Lab federation and offering its online labs to be used in the framework of the Go-Lab project activities.

2.3 Go-Lab Federation of online labs: From Small to Big Ideas of Science

On a pedagogical level we aim to set-up the Go-Lab federation of online labs by deploying the Go-Lab Big ideas of Science that have been presented in Deliverable "D2.1 - The Go-Lab Inventory and Integration of Online Labs – Labs Offered by Large Scientific Organisations" (Go-Lab Project – D2.1). When it comes to repositories, the organization of online labs is mostly based on categorizing the labs in terms of subject domain and age range, thus forming *smaller divisions* within a collection of autonomous labs. However, little is done towards interconnecting labs between different subject domains so as to demonstrate an integrated approach in introducing scientific ideas and concepts. In Go-Lab we are introducing the "Big Ideas of Science" as a backbone structure that students can build upon so as to connect the different science subjects they are taught in school as well as, events and phenomena from their lives to what they are taught during their school life. This interconnection is crucial if we are to communicate the links between concepts or laws and experimentation offered by the online labs. It is also important to demonstrate how these Big Ideas of Science are present since students' early school life so that both teachers and students are aware of the contribution of an activity at any given grade in building a bigger picture which combines all of the scientific aspects of our world. By introducing to students the Big Ideas of Science through multiple labs they can understand the common background between different natural phenomena while they can also examine the same concept from different perspectives and within different settings. They are given the opportunity to connect different subject domains of science and develop a deeper understanding of each concept while moving from one grade to the next. In addition, it can enable students as individuals to understand aspects of the world around them and understand certain concepts and the connection between different principles and phenomena which at first sight might appear to be irrelevant.

Moreover, Go-Lab pedagogy is based on inquiry-based approach that is widely advocated and is being implemented in many different countries across the globe. When doing inquiry, students are basically trying to build and grasp new ideas based on earlier ones. Thus, the "Big Ideas of Science" and the progression from small to big ideas can play an important role in promoting inquiry-based activities using online labs from the Go-Lab federation.

Each online lab is designed to investigate specific concepts and phenomena. Different concepts and phenomena that are investigated from different labs may look independent at a first glance however; they may be related to common Big Ideas of Science. For each of the online labs that will be selected and implemented in the framework of the Go-Lab project, the aim is to set out the small, basic ideas using the educational objectives of each individual learning activity, leading to the broader ideas that allow understanding of natural phenomena, laws and principles of our world (see Figure 3 and Figure 4).

Thus, by classifying the Go-Lab online labs using the Big Ideas of Science, we aim to orchestrate our repository so that labs are not solely related based on their subject (forming smaller divisions) but also in a cross-subject manner which will reveal their interconnections and allow them to be part of a federation of labs rather than a collection. This organization will also act as a recommendation system for teachers as they will be able to search for labs that are supporting the same Big Ideas of Science and present to their students phenomena that could be possibly relevant to their everyday experiences.

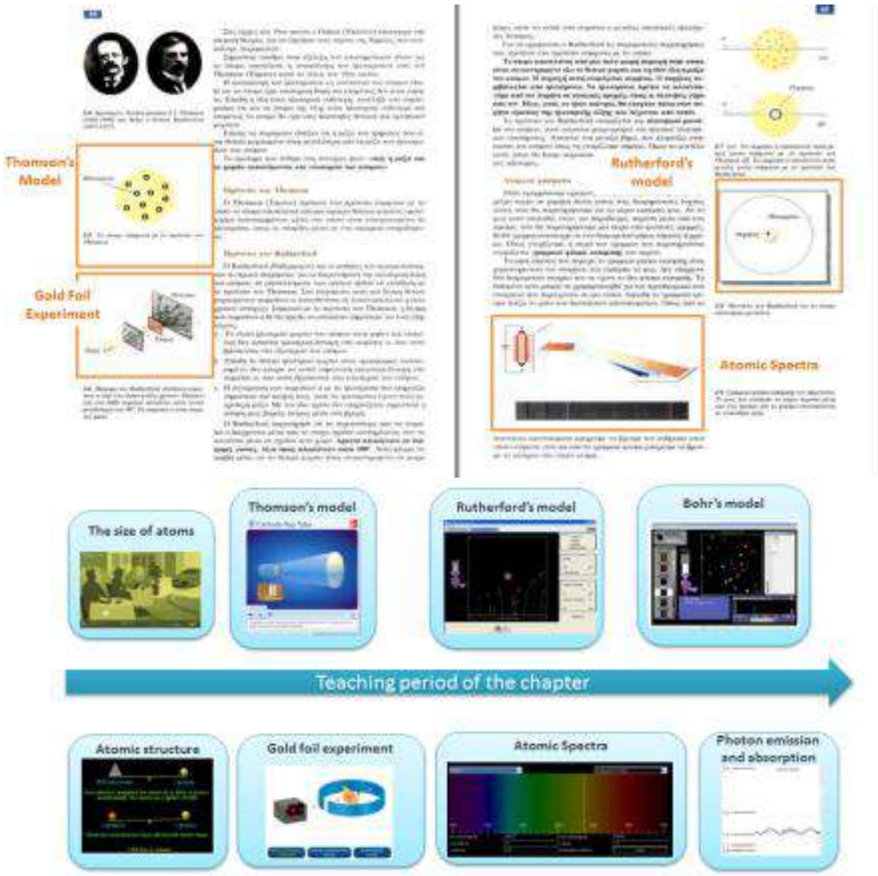


Figure 3. The Go-Lab online labs could support the understanding of objects, phenomena and relationships in connection to the natural world.

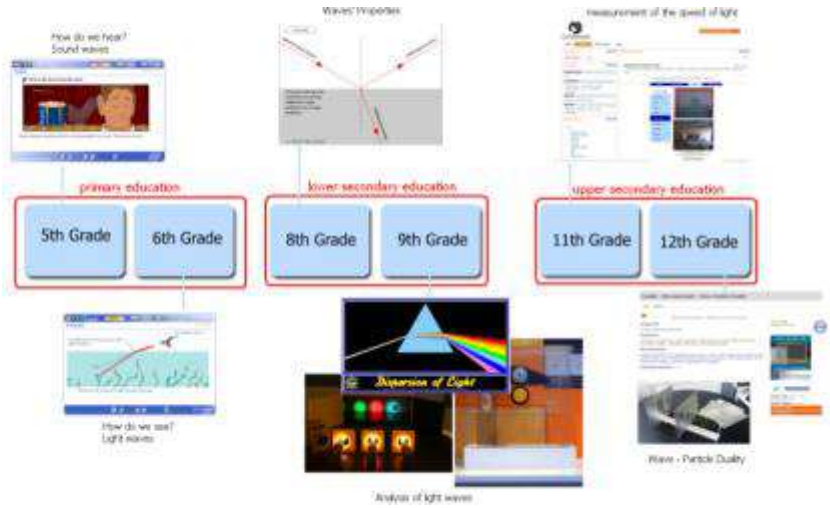


Figure 4. The organisation scheme based on the Big Ideas of Science could support the progressive introduction phenomena and concepts.

The technical aspects of the realization of the Go-Lab Federation of online labs and the plug and play approach for the integration of new online labs and collections of online labs are described in Deliverable D4.3 (Go-Lab Project – D4.3).

3 The Go-Lab Inventory of Online Labs – Year 2

The aim of this section is to present the online labs that have been included in the Go-Lab Inventory for the 2nd year of the project. In total 35 online labs have been selected to be included in the Go-Lab Inventory following the selection criteria mentioned in Section 2.1. These online labs have been described by following the revised metadata model that is described in section 5.5. This has enabled their integration to the Go-Lab Repository (http://www.golabz.eu/).

3.1 Overview of the Go-lab Inventory of Online Labs – Year 2

In this section, an overview of the online labs that that have been included in the Go-Lab Inventory for the 2nd year of the project is presented. The detailed metadata of these online labs are presented in Appendix 1 and they have been provided by their lab owners by using the Google form available at: https://docs.google.com/forms/d/1oENAmYeTJBFI97v-wZdKLowxyUi0-O7P4ymrJFFIgGU/viewform

Figure 5. The Go-Lab Lab Profile Form for Lab Owners

Table 1 presents the list of online labs that have been included in the Go-Lab Inventory for Year 2. More precisely, Table 1 includes the online lab title, its URL, as well as the URL of the online as presented in the Go-Lab Repository.

Table 1. List of Online Labs of the Go-Lab Inventory for Year 2

No	Online Lab Title	Online Lab URL	Go-Lab Repository URL
1	RED Lab	http://graasp.epfl.ch/metawidget/0/4a3b8c20b0e272ffd66eb78900df722d6958bfef	http://www.golabz.eu/lab/red-lab

2	Splash: Virtual Buoyancy Laboratory	http://go-lab.gw.utwente.nl/production/splash/labs/splash/virtual.html	http://www.golabz.eu/lab/splash-virtual-buoyancy-laboratory
3	Radioactivity Lab	http://ilabs.cti.ac.at/radioactivity2ls/Home.aspx	http://www.golabz.eu/lab/radioactivity-lab
4	Satellite/Moon/Comet Trajectories	http://graasp.epfl.ch/sharedapp/1073c0fd5e959e19ef6bc6c93acfc0713beb03d8	http://www.golabz.eu/lab/satellitemooncomet-trajectories
5	GearSketch	http://go-lab.gw.utwente.nl/production/gearsketch/gearsketch.html	http://www.golabz.eu/lab/gearsketch
6	Segway Control Simulation	http://goo.gl/WSghyT	http://www.golabz.eu/lab/segway-control-simulation
7	Acid-Base Solutions	http://phet.colorado.edu/en/simulation/acid-base-solutions	http://www.golabz.eu/lab/acid-base-solutions
8	Minerva	http://atlas-minerva.web.cern.ch	http://www.golabz.eu/lab/minerva
9	Our Acidifying Ocean	http://i2i.stanford.edu/AcidOcean/AcidOcean.htm	http://www.golabz.eu/lab/our-acidifying-ocean
10	Sun4all	http://www.astro.mat.uc.pt/novo/observatorio/site/arquivo.html	http://www.golabz.eu/lab/sun4all
11	Turn Stability	http://sim01.cti.ac.at/wsdemos/easyjava/Simulations/_apps/AICC/AICC.app/AICC.html	http://www.golabz.eu/lab/turn-stability
12	Long Jump	http://sim01.cti.ac.at/html/longjump/long_jump_simulation1.files/users/pester/longjump.html	http://www.golabz.eu/lab/long-jump
13	Barnacle Competition	http://virtualbiologylab.org/BarnacleCompetition.htm	http://www.golabz.eu/lab/barnacle-competition
14	Bee Foraging	http://virtualbiologylab.org/BeeForaging.htm	http://www.golabz.eu/lab/bee-foraging
15	Biomagnification	http://virtualbiologylab.org/Biomagnification.htm	http://www.golabz.eu/lab/biomagnification
16	Collective Vigilance Behaviour	http://virtualbiologylab.org/Vigilance.htm	http://www.golabz.eu/lab/collective-vigilance-behaviour
17	Individual Vigilance Behaviour	http://virtualbiologylab.org/Vigilance.htm	http://www.golabz.eu/lab/individual-vigilance-behaviour
18	Estimating Population Size	http://virtualbiologylab.org/PopulationEstimation.htm	http://www.golabz.eu/lab/estimating-population-size

19	Habitat Fragmentation	http://virtualbiologylab.org/HabitatFrag1.htm	http://www.golabz.eu/lab/habitat-fragmentation
20	Industrial Melanism	http://virtualbiologylab.org/IndustrialMelanism.htm	http://www.golabz.eu/lab/industrial-melanism
21	Island Biogeography	http://virtualbiologylab.org/IslandBiogeography.htm	http://www.golabz.eu/lab/island-biogeography
22	Logistic Growth	http://virtualbiologylab.org/LogisticGrowth.htm	http://www.golabz.eu/lab/logistic-growth
23	Searching Behaviour	http://virtualbiologylab.org/SearchingBehavior.htm	http://www.golabz.eu/lab/searching-behaviour
24	Microcosm	http://virtualbiologylab.org/Microcosm.htm	http://www.golabz.eu/lab/microcosm
25	Plant Diversity	http://virtualbiologylab.org/PlantDiversity.htm	http://www.golabz.eu/lab/plant-diversity
26	Fishbowl Population Genetics	http://virtualbiologylab.org/PopGenFishbowl.htm	http://www.golabz.eu/lab/fishbowl-population-genetics
27	Random Genetic Drift	http://virtualbiologylab.org/GeneticDrift.htm	http://www.golabz.eu/lab/random-genetic-drift
28	Random Genetic Effects	http://virtualbiologylab.org/RandomEffects.htm	http://www.golabz.eu/lab/random-genetic-effects
29	Sexual Selection in Guppies	http://virtualbiologylab.org/EndlersGuppies.htm	http://www.golabz.eu/lab/sexual-selection-guppies
30	Stream Diversity	http://virtualbiologylab.org/StreamDiversity.htm	http://www.golabz.eu/lab/stream-diversity
31	Tragedy of the Commons	http://virtualbiologylab.org/TragedyCommons.htm	http://www.golabz.eu/lab/tragedy-of-the-commons
32	Foucault's Pendulum	http://www.3dtrainingdesign.co.uk/GoLab/FoucaultPendulum/TW_Applet.html	http://www.golabz.eu/lab/foucault-pendulum
33	Determination of EMF of a Cell	http://amrita.olabs.co.in/olab/html5/?sub=CHE&cat=ELC&exp=EMF_measurement&tempId=olab_ot&linktoken=&elink_lan=en-IN	http://www.golabz.eu/lab/determination-emf-cell
34	Mark and Recapture	http://virtualbiologylab.org/MarkRecapture.htm	http://www.golabz.eu/lab/mark-and-recapture
35	Osmotic Power Lab	http://golab.collide.info/labs/osmotic-power-public/index.html	http://www.golabz.eu/lab/osmotic-power-lab

3.2 *Analysis of the Go-Lab Inventory of Online Labs for Year 2*

At this section we present the analysis of the thirty-five (35) online labs that are included in the Go-Lab Inventory for the 2nd year. This section has been divided into seven (7) sub-sections, each one of them regards to a different aspect of analysis, as follows: (a) Lab type analysis, (b) age range analysis, (c) big ideas of science analysis, (d) subject domain analysis, (e) multilingualism, (f) difficulty level analysis, and (g) interaction level analysis. The full description of the metadata elements of all these 35 labs are presented in the Appendix of this deliverable.

3.2.1 Lab Type Analysis

The Go-lab Inventory for the 2nd Year includes 35 online labs. In respect to their type, 30 (86%) of them are Virtual Labs, 3 (9%) of them are Data Sets and 2 (6%) of them are Remote Labs.

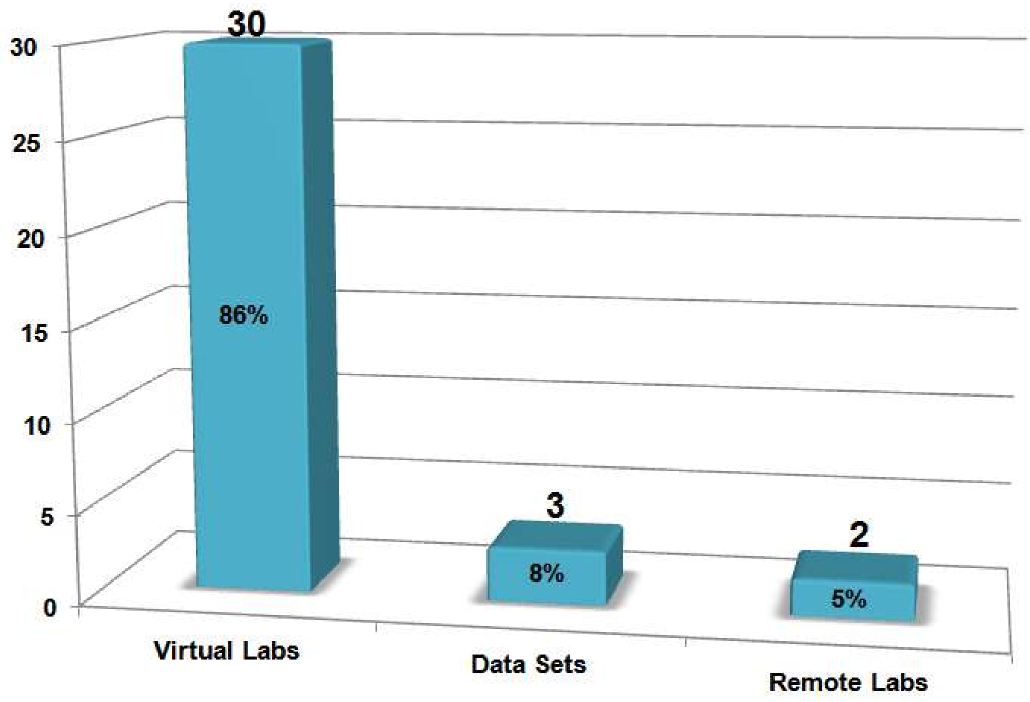


Figure 6. Labs of Year 2 per type

Table 2. Type Classification of Labs of Year 2

Type	Name
Virtual Labs (30)	Acid-Base Solutions Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Determination of EMF of a Cell Estimating Population Size Fishbowl Population Genetics Foucault's Pendulum GearSketch

	Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Long Jump Mark and Recapture Microcosm Osmotic Power Lab Our Acidifying Ocean Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Segway Control Simulation Sexual Selection in Guppies Splash: Virtual Buoyancy Laboratory Stream Diversity Tragedy of the Commons Turn Stability
Remote Labs (2)	Radioactivity Lab RED Lab
Data Sets (3)	Minerva Satellite/Moon/Comet Trajectories Sun4all

3.2.2 Age Range Analysis

The Online labs that are included to the Go-Lab Inventory for Year 2, cover all the ages that Go-Lab aims to cover, starting from the age of 10 all the way up to the age of 18. More specifically, there are 34 (97%) online labs that cover – not exclusively – the ages between 16 and 18, all 35 online labs cover – not exclusively – the ages between 14 and 16, there are 9 (26%) online labs that cover – not exclusively – the ages between 12 and 14 and there are 4 (11%) online labs that cover – not exclusively – the ages between 10 and 12.

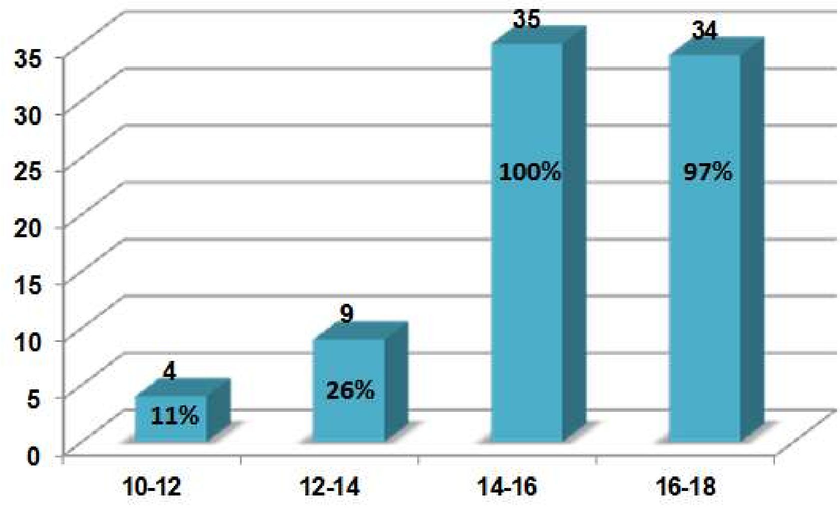


Figure 7. Labs of Year 2 by age range

Table 3. Labs of Year 2 by age range and type

Age Range	Type	Name
10-12	Remote Labs (0)	-
	Virtual Labs (3)	Foucault's Pendulum GearSketch Splash: Virtual Buoyancy Laboratory
	Data Sets (1)	Sun4all
12-14	Remote Labs (0)	-
	Virtual Labs (7)	Foucault's Pendulum GearSketch Splash: Virtual Buoyancy Laboratory Determination of EMF of a Cell Long Jump Our Acidifying Ocean Turn Stability
	Data Sets (2)	Satelite/Moon/ Comet Trajectories Sun4all
14-16	Remote Labs (2)	Radioactivity Lab Red Lab
	Virtual Labs (30)	Foucault's Pendulum GearSketch Splash: Virtual Buoyancy Laboratory Determination of EMF of a Cell Long Jump Our Acidifying Ocean Turn Stability Acid-Based Solutions

		Barnacle Competition
		Bee Foraging
		Biomagnification
		Collective Vigilance Behaviour
		Estimating Population Size
		Fishbowl Population Genetics
		Habitat Fragmentation
		Individual Vigilance Behaviour
		Industrial Melanism
		Island Biogeography
		Logistic Growth
		Mark and Recapture
		Microcosm
		Osmotic Power Lab
		Plant Diversity
		Random Genetic Drift
		Random Genetic Effects
		Searching Behaviour
		Segway Control Simulation
		Sexual Selection in Guppies
		Stream Diversity
		Tragedy of the Commons
	Data Sets (3)	Sun4all
		Satellite/Moon/ Comet Trajectories
		Minerva
16-18	Remote Labs (2)	Radioactivity Lab
		Red Lab
	Virtual Labs (29)	Foucault's Pendulum
		GearSketch
		Determination of EMF of a Cell
		Long Jump
		Our Acidifying Ocean
		Turn Stability
		Acid-Based Solutions
		Barnacle Competition
		Bee Foraging
		Biomagnification
		Collective Vigilance Behaviour
		Estimating Population Size
		Fishbowl Population Genetics
		Habitat Fragmentation
		Individual Vigilance Behaviour
		Industrial Melanism
		Island Biogeography
		Logistic Growth
		Mark and Recapture

		Microcosm Osmotic Power Lab Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Segway Control Simulation Sexual Selection in Guppies Stream Diversity Tragedy of the Commons
	Data Sets (3)	Sun4all Satellite/Moon/ Comet Trajectories Minerva

3.2.3 Big Ideas of Science Analysis

Each lab address at least one big idea of science. The big ideas of science that are addressed by the labs are presented below (Figure 8). In fact 21 out of the 35 online labs (60%) labs address Big Idea No. 6, 21 out of the 35 online labs (60%) labs address Big Idea No. 7, 7 out of the 35 online labs (20%) address Big Idea No. 2, 3 out of the 35 online labs (9%) address Big Idea No.3, 3 out of the 35 online labs (9%) address Big Idea No.1, 2 out of the 35 online labs (6%) address Big Idea No.4, and 3 out of the 35 online labs (9%) address Big Idea No.8.

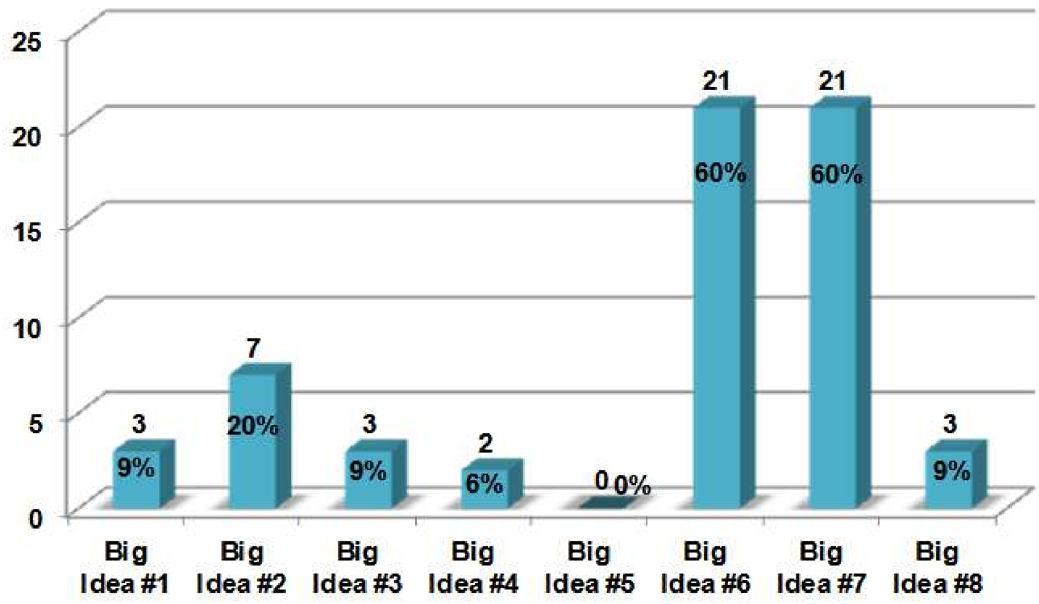


Figure 8. Big Ideas of Science addressed by online labs of Year 2

3.2.4 Subject Domain Analysis

Most of the labs are focused on one specific subject sub-domain (94% of the online labs). In fact, only two of the online labs (6%) are multidisciplinary. More specifically 21 out of 35 (60%) labs cover the biology subject domains, 11 out of 35 labs (31%) cover physics subject domains, 2 out of 35 labs (6%) cover astronomy subject domains, 2 out of 35 labs (6%) cover chemistry subject domains, and 2 out of 35 labs (6%) cover Environmental Education subject domains. This analysis is presented in Figure 9.

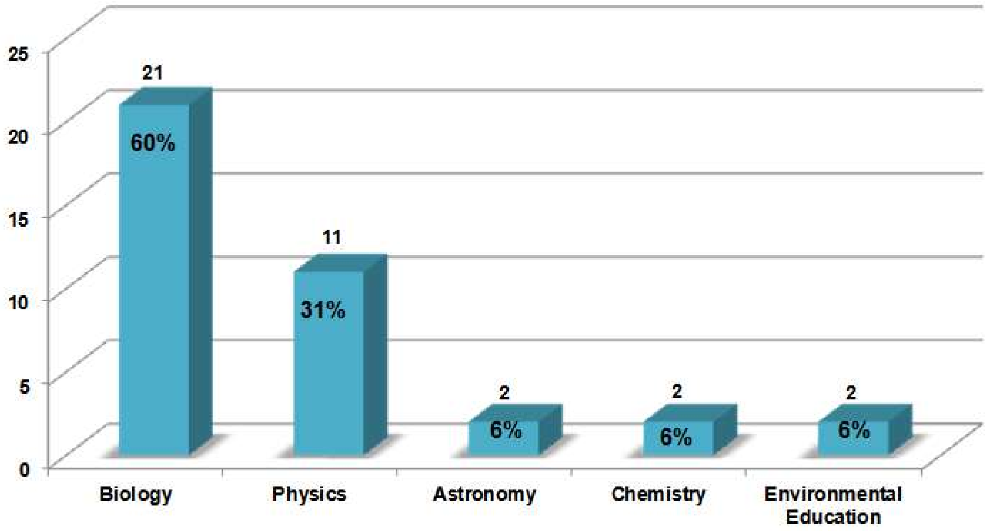


Figure 9. Subject domains covered by online labs of Year 2

As we can notice from Figure 9, the online labs selected to populate the Go-Lab Inventory for year 2 are addressing a variety of subject domains. This is inline with the criteria set in Section 2.1 for the population of the Go-lab Inventory towards the preparation of the large scale pilots.

Table 4. Subject domain covered by online labs of Year 2 and type

Domain	Type	Name
Biology (21)	Remote Labs (0)	-
	Virtual Lab (21)	Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Estimating Population Size Fishbowl Population Genetics Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Mark and Recapture Microcosm Osmotic Power Lab Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour

		Sexual Selection in Guppies Stream Diversity Tragedy of the Commons
	Data Sets (0)	-
Physics (11)	Remote Labs (1)	Red Lab
	Virtual Lab (8)	Foucault's Pendulum GearSketch Long Jump Osmotic Power Lab Radioactivity Lab Segway Control Simulation Splash: Virtual Buoyancy Laboratory Turn Stability
	Data Sets (2)	Minerva Satellite/Moon/Comet Trajectories
Chemistry(2)	Remote Labs (0)	-
	Virtual Lab (2)	Acid-Base Solutions Determination of EMF of a Cell
	Data Sets (0)	-
Environmental Education (2)	Remote Lab (0)	-
	Virtual Lab (2)	Osmotic Power Lab Our Acidifying Ocean
	Data Sets (0)	-
Astronomy (2)	Remote Lab (0)	-
	Virtual Lab (0)	-
	Data Sets (2)	Satellite/Moon/Comet Trajectories Sun4all

3.2.5 Multilingualism

All 35 online labs are offered in English language. Also, the vast majority of them are not multi language. In the following chart (Figure 10) we present the languages that are supported by at least one lab. We can notice that a great variety of European languages are supported by the labs. More specifically English language is supported by 35 (100%) online labs, German is supported by 5 (14%) online labs, French is supported by 3 (9%) online labs, Portuguese is supported by 3 (9%) online labs, Spanish is supported by 2 (6%) labs, and there is twenty (20) more languages that are supported from at least one online lab.

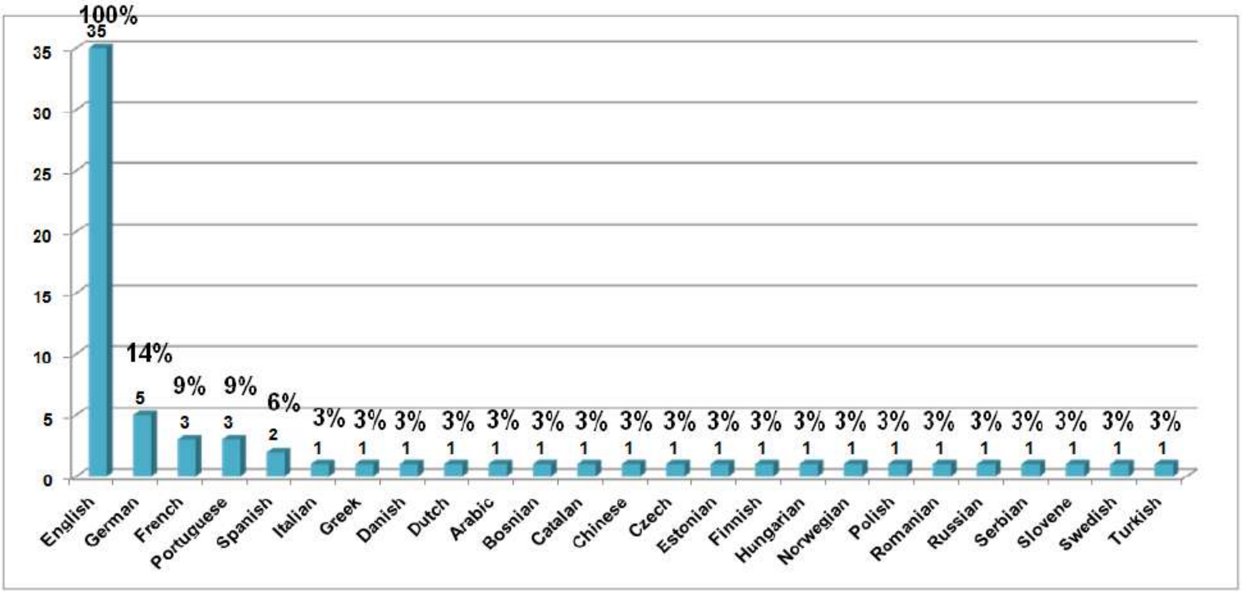


Figure 10. Languages that are supported by the online labs of Year 2

3.2.6 Difficulty and Interaction Level Analysis

The vast majority of the online labs have been described as of a medium level of difficulty. More specifically 30 (86%) of the online labs are – not exclusively – of medium level of difficulty, 3 (9%) are of low level of difficulty and 4 (11%) are of high level of difficulty. The chart which is presented in Figure 11, presents this analysis.

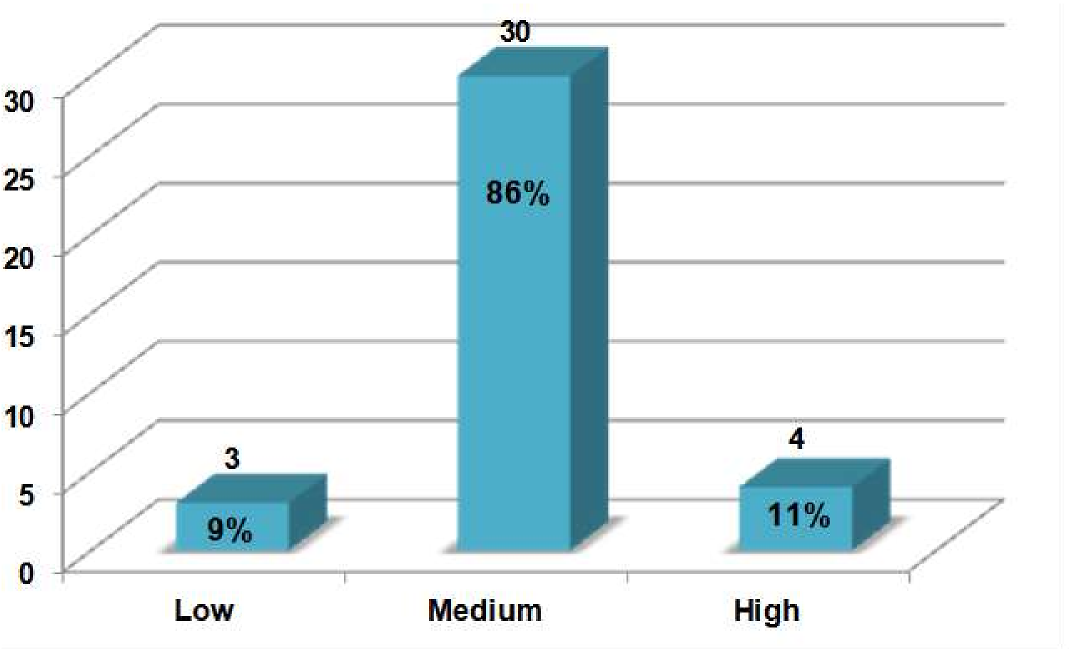


Figure 11. Online labs of Year 2 characterized by Difficulty Level

Moreover, regarding the Interaction Level, the majority of the online labs has been characterized as of high level of Interaction. Thirty (30) of the online labs (85%) are of high level of Interaction, 3 (9%) of the online labs are of medium level and 2 (6%) of the online labs are of low level. The aforementioned statistics are presented in the chart below.

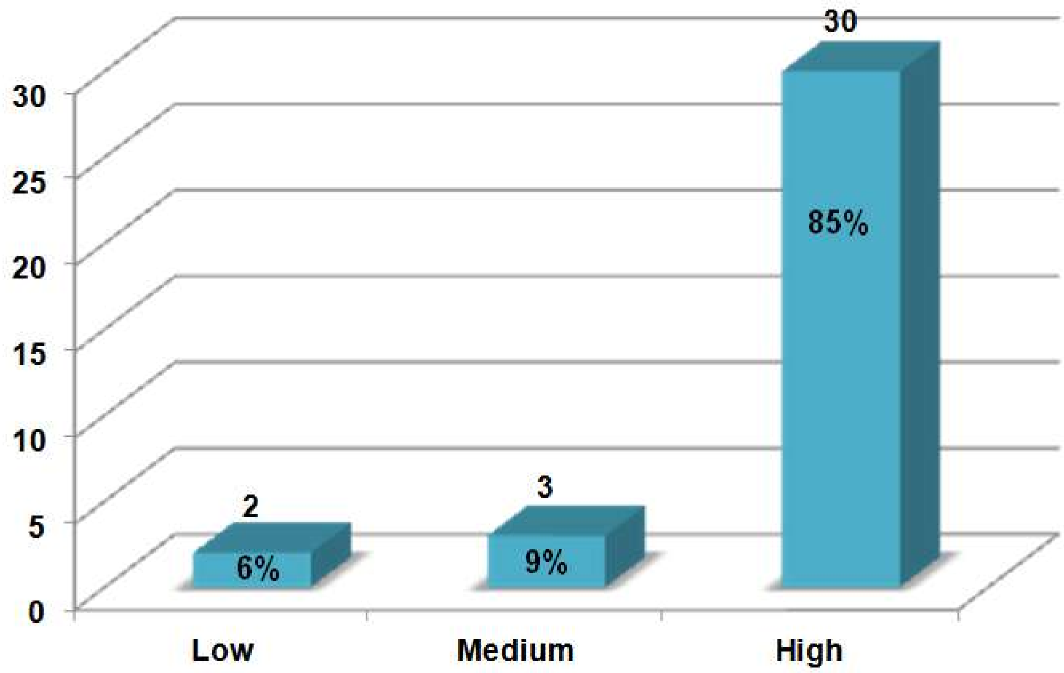


Figure 12. Online labs of Year 2 characterized by Interaction Level

As we can notice from Figure 11 and Figure 12, the online labs selected to populate the Go-Lab Inventory for year 2 are mostly of medium difficult and high interactivity. This is inline with the quality criteria set in Section 2.1 for the population of the Go-lab Inventory towards the preparation of the large scale pilots.

3.3 Analysis of the Go-Lab Inventory of Online Labs for Year 1 and Year 2

At this section we present the analysis of the forty-eight (48) online labs that are included in the Go-Lab Inventory for the 1st and the 2nd year. This section has been divided into seven (7) sub-sections, each one of them regards to a different aspect of analysis, as follows: a) Lab type analysis, b) age range analysis, c) big ideas of science analysis, d) subject domain analysis, e) language analysis, f) difficulty level analysis, and g) interaction level analysis.

3.3.1 Lab Type Analysis

The Go-lab Inventory for the 1st and the 2nd Year includes 48 online labs. In respect to their type, 35 (73%) of them are Virtual Labs, 4 (8%) of them are Data sets and 9 (19%) of them are Remote labs.

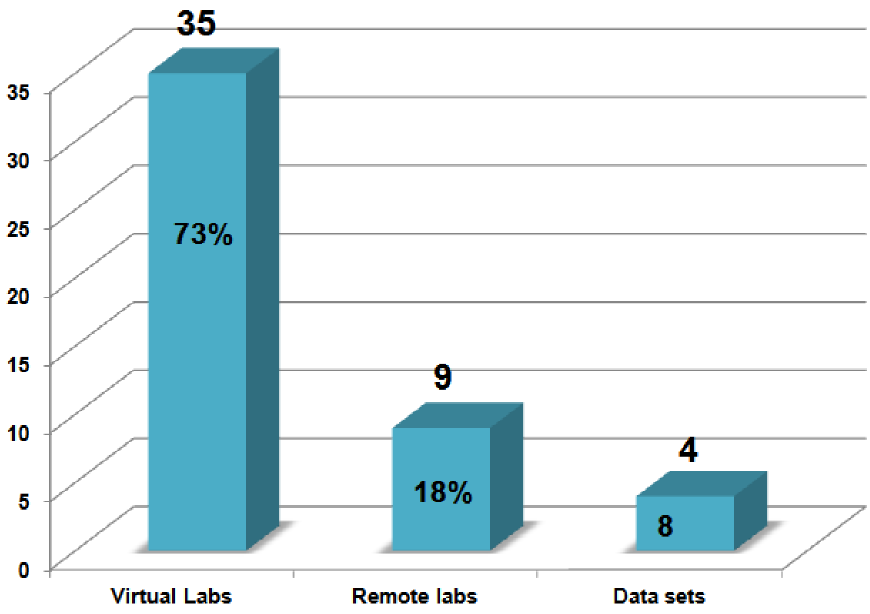


Figure 13. Total Available labs per type

Table 5. Type classification of Total Online Labs

Type	Name
Virtual Labs (35)	Acid-Base Solutions Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Determination of EMF of a Cell Estimating Population Size Fishbowl Population Genetics Foucault's Pendulum GearSketch Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Long Jump Mark and Recapture Microcosm Osmotic Power Lab Our Acidifying Ocean Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Segway Control Simulation

	Sexual Selection in Guppies Splash: Virtual Buoyancy Laboratory Stream Diversity Tragedy of the Commons Turn Stability Electricity Lab CERNLand LHC Game Craters on earth and other planets Galaxy Crash
Remote Labs (9)	Radioactivity Lab RED Lab Black-body Radiation Lab Methyl Orange Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS ELVIS/OP – AMP Labs VISIR The Faulkes Telescope Project WebLab-DEUSTO Aquarium
Data Sets (4)	Minerva Satellite/Moon/Comet Trajectories Sun4all HY.P.A.T.I.A. - Hybrid Pupils' Analysis Tool for Interactions in ATLAS

3.3.2 Age Range Analysis

The Online labs that are included to the Go-Lab Inventory for the Year 1 and the Year 2 cover all age ranges that Go-Lab targets, starting from the age of 10 all the way up to the age of 18. More specifically, there are 44 out of 48 (92%) online labs that cover – not exclusively – the ages from 16 to 18, there are 47 out of 48 (98%) online labs that cover – not exclusively – the ages between 14 and 16 , there are 17 out of 48 (35%) online labs that cover – not exclusively – the ages between 12 and 14 and there are 8 out of 48 (17%) online labs that cover – not exclusively – the ages between 10 and 12.

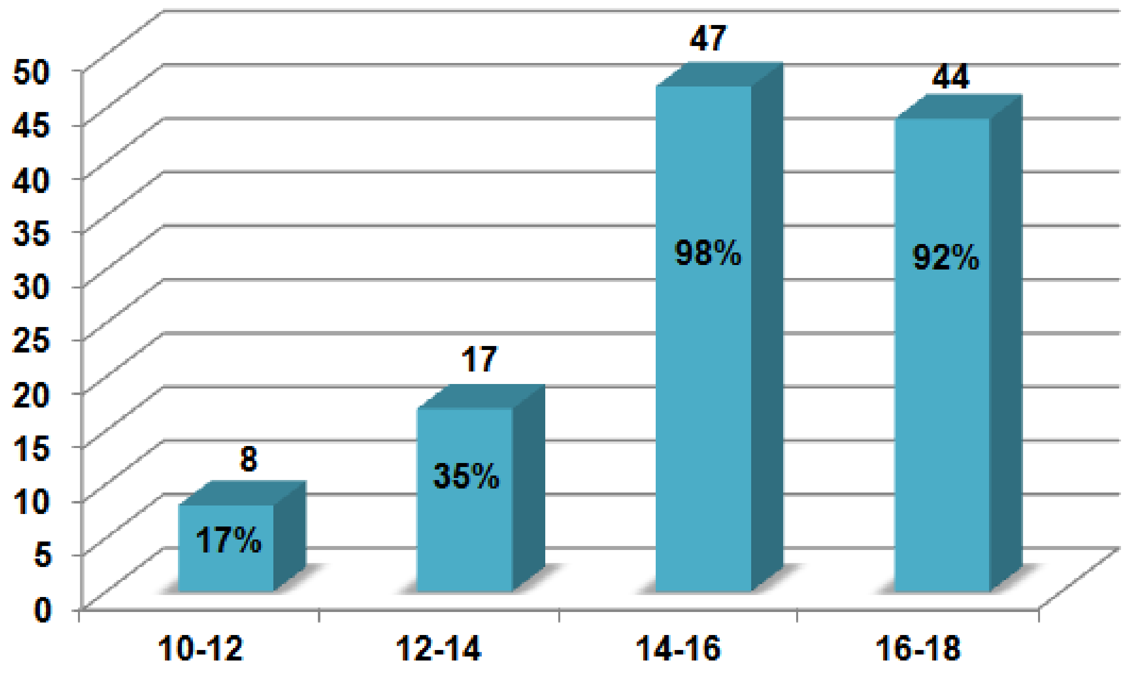


Figure 14. Go-Lab online labs by Age Range

Table 6. Go-Lab online labs by age range and type

Age Range	Type	Name
10-12	Remote Labs (2)	Faulkes Telescope Project WebLab-DEUSTO Aquarium
	Virtual Labs (5)	Foucault's Pendulum GearSketch Splash: Virtual Buoyancy Laboratory CERNland Craters on Earth and Other Planets
	Data Sets (1)	Sun4all
12-14	Remote Labs (4)	Black-body Radiation VISIR Faulkes Telescope Project WebLab-DEUSTO Aquarium
	Virtual Labs (11)	Determination of EMF of a Cell Long Jump Our Acidifying Ocean Turn Stability Galaxy Crash LHC Game Electricity lab Foucault's Pendulum GearSketch

		Splash: Virtual Buoyancy Laboratory Craters on Earth and Other Planets
	Data Sets (2)	Sun4all Satellite/Moon/ Comet Trajectories
14-16	Remote Labs (9)	Faulkes Telescope Project WebLab-DEUSTO Aquarium Black-body Radiation VISIR Radioactivity Lab Red Lab Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS ELVIS / OP – AMP Labs Methyl Orange
	Virtual Labs (34)	Foucault's Pendulum GearSketch Splash: Virtual Buoyancy Laboratory Craters on Earth and Other Planets Determination of EMF of a Cell Long Jump Our Acidifying Ocean Turn Stability Galaxy Crash LHC Game Electricity lab Acid-Based Solutions Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Estimating Population Size Fishbowl Population Genetics Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Mark and Recapture Microcosm Osmotic Power Lab Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Segway Control Simulation

		Sexual Selection in Guppies Stream Diversity Tragedy of the Commons
	Data Sets (4)	Sun4all Satellite/Moon/ Comet Trajectories Minerva HY.P.A.T.I.A.. - Hybrid Pupils' Analysis Tool for Interactions in ATLAS
16-18	Remote Labs (8)	Faulkes Telescope Project Black-body Radiation VISIR Radioactivity Lab Red Lab Boole-Deusto + WebLab-Deusto DIGITAL SYSTEMS ELVIS / OP – AMP Labs Methyl Orange
	Virtual Labs (32)	Foucault's Pendulum GearSketch Craters on Earth and Other Planets Determination of EMF of a Cell Long Jump Our Acidifying Ocean Turn Stability Galaxy Crash Electricity lab Acid-Based Solutions Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Estimating Population Size Fishbowl Population Genetics Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Mark and Recapture Microcosm Osmotic Power Lab Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Segway Control Simulation

		Sexual Selection in Guppies
		Stream Diversity
		Tragedy of the Commons
	Data Sets (4)	Minerva
		Satellite/Moon/Comet Trajectories
		Sun4all
		HY.P.A.T.I.A. - Hybrid Pupils' Analysis Tool for Interactions in ATLAS

3.3.3 Big Ideas of Science Analysis

The labs address big ideas of science. The big ideas of science that are addressed by the labs are presented below (Figure 15). In fact 22 out of the 48 online labs (46%) labs address the Big Idea No. 7, 21 out of the 48 online labs (44%) labs address the Big Idea No. 6, 14 out of the 48 online labs (29%) address the Big Idea No. 1, 19 out of the 48 online labs (40%) address the Big Idea No.2, 10 out of the 48 online labs (21%) address the Big Idea No.3, 7 out of the 48 online labs (15%) address the Big Idea No.4, 6 out of the 48 online labs (13%) address the Big Idea No.5 and 4 out of the 48 online labs (8%) address the Big Idea No.8.

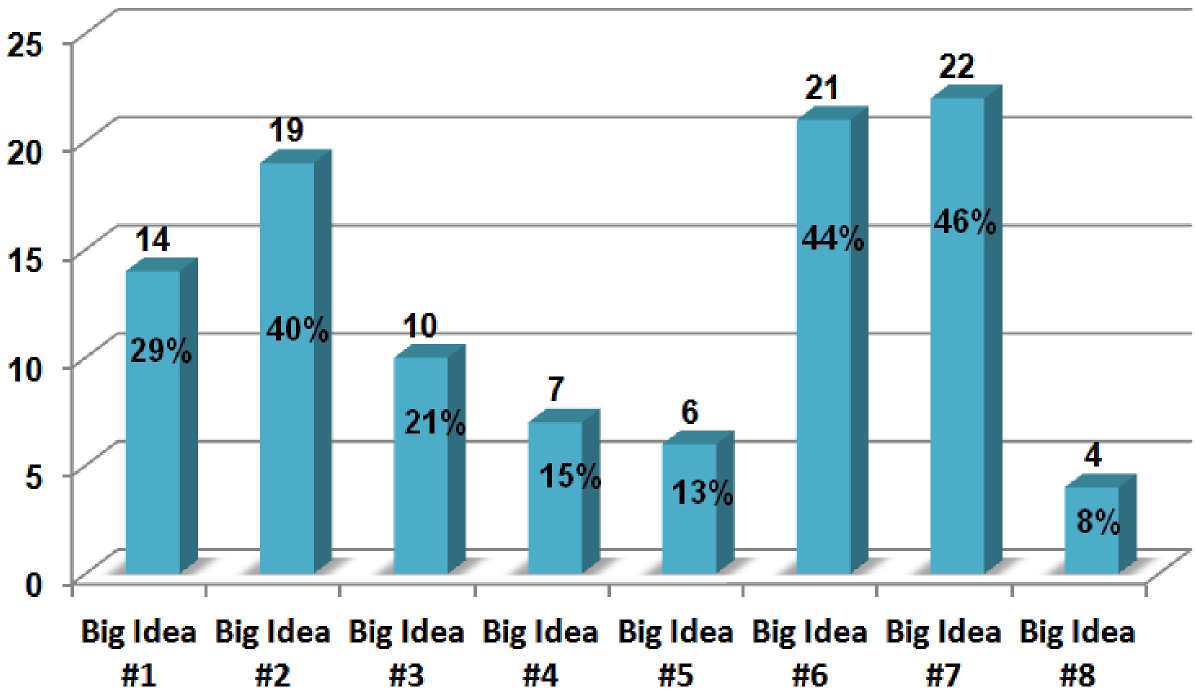


Figure 15. Big Ideas of Science addressed by Go-Lab online labs

3.3.4 Subject Domain Analysis

Most of the labs are focused on one specific subject sub-domain (96% of the online labs). In fact, only two of the online labs (4%) are multidisciplinary. More specifically 21 out of 48 (44%) labs cover the Biology subject domain, 17 out of 48 labs (35%) cover the Physics subject domain, 10 out of 48 labs (21%) cover the Astronomy subject domain, 3 out of 48 labs (6%) cover the Chemistry subject domain, 2 out of 48 labs (4%) cover the Environmental Education subject domain, and 1 out of 48 labs (2%) cover the Geography and earth science subject domain. This analysis is presented in the Figure 16 below.

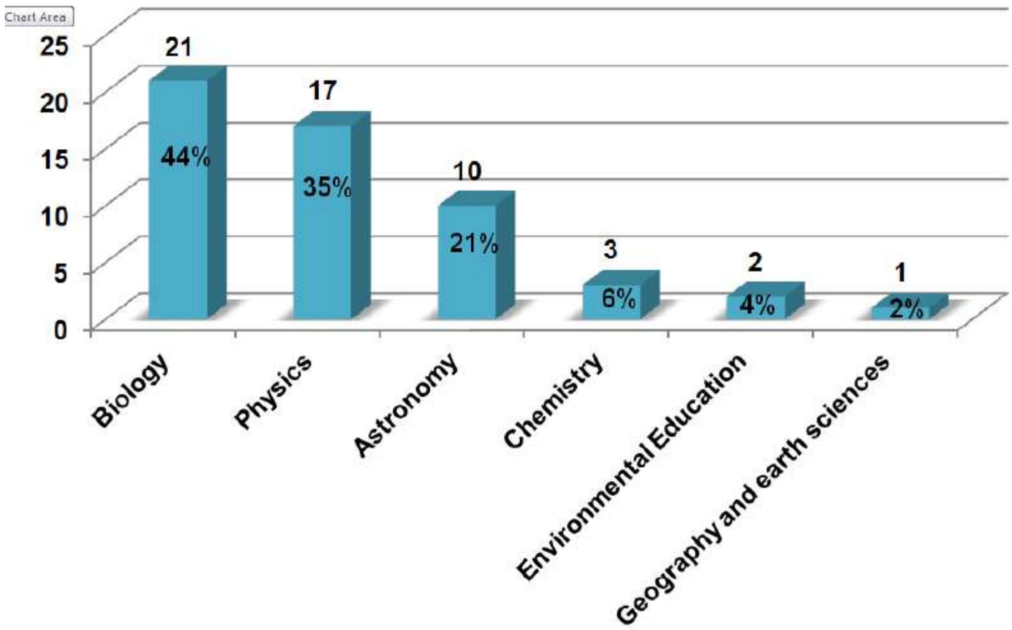


Figure 16. Subject Domain Analysis of the Go-Lab online labs

Table 7. Subject Domain covered of the Go-Lab online labs and type

Domain	Type	Name
	Remote Labs (0)	-
Biology (21)	Virtual Lab (21)	Barnacle Competition Bee Foraging Biomagnification Collective Vigilance Behaviour Estimating Population Size Fishbowl Population Genetics Habitat Fragmentation Individual Vigilance Behaviour Industrial Melanism Island Biogeography Logistic Growth Mark and Recapture Microcosm Osmotic Power Lab Plant Diversity Random Genetic Drift Random Genetic Effects Searching Behaviour Sexual Selection in Guppies Stream Diversity Tragedy of the Commons
	Data Sets (0)	-

Physics (17)	Remote Labs (3)	Red Lab Black-body Radiation Lab WebLab-DEUSTO Aquarium
	Virtual Lab (11)	Foucault's Pendulum GearSketch Long Jump Osmotic Power Lab Radioactivity Lab Segway Control Simulation Splash: Virtual Buoyancy Laboratory Turn Stability CERNLand LHC Game Craters on Earth and Other Planets
	Data Sets (3)	Minerva Satellite/Moon/Comet Trajectories HY.P.A.T.I.A. - Hybrid Pupils' Analysis Tool for Interactions in ATLAS
Chemistry(3)	Remote Labs (1)	Methyl Orange
	Virtual Lab (2)	Acid-Base Solutions Determination of EMF of a Cell
	Data Sets (0)	-
Environmental Education (2)	Remote Lab (0)	-
	Virtual Lab (2)	Osmotic Power Lab Our Acidifying Ocean
	Data Sets (0)	-
Geography and earth sciences (1)	Remote Lab (0)	-
	Virtual Lab (1)	Craters on Earth and Other Planets
	Data Sets (0)	-
Astronomy (10)	Remote Lab (5)	Black-body Radiation Lab Boole-Deusto + WebLab-Deusto Digital Systems ELVIS/OP – AMP Labs VISIR The Faulkes Telescope Project
	Virtual Lab (3)	Electricity lab Craters on Earth and Other Planets

	Galaxy Crash
Data Sets (2)	Satellite/Moon/Comet Trajectories Sun4all

3.3.5 Multilingualism

All forty-eight (48) online labs are offered in English language. Also, the vast majority of them are not multi language. In the following chart (Figure 17) we present the languages that are supported by at least one lab. We can notice that a great variety of European languages are supported by the labs. More specifically English language is supported by 48 out of 48 (100%) online labs, German is supported by 10 out of 48 (21%) online labs, French is supported by 8 out of 48 (17%) online labs, Spanish is supported by 6 out of 48 (13%) online labs, Italian is supported by 4 out of 48 (8%) labs, and there are twenty-two (22) more languages that are supported from at least one online lab.

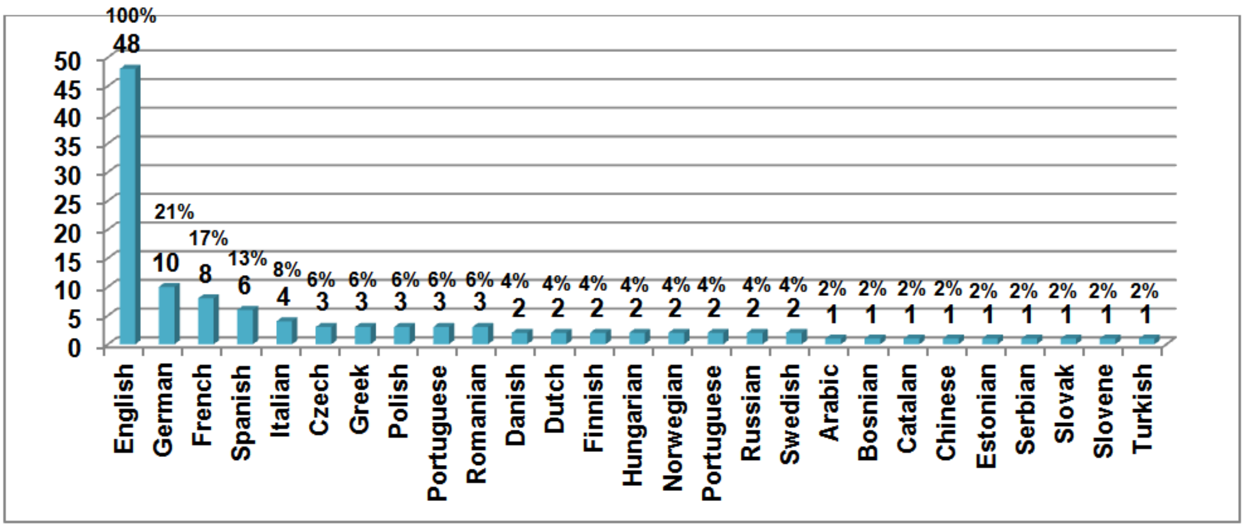


Figure 17. Language Analysis of total online labs

3.3.6 Difficulty and Interaction Level Analysis

The vast majority of the online labs have been described as of a medium level of difficulty. More specifically 37 (77%) of the online labs are – not exclusively – of medium level of difficulty, 8 (17%) are of low level of difficulty and 6 (13%) are of high level of difficulty. The chart which is presented in Figure 18, presents this analysis.

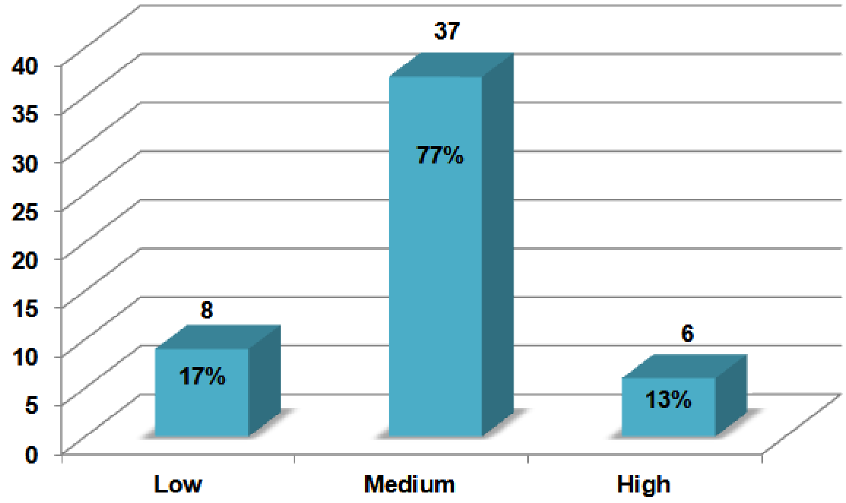


Figure 18. Difficulty Level Analysis of Go-Lab online labs

Moreover, regarding the Interaction Level, the majority of the online labs has been characterized as of high level of Interaction. 38 of the online labs (79%) are of high level of Interaction, 7 (14%) of the online labs are of medium level and 4 (8%) of the online labs are of low level. The aforementioned statistics are presented in the chart below.

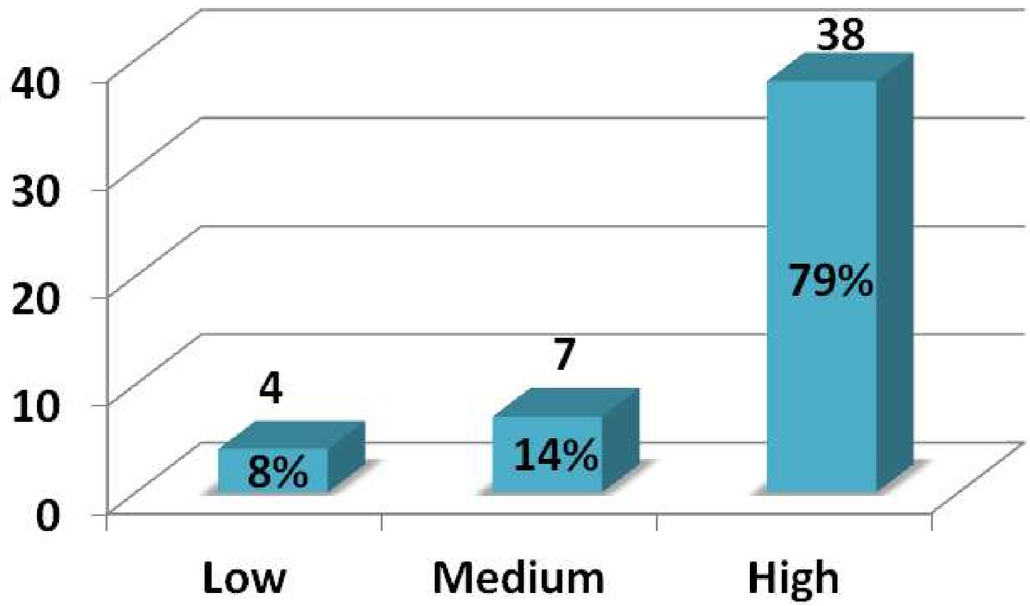


Figure 19. Interaction Level Analysis

4 Validation of the Go-Lab set of “Big ideas of Science”

As presented in deliverable D2.1 (chapter 6), in Go-Lab we refer to “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”. In order to produce the Go-Lab set of ‘Big Ideas of Science’ we did a review on different sets of Big Ideas of Science in general as well as Big Ideas on specific subject areas. The Go-Lab set of Big Ideas of Science was also cross-checked with the Go-Lab science vocabulary so as to ensure that it covers all science subject areas.

Following the production of the Go-Lab set of “Big Ideas of Science” the project team proceeded in validating the proposed approach with teachers and teachers’ trainers in the participating countries. So far, the Big Ideas of Science were presented and discussed in eleven (11) workshops. Overall, in our research so far 233 people have been involved and 186 validation questionnaires were filled in. The Go-Lab set of “Big Ideas of Science” that was used in all the workshops is the one presented below in Table 8. At this point we should also clarify that although the Go-Lab set on the Big Ideas of Science is comprised of two categories (general and specific big ideas) we are focusing our validation only on the specific Big Ideas of Science as these are the set that is going to be used in the Go-Lab repository in order to set up a recommendation system. The reason for doing this is because each of our specific ideas focuses on certain subject areas and they are thus apt for use for a recommendation system in contrast to the general Big Ideas of Science which are universal and are concerned more about science to its total and not specific subject areas (meaning that basically all labs in the Go-Lab repository are under both general Big Ideas of Science).

Table 8. The Go-Lab set on the Big Ideas of Science

<table>
<tr><th>General Big Ideas</th><th>Specific Big Ideas</th></tr>
<tr><td rowspan="2">A. Physical and chemical principles are unchanging and drive both gradual and rapid changes in all systems throughout all scales of the Universe.</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 rowspan="5">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>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>
</table>

	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.

4.1 Research Plan

The evaluation of the Big Ideas of Science was initiated by putting together a respective research plan aiming to record teachers' and teachers' trainers' perspective on the matter. In particular our research plan included questions that aimed to record the participants' current view on the Big Ideas of Science (eg. how familiar they are with the concept) as well as their reactions towards the Go-Lab set of the Big Ideas of Science. The questions of our research plan were the following:

Research Plan Part A – Current Status

- How familiar are teachers with "Big Ideas of Science"?
- Do teachers try to demonstrate to their students the connection between the different subjects they are taught?
- Do they use the concept of "Big Ideas of Science" in their class to interconnect different subjects?
- How important do they find it to have their students understand the connection between the different subjects?
- What are the "Big Ideas of Science" according to the teachers?

Research Plan Part B – Presentation of the Go-Lab approach

- To what degree do they find the suggested set of "Big Ideas of Science" efficient?
- Are there any suggestions to extend it?
- How important do they regard "Big Ideas of Science" when it comes to teaching science?

In order to study the questions mentioned above, we constructed two questionnaires (Annex B) that were used during the workshops. The first questionnaire was delivered to the participants before the beginning of the workshop and it aimed to record to what degree the participants are familiar with the concept of the Big Ideas of Science. In addition we included questions about how important it is to them to interconnect the science subjects they teach at school with other science subjects as well as everyday life; as these are the aspects we wish to promote through the Big Ideas of Science (Go-Lab deliverable D2.1, chapter 6, paragraph 6.1).

The second questionnaire aimed to record the participants' perspective on which are the Big Ideas of Science as well as to what degree their perspective is close to the Go-Lab set. Given that some participants might not have heard of the Big Ideas of Science prior to our workshop, the presented Go-Lab set of Big Ideas of Science would have been be their only reference point on the subject aside from their own personal perspective. Thus, chances were that participants would find it satisfying to a great degree as they would have nothing to compare it to. To this end, participants were presented with one more set of Big Ideas of Science, the set presented in "Principles and big ideas of science education" by Harlen in 2010, which was also the starting point for our work in the production of the Go-Lab set of Big Ideas of Science in deliverable D2.1. Harlen's set played the role of a reference point for the participants helping them do a more accurate evaluation of the Go-Lab set of Big Ideas of Science. It is also worth noticing that we only used Harlen's set of "Big Ideas *of* Science" which are subject-specific ideas and not the set of "Big Ideas *about* Science" as these too are ideas that cover science to a whole and are more concerned with the nature of science. Finally in order to avoid biased answers the two sets were labelled as Set A (Go-Lab set) and Set B (Harlen's set) respectively. Participants were only presented with the origin of the two sets after completing the questions that are about both sets. Harlen's set is presented in Table 9 below:

Table 9. Harlen's set on "Big ideas of Science"

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.

4.2 Workshops setting and alterations

The first part of every workshop was to record the participants' unbiased perspective on the Big Ideas of Science, and especially the degree to which they were familiar with the concept. To this end, before the beginning of the presentation participants were asked to answer a pre-questionnaire (Annex B1). After the completion of the questionnaires the main part of the workshop proceeded which was comprised of four parts:

a. **Familiarization with the concept of the Big Ideas of Science and its definition.** Participants were not presented with any Big Ideas of Science in this part, but only with the general concept. During this part, the tutors also demonstrated why we believe Big Ideas of Science to be important in everyday teaching and what purposes they may serve (Go-Lab deliverable D2.1, chapter 6, paragraph 6.1)

b. **Brainstorming. "What are the Big Ideas of Science according to you?".** In this part teachers were encouraged to brainstorm and write down what are the Big Ideas of Science according to their perspective as teachers. In other words, the main question that was set was "If you had to choose a set of ideas to communicate to your students throughout their school life, that would stick with them for the rest of their lives, what would these ideas be? What are the basic ideas of science that everyone should know regardless their level of education?" Teachers were asked to complete their answers in the post-questionnaire, Question 1 (Annex B2). After the brainstorming participants were asked to read out loud their Big Ideas of Science. Again, it should be noticed that until this point, aside a simple example, no Big Ideas of Science were presented to the teachers in order to avoid biased answers.

c. **Presentation of the Go-Lab Big Ideas of Science and Big Ideas of Science from the bibliography.** During this part participants were presented with the Go-Lab set of Big Ideas of Science as well as another from the bibliography. In particular, as mentioned above, the second set of Big Ideas of Science that was presented was the set presented in “Principles and big ideas of science education”, (Harlen, 2010). The presentation was followed by a discussion among participants during which everyone had a chance to comment on both set as well as compare them. During this part, participants were also asked to fill in the remaining questions of the post-questionnaire (Annex B2).

d. **Big Ideas in Go-Lab.** The workshops’ last part was dedicated to the presentation of the Go-Lab repository and on how we envision integrating the Big Ideas of Science as a recommendation system for the Go-Lab online labs and Inquiry Learning Spaces. The presentation of the Go-Lab repository followed a closing overall discussion where participants could discuss a bit more about Go-Lab, its functionalities and potential as a teaching tool.

After the completion of the first four (4) workshops (fifty (50) questionnaires answered), a preliminary analysis of the results was conducted which let us to change a bit the setting of our workshops. More specifically, it was found out that the Big Ideas of Science that the teachers had written down were closer to writing the general concepts they would like to have big ideas on rather than concrete structured phrases that could be considered as Big Ideas of Science. Some also wrote Big Ideas ‘*about*’ science rather than Big Ideas ‘*of*’ science, meaning ideas that were about the nature of science and its impact on our lives. To this end we changed the second part of the workshop with the aim to allow the teachers to work more on synthesizing Big Ideas of Science. The altered part b is presented below.

Brainstorming. “What are the Big Ideas of Science according to you?” – Version 2 Teachers were again encouraged to brainstorm and write down what are the Big Ideas of Science according to their perspective following the same questions mentioned above. In order to avoid misunderstandings, the presenter also stressed on the fact that teachers are expected to write down big ideas *of* science and not *about* science. Instead of filling them out in their questionnaire, this time they were asked to use post-it notes (one Big Idea of Science per post-it note). When all participants were finished with writing down their Big Ideas of Science they were asked to put their post-it notes on a wall. In turn, they were asked to review all the post-it notes on the wall, discuss among each other and group them together so as to form clusters of notes that had similar concepts on. Once the clustering of the post-it notes was complete, each participant was asked to select one cluster to work on. Thus, participants formed groups, each of which was responsible for one set of post-it notes. The task of each group was to review all notes in their set, and combine them so as to come up with one Big Idea of Science that would cover them all. After all teams were finished, they were asked to read out loud the Big Idea of Science they had come up with and in turn to write it down in the first question of the post-questionnaire. After reviewing the results coming from the remaining workshops (137 questionnaires) where the second version of part b was used, it was clear that the answers coming from the working groups were much closer to concrete and complete Big Ideas of Science. It is worth noticing that participants who participated in the second round were also more enthusiastic and active during the workshop, which clearly indicates that collaborative work among participants during these workshops can be very beneficial.

Figure 20. Participants working collaboratively during the Big Ideas session at the Go-Lab summer school 2014

Figure 21. Participants working collaboratively during the Big Ideas session at the Go-Lab summer school 2014

4.3 General information on the participants

So far, workshops have been conducted in Portugal, Greece and the Netherlands. As however three of the workshops were international, participants come from different countries as well. The total sample of participants comes from Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus, Estonia, Germany, Italy, Poland, Romania, Slovenia, Spain, Switzerland, The Netherlands, UK and USA. The general characteristics of our sample are as follows:

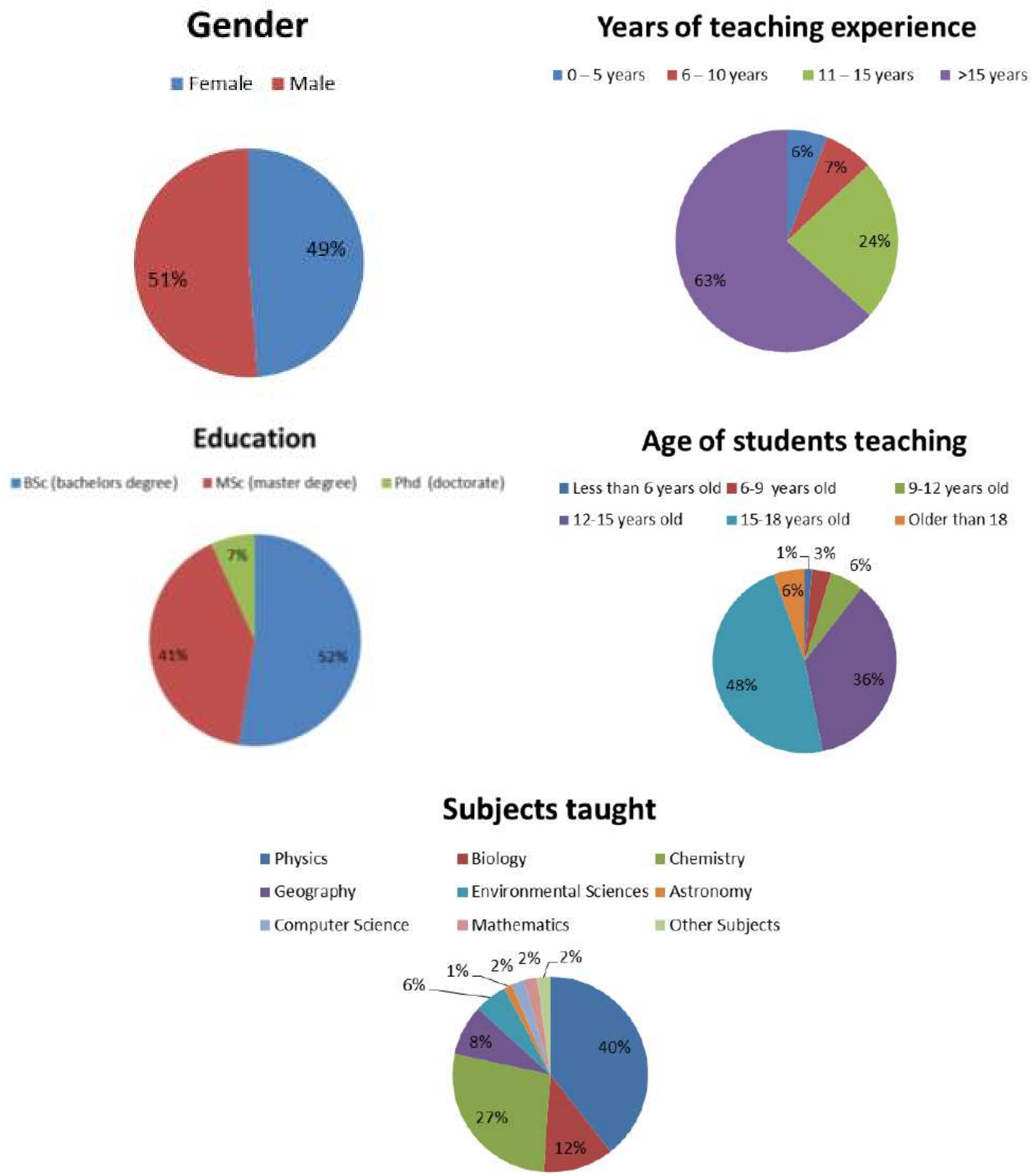


Figure 22. Analysis of background information for the sample of participants

The target group of our research was the teachers who participated in the Go-Lab pilots over the first pilot phase of the project or that had expressed their interest to participate in the second pilot phase. In total we have reached a sample of 233 people. From these 233 people, so far in our research we have obtained and analyzed 186 questionnaires (80%). In the sample of the 186 people that have answered our questionnaire, 25 people were teachers' trainers (13%) in their countries while the rest of them were teachers of primary and secondary education.
With regards to the general characteristics of our sample we can conclude that there is a gender balance between the participants (49% Female, 51% Male) and that the teachers' profiles are in accordance with the teachers expected to participate in the Go-Lab pilot phases as to their majority they teach science subjects (94%) to students between 9 and 18 years old (90%). In addition to this information, 48% of our sample has at least a master's degree and 87% has more than 11 years of teaching experience so they are considered to be quite experienced teachers.

4.4 Results

4.4.1 Participants' familiarity with the concept "Big Ideas of Science"

During the workshops we gathered our data and information through two questionnaires as well as through discussions with the participants. The first questionnaire, questionnaire A aimed to identify to what degree teachers are familiar with the concept of the Big Ideas of Science and to what degree they could be useful to them. To identify teachers' familiarization with Big Ideas of Science we included two questions in our questionnaire whose results are presented below:

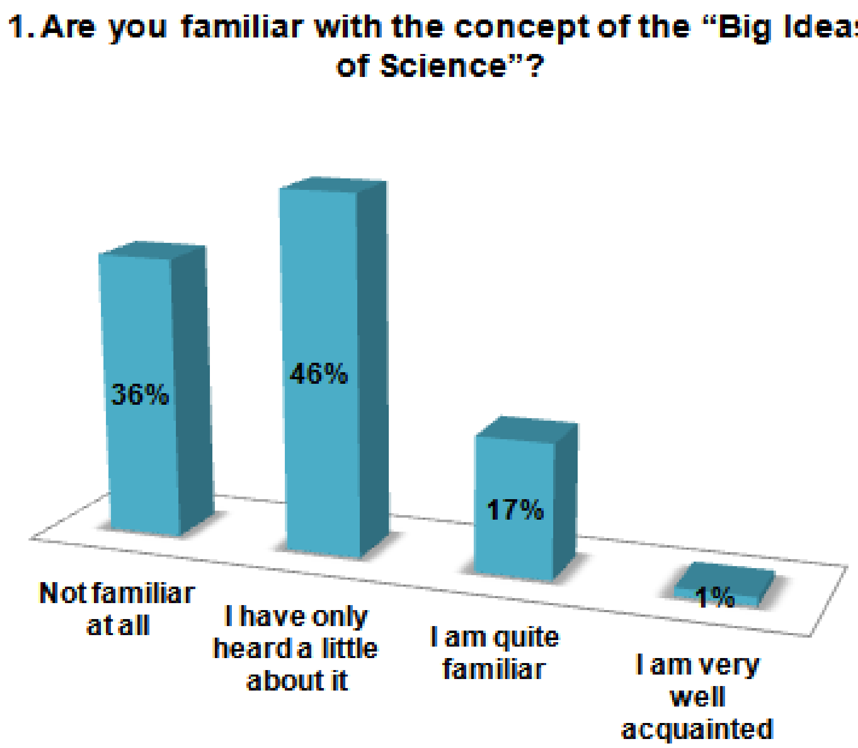


Figure 23. Participants' familiarity with the concept of the "Big Ideas of Science"

Table 10. Teachers opinion on the definition of the "Big Ideas of Science"

2. Which of the following definitions do you believe describes best the “Big Ideas of Science”?	Number of responses	Percentage
1. A set of ideas that briefly outline science’s greatest achievements and discoveries.	23/186	12%
2. A set of cross-cutting scientific concepts that describe the world around us and allow us to conceive the connection between different natural phenomena.	**101/186**	**54%**
3. A set of concepts that outline how science works and what principles (ethical, social, economic and political implications) it is submitted to.	31/186	17%
4. A set of proposals that demonstrate to teachers how to teach science in the most successful and efficient way.	31/186	17%

As it can be seen by the results above, although the majority of participants have enough experience in teaching science (7% between 6 and 10 years of experience and 87% more than 11 years), 82% of them are basically not familiar with the concept of Big Ideas of Science, so in turn they don’t use this concept in their everyday teaching. However, despite the high percentage of people who are not familiar with Big Ideas of Science, 54% of them have selected definition number 2 which is the definition of Big Ideas of Science given in Go-Lab (Go-Lab deliverable D2.1, chapter 6, paragraph 6.1). This could indicate that although teachers are not very familiar with the term “Big Ideas of Science” it is still close to their understanding and they can quite easily relate to it and understand what it stands for.

As the Big Ideas of Science can serve to increase student ability to make connections between different science subjects they are taught in school as well as between what they learn at school and the world around them, the four remaining questions of questionnaire A aimed to record the teachers’ perspective on these matters. In particular, questions 3 and 4 aim to record how often do teachers tend to connect what they teach their students to everyday life and to other science subject respectively. Questions 5 and 6 are set to identify to what degree to teachers believe that these connections are important for their students. The results are presented in the graphs below.

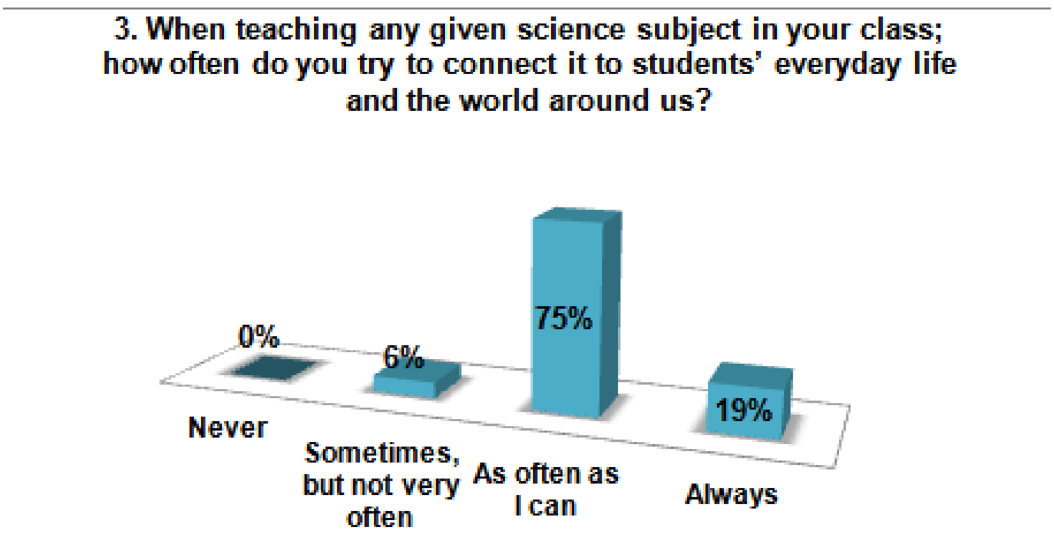


Figure 24. Participants' opinion on the frequency of connecting science subject domains with students' everyday life

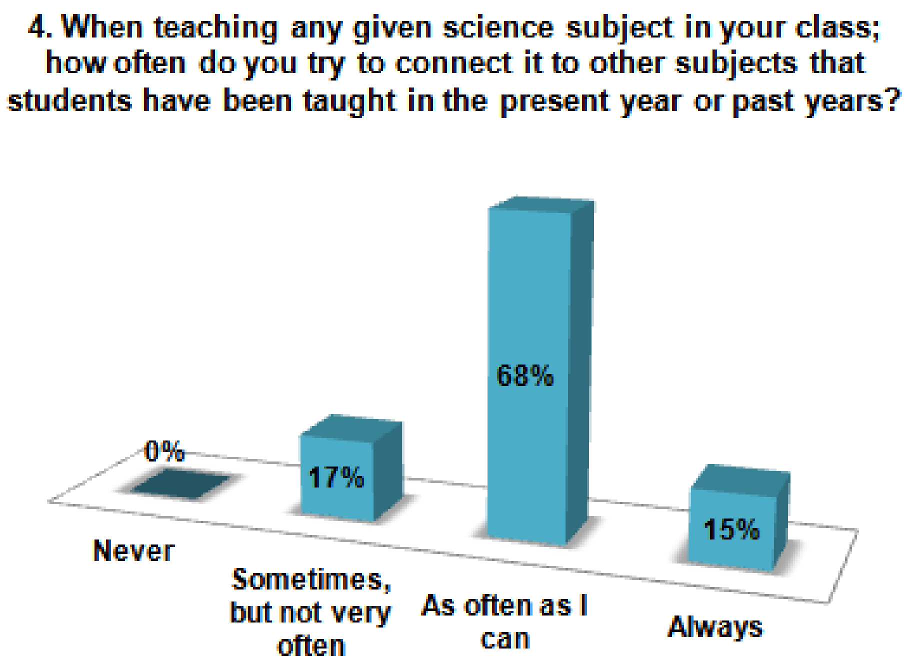


Figure 25. Participants' opinion on the frequency of connecting different science subject domains

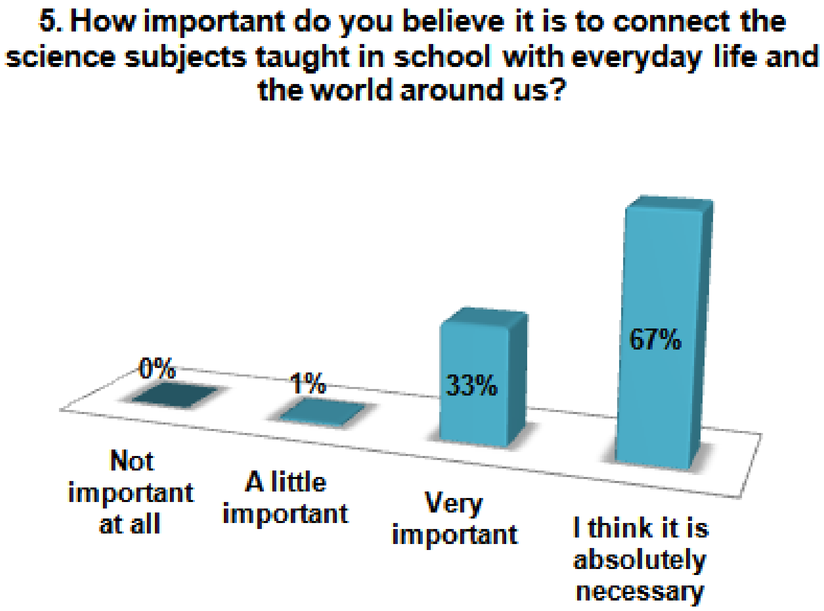


Figure 26. Participants' opinion on the importance of connecting science subject domains with students' everyday life

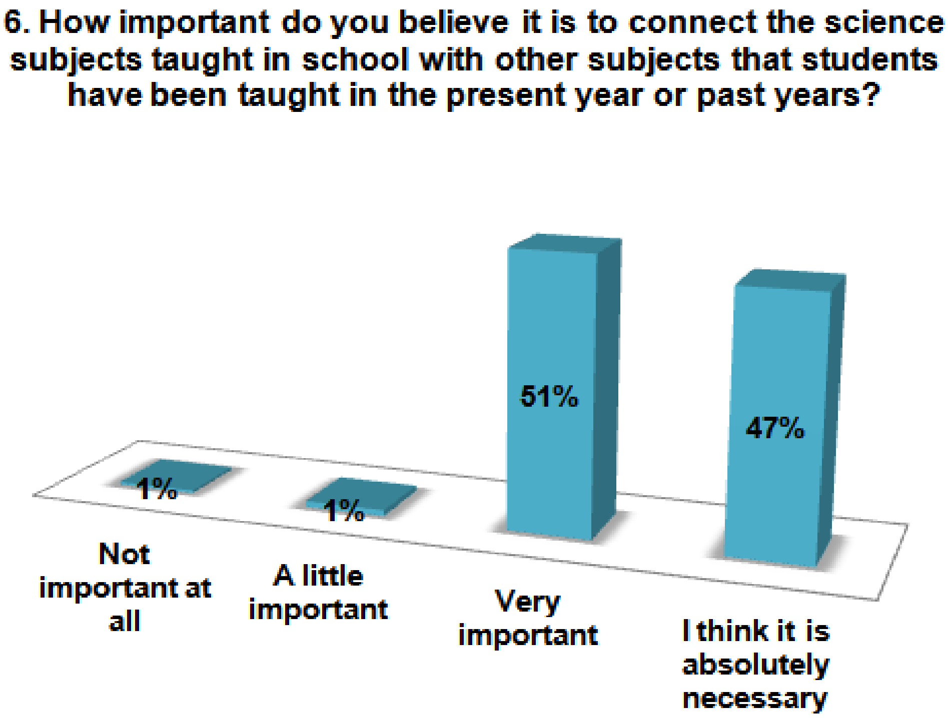


Figure 27. Participants' opinion on the importance of connecting different science subject domains

As seen in the graphs above, it is quite clear that the connection between different science subjects and between science subjects and everyday life are two matters of high importance for practically all teachers participating in our research. This is also why they try to communicate these connections to their students if not always, as often as possible. However, as these teachers have also stated that they are not familiar with the concept of Big Ideas of Science we can assume that they try to make these connections either using some other approach or in a sketchy way which lucks consistence and does not allow students to make strong connections.

So far in our workshops, none of the participants mentioned that they use of some other approach or some specific set of Big Ideas of Science. Thus we can assume that the majority of them work on these two matters without a specific framework in mind. The absence of a concrete set of Big Ideas of Science in the process of interconnecting different science subjects could also mean that students may understand occasionally the common ground between different phenomena and concepts they do not have however a reference point to which they can go back and add build on as they move from one grade to the other. Thus the approach followed by teachers currently seems to luck the elements which will allow them to work on these matters in a coherent way, aggregating knowledge and building on past knowledge in a constructive way. The Go-Lab set of Big Ideas of Science could play the role of such a reference point which teachers can use in their class so as to communicate the matters under discussion in a more productive way.

4.4.2 What are the Big Ideas of Science according to teachers and teachers' trainers? – Comparison with the Go-Lab set of Big Ideas of Science

During the first part of each workshop teachers were presented with the concept of Big Ideas of Science. At first there was an introduction to present the need of connecting the concepts, phenomena and principles that students learn about in order to facilitate them in acquiring a better view of how our world works and what is the relevance between our world and what they are taught in school. The idea of how smaller ideas and individual phenomena and principles can be part of bigger ideas was present along with specific examples. The definition of the Go-Lab set of Big Ideas of Science as well as what their added value can be was also presented. After making sure that all participants had a clear idea on what Big Ideas of Science are we proceeded in the brainstorming phase as described in section 4.2. The results of these brainstorming sessions are presented below.

Brainstorming version 1

In the question ‘What are the Big Ideas of Science according to you?’, out of the 186 questionnaires that were collected, 14 of them (8%) included answers that were either irrelevant, too general or big ideas ‘about’ science instead of big ideas ‘of’ science. Thus, the answers for this particular question from these 14 questionnaires were excluded. All these 14 questionnaires were collected during the first four workshops and as also explained in paragraph 4.2 the relatively high number of off-topic answers (14 out of 50 questionnaires, 28%) also lead us to modifying the process of brainstorming.

From the 172 remaining questionnaires (including post-it notes) that were included in this part of the analysis we obtained 747 single answers from participants. These answers can be categorized in 11 categories:

- **Basic elements and structure of matter** (elements of the periodic table, bonds and reactions, elementary particles): 97 answers
- **Earth** (climate, structure, phenomena, interaction with living organisms and ecosystems, atmosphere): 52 answers
- **Energy** (conservation, transformation, forms, dark energy, connection to matter): 61 answers
- **Fundamental forces** (Gravity, electromagnetism, electricity, magnetism, motions, Newton's laws**,** interaction between objects, fields): 232 answers
- **Living organisms and evolution** (cells, evolution, origin, biodiversity, DNA): 157 answers
- **Quantum mechanics:** 6 answers
- **Relativity theory:** 7 answers
- **Time and Scales:** 19 answers

- **Universality of laws and principles, conservation of certain quantities in the universe**: 15 answers
- **Universe** (Origin and evolution of the universe, scales, solar system, Earth's place in the universe): 82 answers
- **Waves** (light, sound, wave-particle duality): 19 answers

In general, the Go-Lab set of Big Ideas of Science covers 8 out of these 11 categories. The 3 categories that are not covered are a) Quantum mechanics, b) Relativity theory and c) time and scales which have however received a small number of answers.

In our analysis we first investigated one by one the answers in the categories that are covered by the Go-Lab set of Big Ideas of Science and check whether any of them are not covered by the present set of Big Ideas of Science and if any modifications could improve the current set. The results are presented below:

Table 11. Overall review on participants' answers covered by the current set

Category: Basic elements and structure of matter
Relative Go-Lab Big Ideas of Science: 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.
Comments: Most answers in this category are more focused and not so general so all of them are covered by the present Big Ideas of Science. However an extension could be made to outline the different structure levels (elementary particles, nuclei, atoms-elements, molecules).
Category: Earth
Relative Go-Lab Big Ideas of Science: 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.
Comments: Some answers refer to the evolution of our planet the composition and mechanisms that exist. These comments fall under the statement 'processes occurring within this system shapes the climate and the surface of the planet'. However a small extensions could be made to underline how these processes are responsible for the evolution of the planet.
Category: Energy
Relative Go-Lab Big Ideas of Science: 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.
Comments: Some answers are about the transformation of energy into matter and vice versa.
Category: Fundamental forces
Relative Go-Lab Big Ideas of Science: 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.
Comments: All answers in this category are covered by the present Big Ideas of Science. Most answers referred to specific fundamental forces and related laws which however are considered to be small ideas.
Category: Living organisms and evolution
Relative Go-Lab Big Ideas of Science: 1. 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. 2.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.
Comments: Some answers are about the origin of life.
Category: Universality of laws and principles, conservation of certain quantities in the universe
Relative Go-Lab Big Ideas of Science: 1. 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. 2.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.
Comments: Only the conservation of energy is covered and the universality of the fundamental forces. An addition could be made to one of the two Big Ideas of Science or a separate Big Ideas of Science can be set to outline the universality of laws and certain principles.
Category: Universe
Relative Go-Lab Big Ideas of Science: 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.
Comments: There are answers concerning the origin of our Universe. Some also focus on the solar system. Modifications could be made to include these two elements.
Category: Waves
Relative Go-Lab Big Ideas of Science: All matter and radiation exhibit both wave and particle properties.
Comments: Some answers make a distinction between the different types of ways.

After reviewing the categories that are already covered by the current Go-Lab set we then had a review of the answers in the categories that did not seem to be covered by the current set.

Table 12. Overall review on participants' answers not covered by the current set

Category: Quantum mechanics
Comments: Quantum mechanics could be covered by extending Big Ideas of Science: "All matter and radiation exhibit both wave and particle properties."
Category: Relativity theory
Comments: The theory of relativity is about extreme conditions (velocity very close to the speed of light) where measuring time and space are relative to the speed of an observer. The theory of relativity is very closely related to the Gravitational force and thus covered by the respective Big Ideas of Science about fundamental. So far the number of answers about the relativity theory are too few to consider adding another Big Ideas of Science based on them.
Category: Time and Scales
Comments: The Go-Lab set of Big Ideas of Science covers all scales of the Universe. Based on the fact that students correspond better to images rather than text, perhaps a schematic representation of them in a scale could be helpful for the teachers and in turn for the students. Time on the other hand is a concept everyone has a good idea about since our young years. To this end an addition does not appear necessary. On the other hand, the relativity of time is a

matter worth looking into. A Big Ideas of Science covering this matter would be under the theory of relativity and thus covered by the previous suggestion.

Brainstorming version 2

As mentioned in section 4.2 after the first four workshops we decided to change the brainstorming part of the session in order to get more concrete Big Ideas of Science that are derived from the collaborative work of the participants rather than their individual thoughts. The second version was used in seven workshops were 176 people participated. From these workshops we retrieved many Big Ideas of Science some of which are presented in the Table 13 below:

Table 13. Big Ideas of Science produced by participants compared to the Go-Lab set of Big Ideas of Science

Big Ideas of Science presented by the participants.	The Go-Lab set of "Big Ideas of Science"
• The Universe is made by a great number of Galaxies. • Earth is a very small part of the Universe, around a star within a galaxy which is grouped alongside millions of others. • The universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects. The solar system is a very small part of one of billions of galaxies in the universe. Earth is a very small part of the universe.	Earth is a very small part of the Universe. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects.
• Earth and the systems that exist on the planet are related to climate. Earth is a living combination of the interactive systems constantly changing. • Earth is a system with many interconnected components, continuously changing. Humans depend on the Earth but also influence this environment.	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.
• Fundamental particles form the matter we know. • The entire universe is made up of the same elementary units.	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.
• All life on Earth has the same biochemical composition that has evolved through time. • Genetic variance, inheritance and natural selection enable life systems to evolve in response	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.

to many environmental changes. Life exists in all areas of our planet, though its origin is so far not understood. We do not currently know about any life beyond Earth. • Live organisms are made of cells. Cells include genetic material which is transferred from one generation to another. The mutation of our DNA, and our environment lead to evolution based on the laws of natural selection	
• Living things are made up by cells. Cells are the 'unit' of life. • Cells are the fundamental unit of life. All organisms are made of from cells. Our health and bodily functions are due to the organized processes in cells. Every cell is created from existing cells.	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.
• All the changes we can see are due to the presence of forces which act between bodies (charges etc.) Forces are ruled by laws (like Newton's) which define them and the results they produce. • Forces (from a distance or not) are the cause of a change in motion or of a change in the shape of a body. There are 4 forces (gravity, electromagnetism, strong-nuclear and weak nuclear) and they are acting through respective fields. • Forces (interactions) act at a distance via fields.	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.
• Energy is matter and vice versa. Energy is never lost; it's just transformed from one type to another through different mechanisms. • Matter energy and forces are connected.	Energy is conserved; it 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.
• Human beings are just a very-very small part of the whole universe. • Earth is a very small part of the Universe, around a star within a galaxy which is grouped alongside millions of others. • We live on Earth, a part of the solar system. All the planets orbit around the sun, one of the millions stars in the galaxy. Stars look pointy because they are very far away. The universe is full of groups of galaxies.	Earth is a very small part of the Universe. The Universe is comprised of billions of galaxies each of which contains billions of stars and other celestial objects.
• Matter in universe is made up of very small particles.	All matter in the Universe is made of very small particles. They are in constant motion and the

• Matter is build based on the bonds formed between a finite number of elements. • Matter is made of molecules. Molecules are made of atoms and atoms are made of protons, neutrons and electrons. Atoms are combined producing chemical compounds with different attributes. Matter has 3 states, solid, liquid and gas, and it can transform from one to another with the transformation of energy.	bonds between them are formed by interactions between them.
• When we look at the smallest parts of matter and at radiation, classical physics and its determinism don't apply any more. A completely new theory needs to be introduced with the following new ideas and tools: a) uncertainty principle, b) wave-particle duality, c) quantification, d) field theory.	All matter and radiation exhibit both wave and particle properties.

The next step of our analysis, was to go over all the answers added in question 4 of questionnaire B (optional question). Out of the 186 questionnaires 54 of them had a comment including more concrete suggestions. These comments are complementary to the answers given in question 1. Some of these comments are presented below.

Table 14. Participants' comments on the Go-Lab Big Ideas of Science

- "Field" can be a difficult concept to understand.
- Mention that everything in the universe is ruled by a set of fundamental laws ideas.
- Add the concept of dark energy.
- Distinguish that the bond is the interaction.
- Wave-particle duality is very difficult for people to comprehend.
- Wave-particle duality could be expanded to include quantum mechanics.
- When talking about living organisms, mention that it is based in the same biochemistry
- Students are only introduced to nuclear forces at the last grade of school and it is a difficult concept for them.
- I would add some more biology topics.
- One Characteristic of matter is motion.
- Maybe to add on the idea 4 that there is some kind of matter (dark matter) that we don't still know what it is. To also give the students the idea that we don't know everything.
- Maybe something including time, the origin and age of the universe.
- I think the uncertainty principle needs to be mentioned together with wave-particle-dualism.
- Everything in the universe is ruled by a set of fundamental laws ideas.

In addition, some of the comments were more general and did not specifically target one Big Idea of Science. These comments are listed below.

- All these concepts are important but not all students can understand them, especially the younger ones. (8 comments)
- Add the concept of time and the origin of time. (2 comments)
- Ask the opinion of students. (4 comments)

Regarding the general comments, it should be noted that all these comments were typed down by the participants after a conversation on the Go-Lab set of Big Ideas of Science. Thus in most cases, although only the person who stated the comment typed it down, it represents the opinion of the majority of the group.
Another metric we used check the validity and quality of the Go-Lab set of Big Ideas of Science was to ask teachers to compare it with another set of Big Ideas of Science, and in particular with one of those that was reviewed during the making of the Go-Lab set. The set to which we compared the Go-Lab set of Big Ideas of Science was the one produced by Harlen (Harlen, 2010). Teachers were presented with both sets and they were asked which of the two is closer to the Big Ideas of Science they thought and which of the two they find more appropriate for their students. We then asked them to briefly explain their choice. The results are presented below.

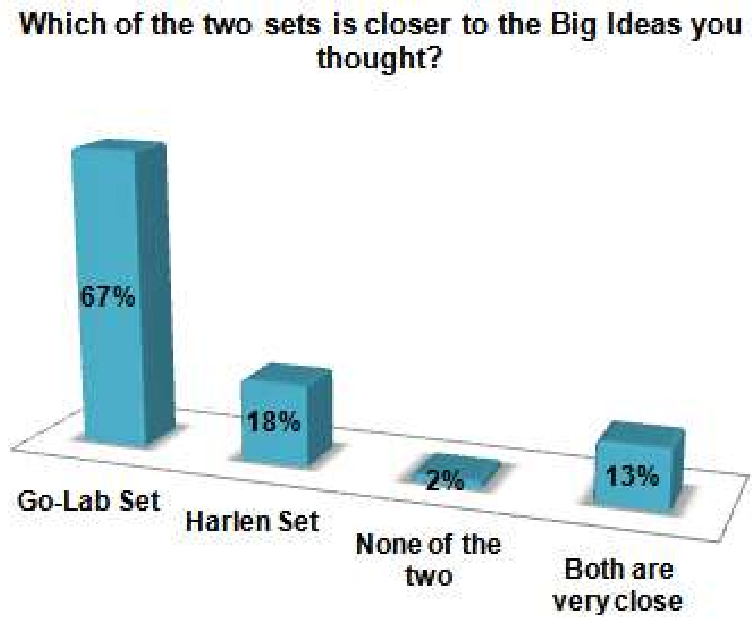


Figure 28. Comparison between Big Ideas of Science produced by participants, the Go-Lab set and Harlen's set of Big Ideas Of Science

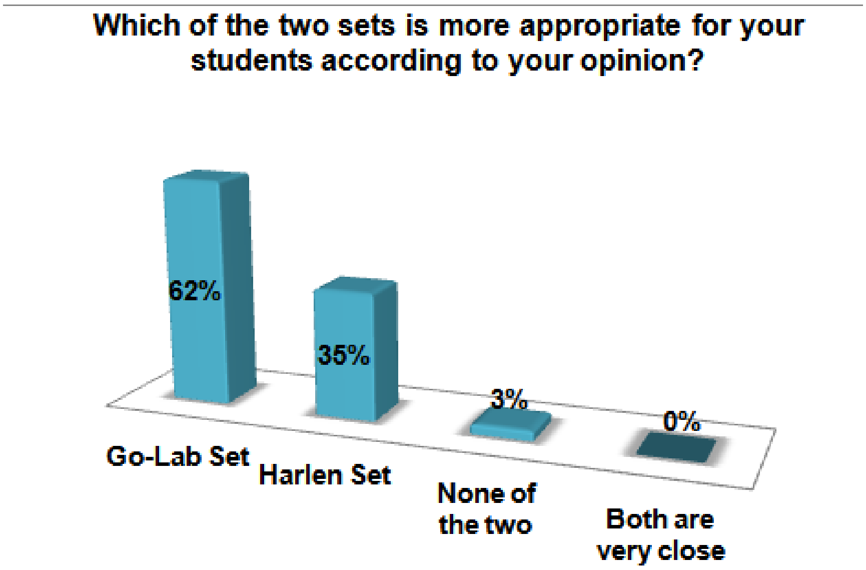


Figure 29. Participants' opinion on using Big Ideas of Science set in the class.

As it can be seen by both graphs, the Go-Lab set of Big Ideas of Science seems to satisfy teachers even compared to Harlen's set of Big Ideas of Science. From the 186 people who answered the questionnaire, 114 (61%) also added and explanation why the prefer one of the two sets compared to the other. The people who answered that they prefer the Go-Lab set of Big Ideas of Science in both previous questions, also state that this set is more general and complete and that it is more explanatory (61 out of 114 comments). People who selected Harlen's set in both previous questions stated that they did so because there are more simple descriptions and it is easier to use in their class (13 comments out of 114). It is also interesting to look at the cases were people selected one of each in each question. In total 38 people gave different answers in the two questions. Out of these 38, 26 people said that the Go-Lab set is closer to the ideas they thought but they find Harlen's set is more appropriate for their students.

Thus, a general conclusion from this comparison is that although the Go-Lab set of Big Ideas of Science is general and complete and thus appropriate to be used in a class, teachers might find it difficult to use it as is in some cases especially with younger students as they would need simpler descriptions. However, the Go-Lab set of Big Ideas of Science is considered to be the set of concepts that any student should have knowledge of when finishing school. In addition, in the framework of Go-Lab this set of Big Ideas of Science is designed so as to be used from teachers and not directly from students. Thus, the design processes had more focus on providing concrete and complete ideas and not so much focus on using simplified terms.

After the brainstorming session, the presentation and the discussion on the two sets of Big Ideas of Science the final two questions for the participants were about the degree to which the find the Go-Lab set of Big Ideas of Science to be satisfying and the degree to which they find Big Ideas of Science to important when teaching science. The results of these two answers are presented below:

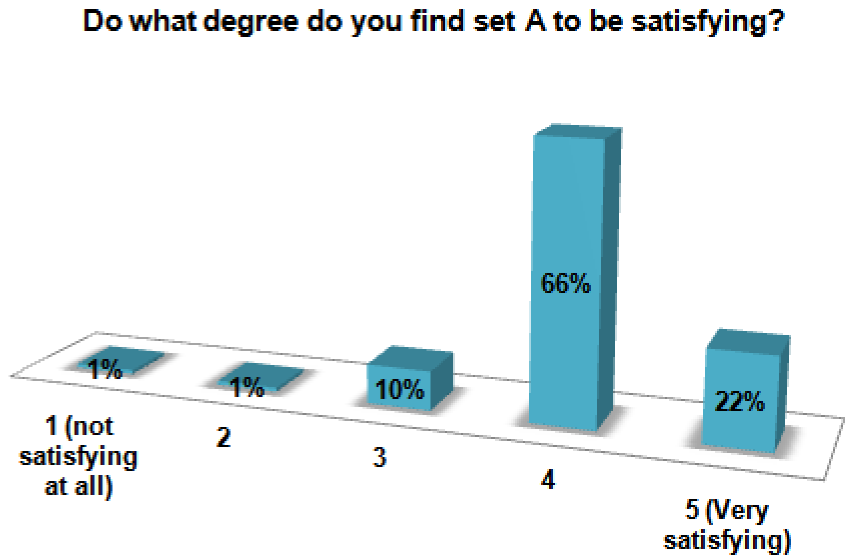


Figure 30. Participants opinion on the validity of the Go-Lab set of Big Ideas of Science

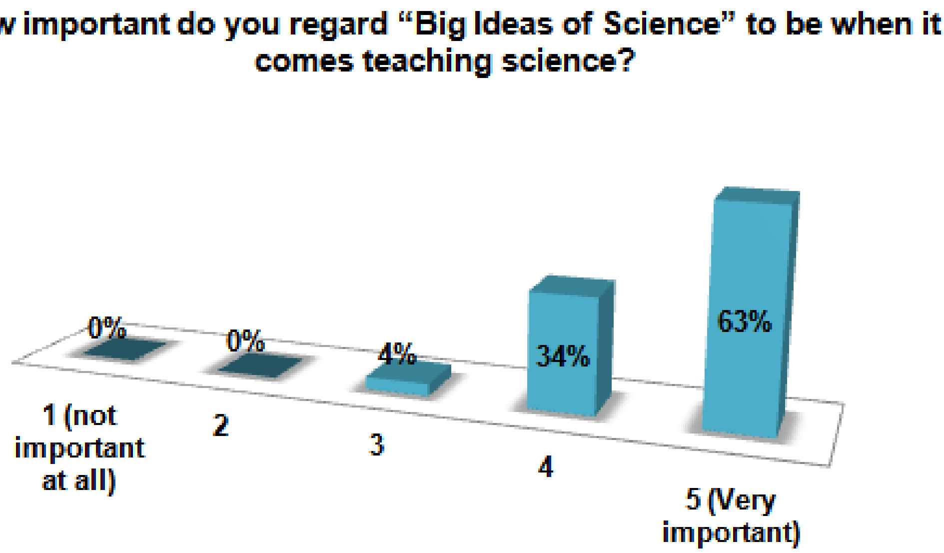


Figure 31. Participants' opinion on the importance of Big Ideas of Science related to teaching science

The results in the graphs above indicate clearly that the teachers and the teachers' trainers that participated in our research so far strongly believe that the Go-Lab set of Big Ideas of Science is satisfying and its use is very important when it comes to teaching science in class.

One last interesting outcome can come from comparing Figure 27 and Figure 31. The main focus of the Go-Lab set of Big Ideas of Science is to interconnect different science subjects. In the pre-questionnaire, in question "How important do you believe it is to connect the science subjects taught in school with other subjects that students have been taught in the present year or past years?" 51% of the participants have answered "Very important" and 47% of them have answered "I think it is absolutely necessary" (98% total positive feedback). In the post-questionnaire, in question "How important do you regard "Big Ideas of Science" to be when it comes teaching science?" 34% of the people gave 4 out 5 (5 being "Very Important") in the likert scale and 63% of them gave 5 out of 5 (97% total positive feedback). These figures and the swift (16%) of participants' opinion towards a higher rating in the latter question may also indicate that their participation in our workshop has contributed in strengthening their view on the importance of connecting different science subjects in the classroom. In addition, given the high rating the Big Ideas of Science have received we can also conclude that the Go-Lab set of the Big Ideas of Science could play the role of a backbone structure on connecting science subjects.

4.5 Proposed Revisions of the Go-Lab set of Big Ideas of Science

Our work on validating the Go-Lab set of Big Ideas of Science was done through the realization of relative workshops as they are described in section 4.2. After analysing the data collected we can safely conclude that the Go-Lab set of Big Ideas of Science is very close to teachers and teachers' trainers notion on the Big Ideas of Science and that they can be used in class in order to connect different subject domains. However, according to teacher's comments a 'lighter' version of these Big Ideas of Science which could be used by teachers who teach younger students could be produced. As however the Go-Lab set of Big Ideas of Science is meant to be used by the teachers only within the Go-Lab repository, this goes beyond the focus of this research and it could be part a next round of workshops. In addition, after taking into consideration the suggestions of teachers gathered from the questionnaires and in particular: a) their individual answers on what are the Big Ideas of Science according to them; b) their comments on the current Go-Lab set of Big Ideas of Science; c) the comparison with Harlen's set and d) the overall discussions during workshops, we have made some revisions to our current set of Big Ideas of Science and propose a set of modifications.

Aside from minor modifications in the writing of each idea the main modification we decided to do was to change their structure a little. As most of our Big Ideas of Science can be a bit extensive, in the spirit of serving the needs of teachers who requested shorter and simpler Big Ideas of Science as well as in order to make sure that our Big Ideas of Science can be used effectively within Go-Lab repository we decided to divide each Big Ideas of Science into two parts. The first part will be a first short sentence which contains very briefly the essence or the core part of a Big Idea of Science. The second part would be the remaining text of each Big Idea of Science as it is now which basically compliments the first sentence and completes the meaning of the Big Ideas of Science. Thus, the Go-Lab set of Big Ideas of Science is going to be modified as follows:

Table 15. The updated set of the Go-Lab set of Big Ideas of Science

Current Go-Lab set of Big Ideas	Modified Go-Lab set of Big Ideas
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.	**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. Energy can also turn into mass and vice versa.
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.	**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.	**3. Earth is a very small part of the universe.** The Universe is comprised of billions of galaxies each of which contains billions of stars (suns) and other celestial objects. Earth is small part of a solar system with our Sun in its centre that in turn 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.	**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. Elementary particles as we know them so far form atoms and atoms form molecules. There is a finite number of types of atoms in the universe which are the elements of the periodic table.
5. All matter and radiation exhibit both wave and particle properties.	**5. In very small scales our world is subjected to the laws of quantum mechanics.** All matter and radiation exhibit both wave and particle properties. We cannot simultaneously know the position and the momentum of a particle.
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.	**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.
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.	**7. Organisms are organized on a cellular basis.** They require a supply of energy and materials. All life forms on our planet are based on this 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.	**8. Earth is a system of systems which influences and is influenced by life on the planet.** The processes occurring within this system influence the evolution of our planet, shapes its climate and surface. The solar system also influences Earth and life on the planet.

4.6 Integration of the "Big Ideas of Science" in the Go-Lab repository

The integration of Big Ideas of Science has already been implemented in the Go-Lab repository on multiple levels:

- A "Big Ideas" tab has been add in the top bar of the Go-Lab repository

Figure 32. Top menu of the Go-Lab repository

- By clicking on the "Big Ideas" tab the user can see the entire set of Big Ideas of Science.

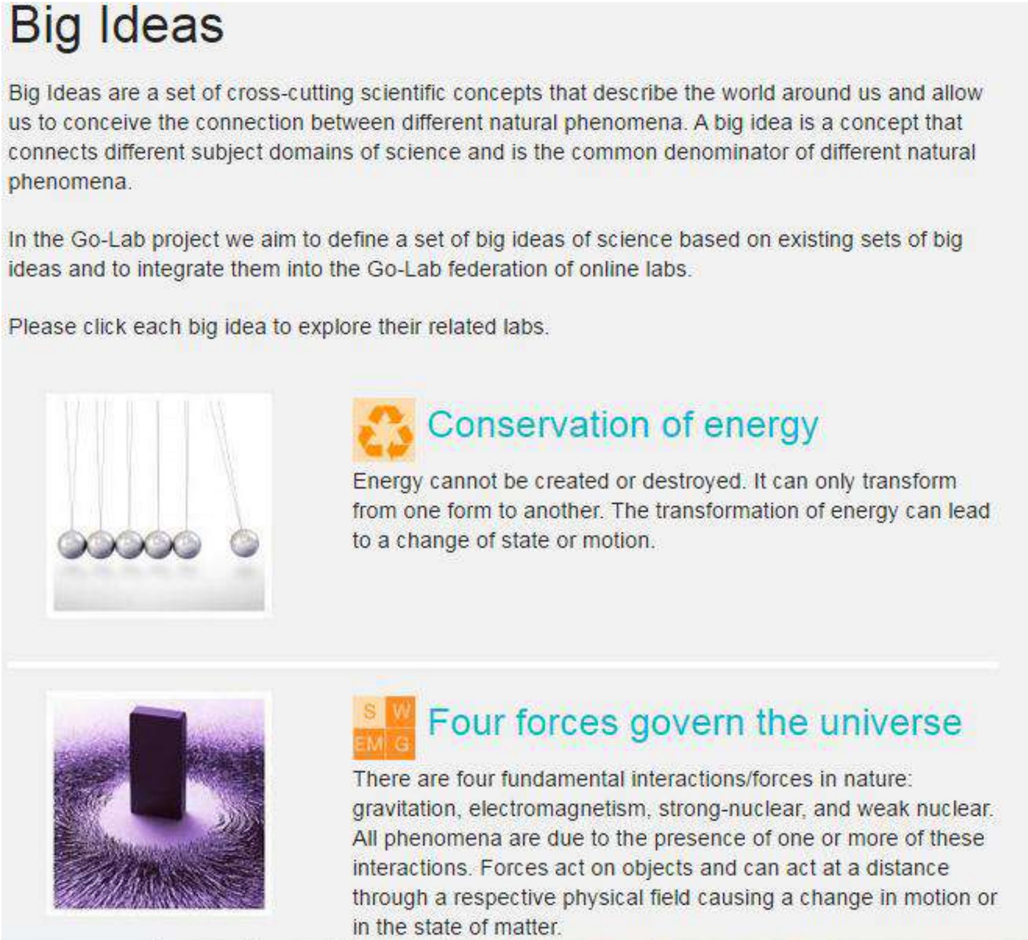


Figure 33. Big Ideas of Science page in the Go-Lab repository

- In the node page of each lab the Big Ideas of Science related to it are presented in the form of coloured thumbnails.

Figure 34. The node page of a Go-Lab lab where the Big Ideas of Science are also depicted

- By clicking on a thumbnail the user can see what other labs are under the same Big Ideas of Science.

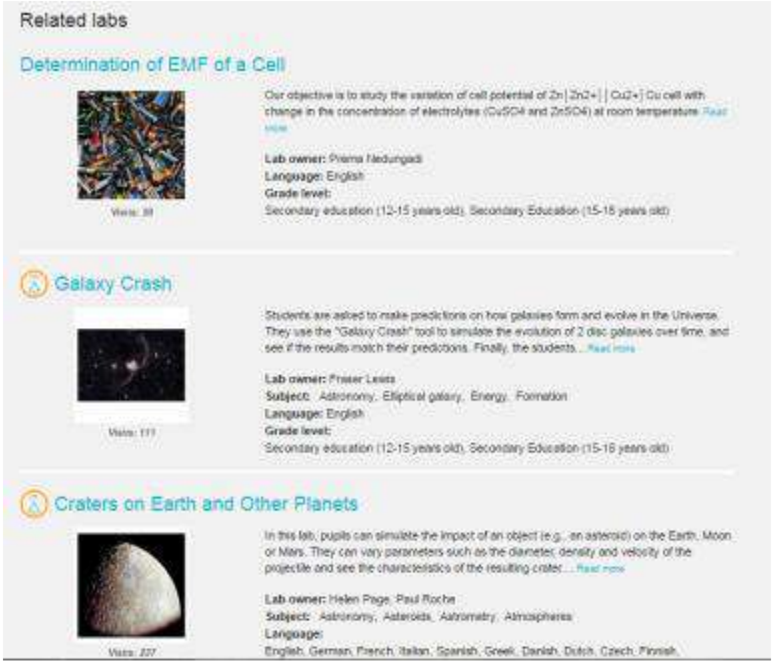


Figure 35. List of labs related to a single Big Idea of Science presented in the Go-Lab repository

The integration of the Big Ideas of Science in the Go-Lab repository is described in detail in the Go-Lab deliverable D5.2 chapter 2.

4.7 Next Steps

The next step in our research is to further investigate the validity of our Go-Lab set of Big Ideas of Science by including more participants and especially an increased number of teachers' trainers. The project team will also attempt to reach stakeholders and more researchers so as to further investigate the current set of Big Ideas of Science. In addition, since the Big Ideas of Science are now integrated into the Go-Lab repository, we will extend our research so as to check teachers and teachers' trainers' opinion on the two following matters:
a) Do teachers believe that having "Big Ideas" in every ILS and online lab is going to facilitate them in communicating to their students the connection between different subjects?
b) Does a recommendation system for ILSs and online labs based on the "Big Ideas of Science" be useful to them?
The results of this research are expected to be presented in the coming year of the project.

5 Validating the Metadata Model of the Go-Lab Online Labs

The aim of this section is to present the work that has been done with users (namely science teachers and lab owners) towards validating the metadata model of the Go-Lab Online Labs. In order to design appropriately our validation methodology, we have reviewed studies from the literature that focus on validating metadata models on related application domains. Table 16 presents briefly these studies along with their basic parameters.

Table 16. Studies on Validating Metadata Models

Study	Application Domain	Validation Instrument
Zhang & Li (2008)	Metadata Model for Images	Questionnaire
Krull et al. (2006)	Metadata Model for Educational Resources	Questionnaire
Howarth (2003)	Metadata Model for Educational Resources	Questionnaire
Carey et al. (2002)	Metadata Model for Educational Resources	Questionnaire & Interview

As we can notice from Table 16, all previous studies have used questionnaires for asking the opinion of the users about the metadata elements of the models that they have proposed. As a result, a similar approach has been followed in our case and it is described in details in the next section.

5.1 Pilot Experiment Settings

In order to validate the metadata element set, three different surveys were carried out (Annex C). Each survey collected teachers' opinions on the importance of certain metadata elements. The reason for having three different surveys is the fact that we wanted to investigate the importance of metadata elements in different contexts of use and check if the same elements are equally (or less) important in all these different contexts of use.

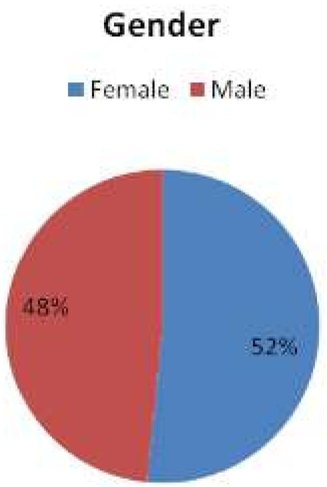
Teachers were asked to rate each metadata element with a five-point like scale, where 1 denotes “low importance” and 5 denotes “high importance” for the following there different contexts of use:

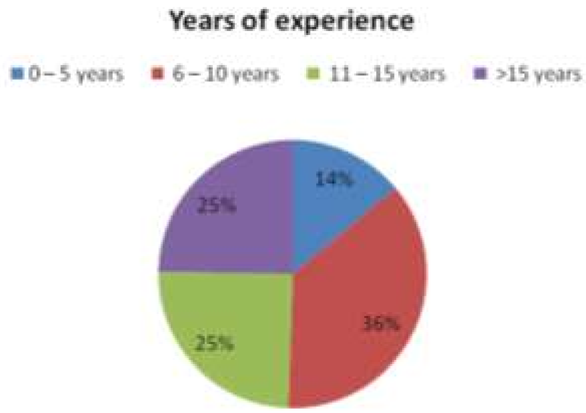
1. Importance of Metadata Elements within the context of **making a general search for labs** in the Go-Lab repository.
2. Importance of Metadata Elements within the context of **filtering search results for labs** in the Go-Lab repository.
3. Importance of Metadata Elements within the context of **viewing the preview page of a Go-Lab online lab** in the Go-Lab repository

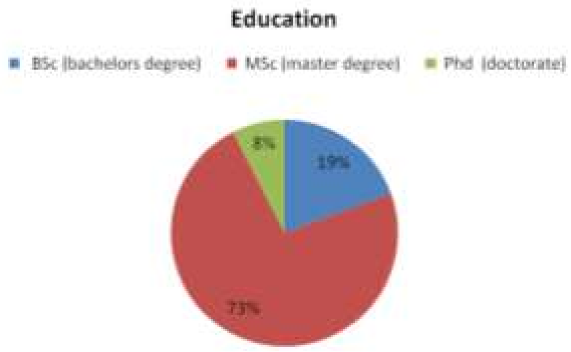
It should be noted that out of the 34 elements that are part of the lab metadata full element set, only 26 where included in the questionnaires. Elements such as “Title”, “Location URL”, and “Contributor(s)” (except for the case of questionnaire 3.) and “Description” were not included in the survey, because we consider them to be essential to begin with and thus no research was needed on defining their importance. Besides these four elements, the reason for not including all the rest elements in every questionnaire is due to the fact that we wanted to avoid producing too long questionnaires that would discourage teachers from completing them and thus lower the quality and quantity of the gathered data. The selection of elements to be included in each of the three questionnaires was based on the context of each questionnaire; on what elements could be considered of primary importance within each context, as well as based on the review of other existing lab repositories and federations (as presented in deliverable D2.1, chapter 8) that use guided research and which elements are most commonly used among them. In addition we made sure to include elements that are considered to be of high importance for the project as described also in Go-Lab DoW (Part A, pp.12), such as the “Educational Objectives”, the “Big Ideas of Science”, “Inquiry Learning Spaces” available and “Inquiry Cycle Phase”.

5.2 General Information on the Participants of the Pilot Experiment

The teachers who participated in the validation workshops were among those who were invited to be part of the first Go-Lab pilot phase. Among the 108 teachers who approximately participated in the first Go-Lab pilot, we obtained 93 questionnaires (86%). The general characteristics of our sample are presented below.







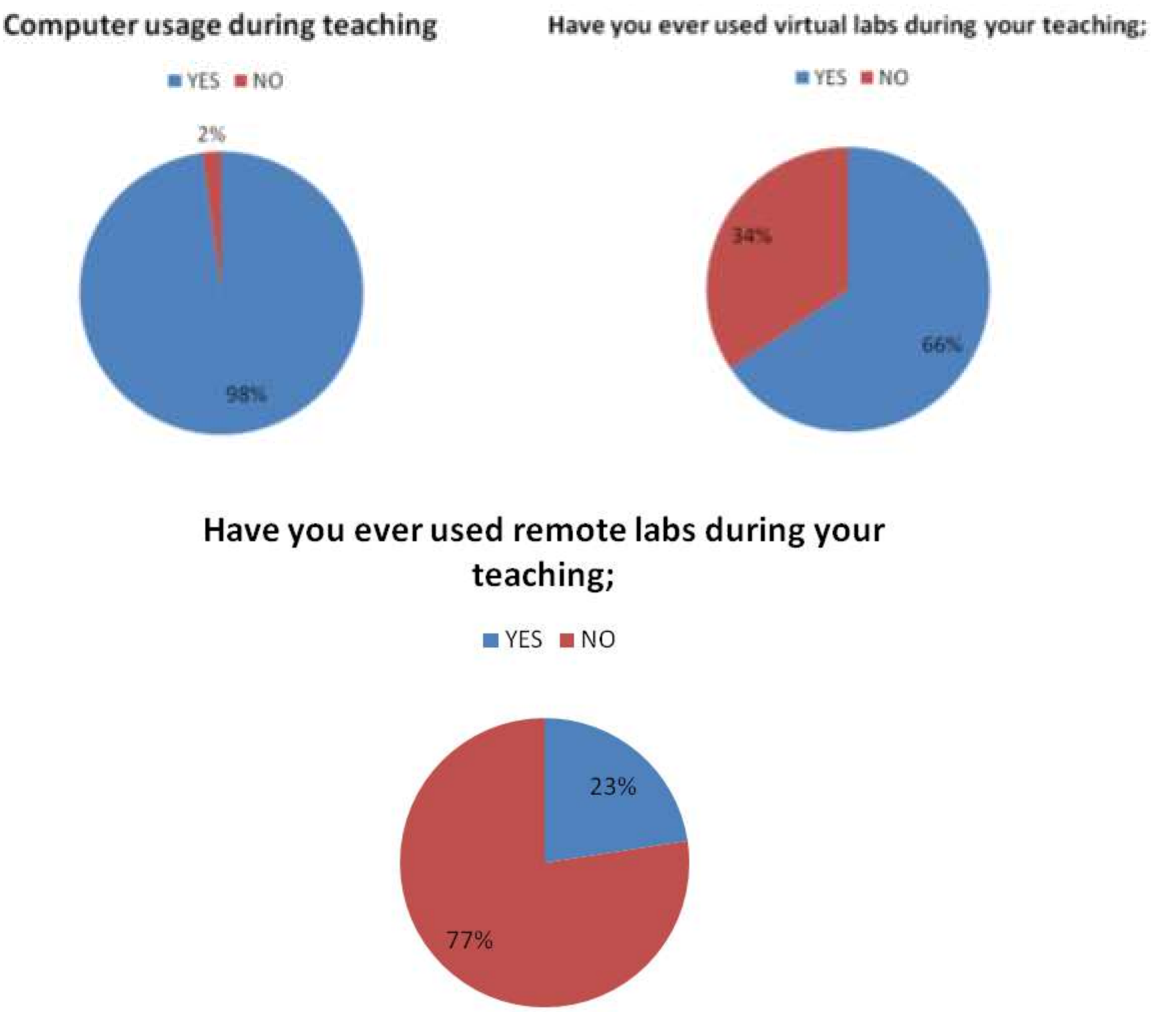


Figure 36. Analysis of background information on the sample of participants

By looking at the graphs above we conclude that there is a gender balance between the participants (48% Female, 52% Male) and that the majority of them are experienced teachers as 86% have more than 6 years of experience. Furthermore, almost our entire sample is experienced in working with online labs (98% use remote labs and 66% use remote labs) and all of the participating people have computer knowledge. Moreover, given that 81% of them have at least a master's degree we can assume that they have enough computer experience so as to provide valid answers to our questionnaires. A separate analysis on the general information coming from each questionnaire also indicates that there are no major differences among the three different samples and that the entire sample of 93 people is uniform.

5.3 Validation Results

The questionnaires were delivered to teachers during workshops and the first pilot phase of the Go-Lab project. Each teacher was asked to fill in only one questionnaire, so in total N=93 teachers were included in our research. More specifically, 28 teachers answered the questionnaire about making a general search, 32 teachers answered the questionnaire about filtering search results and 33 teachers answered the questionnaire about viewing the preview page of a Go-Lab online lab. Before filling in the questionnaires, all teachers attended a presentation of the Go-Lab project as well as a demonstration of the Go-Lab repository, its content and its functionalities as well as a demonstration of the search engine. Moreover, they all had a computer during the workshops so they had a chance to navigate within the Go-Lab repository and use it themselves. Thus they had a concrete idea of what metadata elements are about and how they can be deployed within the Go-Lab repository. The results of the questionnaires are presented in the tables below.

Table 17: Importance of Metadata Elements within the context of making a general search for labs in the Go-Lab repository (N=28)

Metadata Elements Investigated (20 elements)	Mean	Standard Deviation
Keywords	4.50	0.58
Grade levels covered	4.46	0.91
Subject domain	4.46	0.79
Availability of the lab	4.43	0.88
Educational objectives addressed	4.39	0.63
URL(s) and availability of students' material	4.29	0.85
Level of difficulty	4.29	0.71
Available Languages	4.25	0.80
URL(s) for accessing any supportive app(s)	4.14	0.80
Level of interaction	4.11	0.96
Type of the lab	4.04	1.20
URL(s) for accessing relative Inquiry Learning Spaces	4.00	0.86
The big ideas of science that the lab addresses	3.96	1.10
Access permissions	3.89	1.03
The ICT competence level that a teacher should possess.	3.82	1.09
Booking requirement	3.68	1.22
The phases of the Go-Lab inquiry cycle supported	3.68	0.98
Support of students with disabilities	3.61	1.34
Contact details of the lab's owners	3.25	1.24

Information about the provider(s)	3.25	1.35

Table 18: Importance of Metadata Elements within the context of filtering search results for labs in the Go-Lab repository (N=32)

Metadata Element Investigated (19 elements)	Mean	Standard Deviation
Grade levels covered	4.55	0.72
Subject domain	4.53	0.62
Keywords	4.44	0.67
Availability of the lab	4.44	0.67
Type of the lab	4.38	0.79
Available Languages	4.28	0.96
Booking requirement	4.22	0.83
Educational objectives addressed	4.19	1.00
Access permissions	4.16	0.95
Availability of students' material	4.16	0.88
Level of interaction	4.06	0.80
Level of difficulty	4.00	0.88
The big ideas of science that the lab addresses	3.97	1.03
The principal users for whom the lab was designed.	3.63	1.07
The phases of the Go-Lab inquiry cycle supported	3.63	1.01
The ICT competence level that a teacher should possess.	3.50	1.24
Support of students with disabilities	3.41	1.16
Contact details of the lab's owners	3.00	1.34
Information about the provider(s)	2.81	1.33

Table 19: Importance of Metadata Elements within the context of viewing the preview page of a Go-Lab online lab (N=33)

Metadata Element Investigated (27 elements)	Mean	Standard Deviation
Grade levels covered	4.55	0.51
Keywords	4.55	0.71
URL(s) for accessing student's material	4.45	0.67
Available Languages	4.39	0.79
Subject domain	4.39	0.66
Educational objectives addressed	4.36	0.86
Information about how the use of the lab can support students in developing different skills	4.30	0.85
The big ideas of science that the lab addresses	4.30	0.77
Availability of the lab	4.22	0.87
Level of difficulty	4.15	0.83
URL(s) for accessing any supportive app(s)	4.15	0.67
URL(s) for accessing relative Inquiry Learning Spaces	4.09	0.84
Type of the lab	4.06	1.00
Booking requirement	4.00	1.00
The ICT competence level that a teacher should possess.	3.97	1.10
Level of interaction	3.94	0.97
Technical requirements needed	3.88	1.05
Support of students with disabilities	3.82	0.98
Access permissions	3.76	1.32
The principal users for whom the lab was designed.	3.73	1.26
Technical format	3.70	1.26
Critical dates related to the lab's lifecycle	3.70	1.31
The phases of the Go-Lab inquiry cycle supported	3.61	1.22

Current version of the lab	3.30	1.21
Information about the provider(s)	3.09	1.28
Contact details of the lab's owners	3.06	1.22
Information on the contributors of the lab	2.94	1.27

For all three questionnaires, the ranking on average of each metadata element can be seen in the Figure 37. The elements in the green box are those that scored above 4 while those in the red box have scored between 4.00 and 3.50.

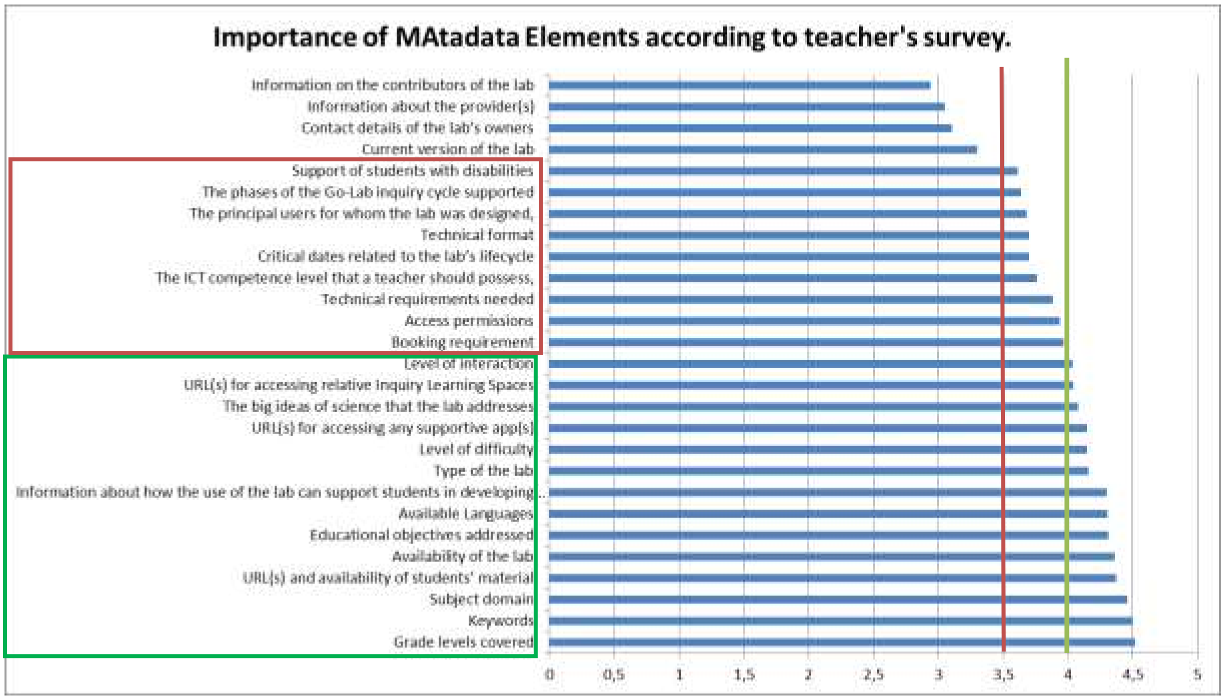


Figure 37: Average scores for the metadata elements included in the survey

All questionnaires had a common last part which concerned the proposed vocabularies for some metadata elements used for searching in the Go-Lab repository. The questions in this section concerned three elements in particular; "Grade level", "Supporting students with disabilities" and the "Big Ideas of Science". The aim of this section was to define whether the proposed vocabularies match teachers' needs.

Table 20. Teachers' opinion about the proposed vocabularies for the metadata elements used for searching Go-Lab Online labs (N=93).

	appropriate	appropriate to some extent – sufficient	I have no opinion	appropriate to some extent – deficient	not appropriate
Grade Level	**52 (56%)**	23 (25%)	10 (11/%)	4 (4%)	4 (4%)
Supporting Students with Disabilities	**59 (63%)**	15 (16%)	16 (17%)	1 (1%)	2 (2%)
Big Ideas of Science	**40(43%)**	22 (24%)	25 (27%)	4 (4%)	2 (2%)

5.4 Proposed Revisions of the Metadata Element Set

Based on the teacher survey data the most important metadata elements across all three contexts were:

- Grade levels covered (average on all three questionnaires: 4.52)
- Keyword(s) (average on all three questionnaires: 4.50)
- Subject domain (average on all three questionnaires: 4.46)

Additional elements that on average received above or equal to 4.00 are:

- URL(s) for accessing student's material (average on all three questionnaires: 4.37)
- Availability of the lab (average on all three questionnaires: 4.36)
- Educational objectives addressed (average on all three questionnaires: 4.31)
- Available Languages (average on all three questionnaires: 4.31)
- Type of the lab (average on all three questionnaires: 4.16)
- Level of difficulty (average on all three questionnaires: 4.15)
- URL(s) for accessing any supportive app(s) (average on all three questionnaires: 4.14)
- The Big Ideas of Science the lab addresses (average on all three questionnaires: 4.07)
- URL(s) for accessing relative Inquiry Learning Spaces (average on all three questionnaires: 4.05)
- Level of interaction (average on all three questionnaires: 4.04)

The least important metadata elements across all three contexts were: "Information about the provider(s)" (average on all three questionnaires: 3.05) and "Contact details of the lab's owners" (average on all three questionnaires: 3.10). It is worth noticing that no elements received very low score, in fact, the lowest score in average was 3.05 - corresponding to element "Information about the provider(s)" - which is still on the positive side of the likert scale. Thus, an overall conclusion could be that none of the metadata elements can be regarded as non-useful.

When examining the three contexts individually, other popular metadata elements specific to a particular context were:

- Available languages and educational objectives (4.25 and 4.39 respectively in the case of a general search)
- Type of the lab (4.38 in the case of a filtered search)
- URL(s) for accessing student's material (4.45 in the case of a preview page).

The least popular metadata elements specific to a particular context were:

- Information about the provider(s) (3.25 in the case of a general search)
- Information on the contributors of the lab (2.94 in the case of a preview page).
- Information about the provider(s) (2.81 in the case of a filtered search)

The teachers' survey indicates that there are three priority metadata elements (keywords, subject domain, and grade levels covered) that are very important to teachers when they choose an online lab. Therefore it is important that these metadata elements are emphasized during the process of filling-in values for these elements, and a creator is discouraged or prevented from entering ambiguous or inaccurate data. It is also important that their position in the Go-Lab search engine is very prominent.

The teachers' survey also shows a number of less popular metadata elements. However, the mean value of the lowest scoring element (3.05 out of a 5.0 scale) did not warrant an automatic elimination from the list of metadata elements. In fact, the low scores may simply reflect that for teachers, metadata information about the lab owner's is irrelevant for designing and implementing a learning activity around these labs. Nevertheless, other users (educational researchers, students) of Go-Lab may find this information relevant and therefore we do not recommend eliminating it.

One place for concern from the teacher survey data is revealed in
Table **18** where the metadata element 'The phases of the Go-Lab inquiry cycle supported' received a relatively low score of 3.68. This could be either because teachers are unfamiliar with the inquiry cycle framework and therefore do not appreciate the pedagogical value of this scheme or because they fill that a lab can be used for any phase to begin with. Because Go-Lab Inquiry Learning Spaces are centred about an inquiry cycle framework, it will be important to provide support to teachers so that they fully understand the value of structuring inquiry learning according to a robust pedagogical framework.

Overall, based on the analysis, on the discussions during the workshops, the comments received and on the scores that each element received we have also decided to propose the following actions:

- Merge elements: "Contributor(s)", "Contact Details", "Provider(s)", "Rights Holder(s)" into one element to avoid repetition.
- Provide a brief explanation for the options of elements: "Level of Difficulty" and "Level of Interaction". Both these elements appear to be quite important for teachers, however, during the workshops many teachers had asked for clarifications.

With regards to evaluating the proposed vocabularies it is worth mentioning, that in all cases teachers have found the proposed vocabularies to be sufficient. In the case of "Grade level" the only term that seems to be missing according to some teachers' comments (5 out of 18 comments) is "vocational training". Although more than half teachers (56%) find the vocabulary appropriate, there were however several comments (9 comments out of 18) which indicated that European countries do not share the same organizational systems. There are cases were children of the same age are regarded to be students of primary education for some counties and of secondary to some others. To this end, we have decided to change the vocabulary for this element and make a classification according to the age of students. Thus, we have changed the element's name from "Grade level" to "Age Range" and the classification is as follows:

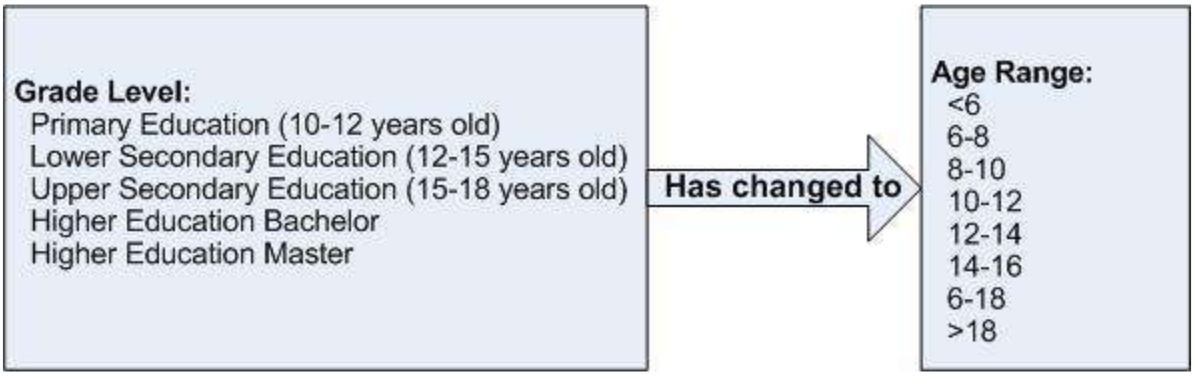


Figure 38. Change from 'Grade Level' metadata element to 'Age Range"

With regards to elements “Supporting students with disabilities” 63% of the teachers find the vocabulary appropriate and 79% find it appropriate or sufficient. About 17% of teachers indicated that they have no opinion which can be due to the fact that most teachers are not specialized in working with students with disabilities. Based on the numbers mentioned above, as well as the comments of the teachers there is no need to change this vocabulary.

Another element that was investigated was the “Big Ideas of Science”. What is interesting about teachers’ answers in this case is that 27% answered they have no opinion on the matter. This however is not alarming as it is highly possible that teachers are not familiar with this concept. The fact that teachers were not familiar with the Big Ideas of Science also comes from their comments where all 9 comments in this section where about them indicating that they are not very familiar with the term. Still, 67% find the classification to be appropriate or sufficient. The comments made do not indicate any need for changing the existing set of Big Ideas, however, the fact that 27% of the teachers’ said that they do not have an opinion clearly indicated that there was a need for further and more analytical investigation of the “Big Ideas of Science”. The more analytical investigation that was performed for the “Big Ideas of Science” was presented in chapter 4. Finally in the question regarding teachers’ opinion on using the Big Ideas of Science as a recommendation system, 49% answered that they find this feature very useful and 26% answered that they find it useful to some extent. Again, like in the previous question, a relatively high percentage (17%) answered that they have no opinion. This can be again due to the fact that teachers are not familiar with the Big Ideas of Science. The overall results on teachers’ opinion on the proposed vocabularies for the metadata elements used for searching Go-Lab Online Labs are presented below in Table 21:

Table 21. Teachers’ opinion on the proposed vocabularies of some metadata elements.

	Grade Level	Supporting students with disabilities	Big Ideas of Science	Big Ideas of Science as a recommendation system
appropriate	**56%**	**63%**	**43%**	(very useful) **49%**
appropriate to some extent – sufficient	25%	16%	24%	(useful to some extent – sufficient) 26%
I have no opinion	11%	17%	27%	(I have no opinion) 17%

appropriate to some extent – deficient	4%	1%	4%	(useful to some extent – deficient) 6%
not appropriate	4%	2%	2%	(not useful) 2%

Additionally, we have also decided to make changes on the following extra information requested by internal lab owners:

- Eliminate "Lifecycle Dates" and "Latest Version" because these values need constant updating and there seems to be little added value.
- Eliminate "Current number of lab users" because this value needs constant updating and there seems to be little added value.
- Eliminate "Context of use", because in principle, all labs are to be used in the school classroom and because it is completely subjective as it depends more on the way the teachers decides to use the lab rather than the lab owner's intention.
- Merge "Use of Scaffolds" with "Supportive App(s)" because scaffolds are supportive apps, and they can be used in any given lab.

5.5 The Modified Metadata Element Set for Online Labs

Table 22 presents the modified metadata element set for Go-Lab online labs after the modifications described in Section 5.4. Following this metadata element set the Go-lab Online Labs that have populated the Go-lab Inventory for Year 2 has been described and they are presented in the Appendix of this deliverable.

Table 22. The modified metadata elements set for online labs

No	Element Name	Description	Datatype	Value Space
1.	**Name of the lab owner**	Please add the name of the lab owner that is responsible for the lab and is also the right holder.	Character String - mandatory	-
2.	**E-mail of the lab owner**	Please add the e-mail name of the lab owner.	Character String- mandatory	-
3.	**Organization of the lab owner**	Please add the organization of the lab owner.	Character String - optional	-
4.	**Lab title**	Please provide the complete title of the lab.	Character String - mandatory	-
5.	**Lab location URL**	Please provide a URL for accessing the lab.	Character String - mandatory	-

6.	**Lab description and primary aims of the lab**	Please provide a textual description of the lab and describe the primary aims the lab inspires to fulfil (e.g. Demonstrate how scientists work, help explain the scientific process).	Character String - mandatory	-
7.	**Lab type**	Please select the specific kind of the lab.	Vocabulary Term - mandatory	• Remote Lab • Virtual Lab • Data Set
8.	**Keywords**	Please add a set of terms that characterize the content of the lab. Use ; to separate the keywords	Character String - mandatory	-
9.	**Language(s)**	Please select the languages that the lab is available in.	Vocabulary Term - mandatory	• EN (English) • EL (Greek) • FR (French) • CA (Catalan) • CS (Czech) • DE (German) • ES (Spanish) • HU (Hungarian) • IT (Italian) • PT (Portuguese) • Other
10.	**Booking required**	Please specify if the lab requires booking.	Vocabulary Term - mandatory	• Yes • No
11.	**Registration required**	Please specify if registration is needed.	Vocabulary Term - mandatory	• Yes • No
12.	**Cost**	Please specify if any payment is required for using the lab.	Vocabulary Term - optional	• Yes • No

13.	**Copyright License**	Please add information about copyrights and restrictions applied to the use of the lab.	Vocabulary Term - optional	• 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)
14.	**External Students' Material(s)**	Please enter the URL(s) for accessing any student's material(s) that is connected to the lab.	Character String - optional	-
15.	**User manual - URL**	Please give the URL of the user manual, if available.	Character String - optional	-
16.	**Current number of lab users**	Please indicate the current number of users of the lab.	Character String - optional	-
17.	**Age Range**	Please indicate the ages for which the lab can be used.	Vocabulary Term - mandatory	• <6 • 6-8 • 8-10 • 10-12 • 12-14 • 14-16 • 16-18 • >18
18.	**Subject Domain**	Please select the lab's subject domain(s).	Vocabulary Term - mandatory	Annex C6
19.	**Big Ideas of Science**	Please select all the Big Ideas of Science that the lab addresses.	Vocabulary Term - mandatory	See page 60 chapter 4 paragraph 4.5

20.	**Educational Objectives**	Please select the educational objectives that the lab addresses.	Vocabulary Term - optional	Annex C7
21.	**Level of Difficulty**	Please indicate the level of difficulty of the lab.	Vocabulary Term - optional	• Easy (students can carry out the tasks on their own.) • Medium (students can carry out the tasks on themselves with little help from the teachers.) • Advanced(students can carry out the tasks on only with the help of the teacher.)
22.	**Level of Interaction**	Please indicatethe level of interaction the lab offers.	Vocabulary Term - optional	• Low (limited variables manipulation during experimentation – 1 variable, focusing more in observation.) • Medium (average variables manipulation during experimentation – 2 or 3 variables.) • High (numerous variables manipulation during experimentation – more than 3 variables.)
23.	**Average time of use (per experiment/session)**	Please indicate how much time would a student use in order to perform an activity using the lab. (1 didactic hour is 45 minutes)	Vocabulary Term - optional	• less than 1 didactic hour • 1 didactic hour • 2 didactic hours • 3 didactic hours • more than 3 didactic hours
24.	**Engaging in Scientific Reasoning**	Please select which areas of scientific reasoning the lab supports.	Vocabulary Term - optional	• Manipulating (please elaborate) • Testing (please elaborate) • Exploring (please elaborate) • Predicting (please elaborate) • Questioning (please elaborate) • Observing (please elaborate) • Analysing (please elaborate) • Making sense of the natural and physical world. (please elaborate)
25.	**Teacher ICT Competence Level**	Please select the competence level that a teacher should possess for the effective use of the lab.	Vocabulary Term - optional	Annex C8
26.	**Supporting Students with Disabilities**	Please select the areas where the lab can support students with disabilities.	Vocabulary Term - optional	• Physical impairments • Visual impairments • Hearing impairments • Learning disabilities • No specific provisions

27.	**Technical Requirements**	Please describe the specific technical requirements your lab has: 1. Operating System; 2. Software Needed; 3. Supported browsers; 4. Technical format.	Character String - optional	-

5.6 *Initial Feedback from External Lab Owners*

As already mentioned, users of the Go-Lab metadata model are also the lab owners, who are going to use this metadata model for describing their online labs towards their storage and integration to the Go-Lab Repository. As a result, the Go-Lab team has conducted an ad hoc validation of the online lab metadata element set with lab owners, who were external to the Go-Lab project. The validation was performed during a meeting with external lab owners in Madrid[2] to discuss the Smart Device and Smart Gateway specifications (see Deliverable D4.1). A detailed report of this meeting and its outcome can be found in the appendices of Deliverable D4.1 (Go-Lab Project – D4.1). The setup was as follows. The initial Go-Lab metadata element set was presented. The lab owners were asked to provide the Go-Lab team with feedback on the metadata fields, related to issues such as: whether they would be able to provide such metadata, whether they deemed these fields useful for teachers and searching, and whether they found these fields useful for other lab owners. Based on this quite ad hoc approach and limited number of participants, the Go-Lab team received the following initial feedback:

- **Too many metadata fields:** Filling in metadata is a laborious task for lab owners, especially lab owners who want to federate their complete Remote Lab Management Systems (RLMS) and have to annotate between 10 and 50 online labs. This has been addressed following the revisions made according to teachers internal lab owners' feedback
- **Pedagogy:** the lab owners proposed that the metadata should try to be pedagogy agnostic, since, they are not aware about how teachers will use their labs during their science teaching activities. However, this needs to be further investigated with more lab owners.
- **Grade level:** The grade level is not uniform across Europe. The lab owners propose to use age ranges instead of grade levels. This has been addressed following the revisions made according to teachers feedback.
- **Social metadata:** The lab owners proposed a form of social rewards such as badges to label online labs that are useful for teachers. Such social rewards should be awarded by teachers themselves and by Go-Lab experts. Other social mechanisms such as ratings and comments can also be useful. This is going to be addressed by WP5 based on the planned activities for the Go-Lab portal.

Based on these preliminary results, during the next year of the project these issues will be further investigated and discussed with additional lab owners, in order to ensure that the metadata elements of the proposed Go-Lab metadata model are also useful for them. More specifically, a validation plan will be setup along with appropriate validation instruments (namely questionnaires), so as to receive further feedback from external lab owners towards identifying their perceptions about the metadata elements of the proposed Go-Lab metadata model..

[2] The meeting was held on 6 June 2014

6 Proposing a Metadata Model for the Go-Lab Inquiry Learning Spaces (ILSs)

The aim of this section is to propose a metadata model for the Go-Lab inquiry learning spaces (ILSs). ILSs have been defined as: "*Go-Lab learning environments that include an online laboratory and the instructional guidance for students*" (Go-Lab Project – D1.3). ILSs are stored in the Go-Lab repository, so as to be searched and re-used by the users of the Go-Lab repository, namely, science teachers. ILSs can be considered similar with the learning activities that are organized around existing online labs and stored in existing repositories and federation of online labs. As result, in the next section we perform a review of metadata elements used by existing repositories and federations of online labs for describing and storing learning activities that are organized around the labs that they store.

6.1 Metadata Models for Learning Activities offered by Online labs Repositories

6.1.1 Overview

Table 23 presents the existing repositories and federations of online labs that were reviewed, as well as the number of learning activities that they store. Table 23 includes the same set of repositories and federations of online labs that have been initially analysed in Deliverable D2.1 (Go-Lab Project – D2.1) for proposing the initial lab metadata element set. In this deliverable, we re-visit these repositories and federations of online labs, in order to identify and analyse the metadata elements used for describing and storing learning activities that are organized around the online labs that they include.

For these repositories and federations of online labs, there are not previous studies that have proved their success in supporting science teachers in the process of searching and retrieving learning activities organized around existing online labs. However, we consider the metadata elements that they use as our initial metadata element set that can be further validated with the Go-Lab pilot teachers in order to propose a useful metadata set for characterizing ILSs, which could be used in the context of the Go-Lab Project.

Table 23: Overview of Existing Repositories and Federation of Online Labs

No	Name	Repository/ Federation URL	Number of Educational Activities
1	PhET	http://phet.colorado.edu	552
2	Library of Labs	https://www.library-of-labs.org/	***N/A***
3	Labshare	http://www.labshare.edu.au/	12
4	Open Sources Physics	http://www.compadre.org/osp	355
5	Smart Science	http://www.smartscience.net/	***N/A***
6	Molecular Workbench	http://mw.concord.org/	75

7	Explore Learning	http://www.explorelearning.com	478
8	ChemCollective	http://www.chemcollective.org/	55
9	Remotely Controlled Laboratories (RCL)	http://rcl-munich.informatik.unibw-muenchen.de	17
10	Skoool	http://skoool.com	264
11	iLabCentral	http://ilabcentral.org	21
12	Lab2Go	http://www.lab2go.net	***N/A***
13	WebLab Deusto	https://www.weblab.deusto.es/weblab	-
Total Number of Learning Activities			**1565**

As we can notice from Table **23**, 12 out of 13 (92,30%) of the examined repositories and federations include learning activities organized around the online labs that they include, whereas only 1 out of 13 (7,69%) of the examined repositories and federations does not include learning activities. In the next section, we present a detailed analysis of the metadata elements used in these repositories and federations for describing learning activities.

6.1.2 Metadata Elements Analysis

The aim of this section is to identify metadata elements used for describing learning activities stored in existing repositories and federations of online labs. To this end, we harmonized the learning activities' metadata elements used by the examined repositories and federations of online labs, so as to produce a master list of learning activities metadata elements. Based on this analysis, a list of 21 metadata elements has been assembled and for each metadata we have also identified the frequency of use at the examined repositories and federations of online labs (see Table **24**).

Table 24. Learning Activities Metadata Elements and Usage Frequency

No	Element Name	Description	Usage Frequency
1	Title	This metadata element refers to the title of the learning activity	12 (100,00%)
2	URL	This metadata element provides a URL for accessing the learning activity	11 (91,66%)
3	Description	This metadata element provides a textual description of the learning activity	10 (83,33%)
4	Subject Domain	This metadata element refers to the learning activity's subject domain	10 (83,33%)
5	Language(s)	This metadata element refers to the languages that the learning activity is available in.	10 (83,33%)
6	Additional materials included	This metadata element describes additional supportive material that can facilitate teachers to deliver the learning activity and students to execute the learning activity	9 (75,00%)
7	Lab(s) Used	This metadata element denotes the online labs used in the learning activity	8 (66,66%)
8	Owner(s)	This metadata element provides information about the	8 (66,66%)

No	Element Name	Description	Usage Frequency
		owner of the learning activity	
9	Age Range	This metadata element refers to the age range for which the learning activity can be used.	8 (66,66%)
10	Keyword(s)	This metadata element refers to a set of terms that characterize the content of the learning activity.	5 (41,66%)
11	Educational Objectives	This metadata element refers to the educational objectives that the learning activity addresses	5 (41,66%)
12	Contributor(s)	This metadata element refers to the entities that have contributed to the authoring of the learning activity	4 (33,33%)
13	Status	This metadata element provides information about the current status of the learning activity.	4 (33,33%)
14	Organizational Requirements	This metadata element refers to the requirements that are needed in order to carry out the learning activity without troubleshooting.	3 (25,00%)
15	Average learning time	This metadata element refers to the amount of time that the learning activity requires in order to be completed	3 (25,00%)
16	Access Rights	This metadata element refers to the learning activity's access permissions	2 (16,66%)
17	Level of Difficulty	This metadata element refers to the level of difficulty of the learning activity.	2 (16,66%)
18	Students' prior knowledge	This metadata element refers to students' prior knowledge in order to execute the learning activity	2 (16,66%)
19	Big Ideas of Science	This metadata element refers to the big ideas of science that the learning activity addresses	1 (8,33%)
20	Scenario	This metadata element indicates whether the learning activity follows a specific scenario	1 (8,33%)
21	Level of Interaction	This metadata element refers to the level of interaction the learning activity offers in terms of (a) variables manipulation during experimentation and (b) interaction and collaboration with peers	1 (8,33%)

Next, we present the frequency of the learning activities metadata elements as identified from Table **24** sorted from the most frequent to the less frequent metadata elements (see Figure 39)

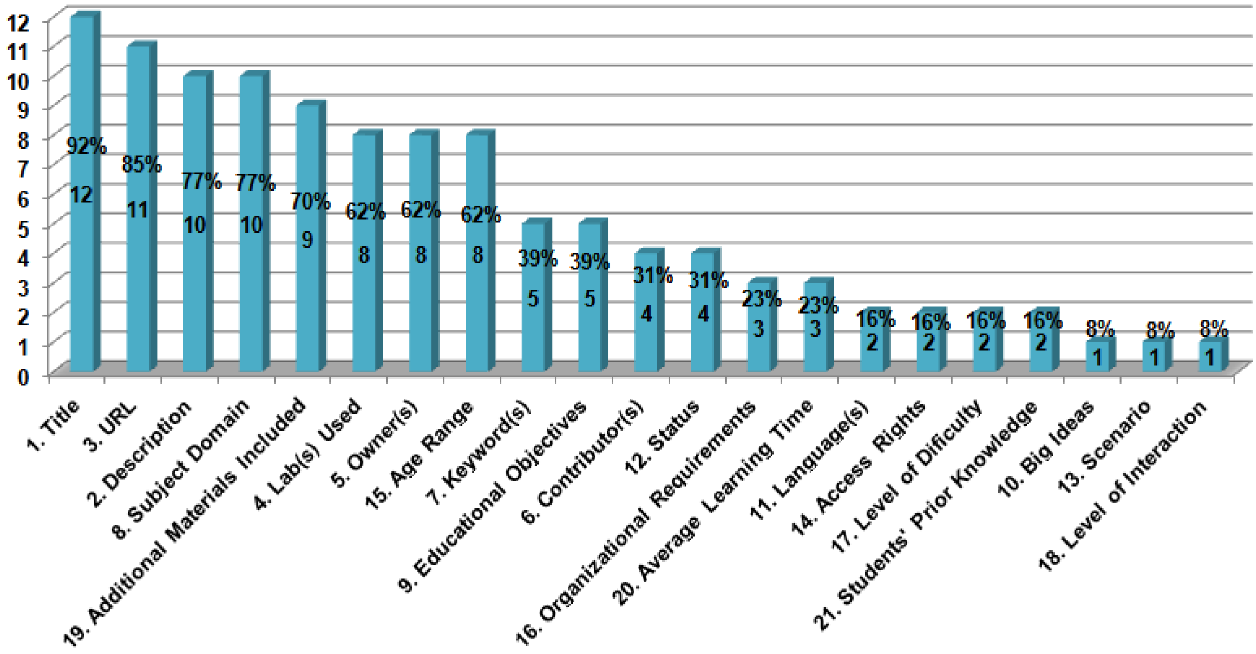


Figure 39: Frequency of Learning Activities Metadata Elements used by Existing Repositories and Federations of Online Labs

As we can notice from Figure 39, most frequent used metadata elements are the following: (i) Title, (ii) URL, (iii) Description, (iv) Language(s), (v) Subject Domain, (v) Additional Material Included, (vi) Lab(s) used, (vii) Owner(s) and (viii) Age Range. On the other hand, less frequent used metadata elements are the following: (i) Access Rights, (ii) Level of Difficulty, (iv) Students' prior Knowledge, (v) Big Ideas, (vi) Scenario and (vii) Level of Interaction. These results could be used as initial indications for the presentation of metadata elements at the Go-Lab repository. However, they need to be validated with teachers as already done for the online lab metadata in chapter 5. Based on the aforementioned analysis, in the next section we present the proposed metadata element set for the Go-Lab ILSs.

6.2 Proposed Metadata Element Set

This section presents the full element set of the metadata model for the Go-Lab Inquiry Learning Spaces (ILSs). For each element of the metadata model the following information is defined:

- **Element Name:** the title of the element as references by the metadata model
- **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. Moreover, it indicates whether the element will be pre-filled by the ILS Platform (namely the Graasp[3]) or whether it will be mandatory or optional
- **Value Space**: the set of allowed values for the element – typically in the form of a vocabulary or a reference to another standard.
- **Input Details**: provides information whether (a) the metadata element will be pre-filled by the Go-Lab Portal and (b) will be editable or not

Table 25. Inquiry Learning Space Metadata Model

[3] http://graasp.eu/

No	Element Name	Description	Datatype	Value Space	Input Details
1	Title	This metadata element refers to the title of the ILS	Character String – Pre-Filled	-	ILS title will come automatically from ILS Platform but it will be editable.
2	Description	This metadata element provides a textual description of the ILS	Character String - Pre-Filled	-	ILS description will come automatically from ILS Platform but it will be editable.
3	URL	This metadata element provides a URL for accessing the ILS	Character String – Pre-Filled	-	ILS URL will come automatically from ILS Platform but it will not be editable.
4	Lab(s) Used	This metadata element denotes the online labs used in the ILS	Vocabulary Term – Pre-Filled	-	Labs Used will come automatically from ILS Platform but it will not be editable.
5	Owner(s)	This metadata element provides information about the owner of the ILS	Character String - Pre-Filled	Name of owner Email Organization *(if there are more than one owners please add their information in the same way)*	Owner(s)* will come automatically from ILS Platform but it will be editable.
6	Contributor(s)	This metadata element refers to the entities that have contributed to the authoring of the ILS	Character String - Pre-Filled	Name of Contributor Email Organization *(if there are more than one contributors please add their information in the same way)*	Contributor(s) will come automatically from ILS Platform (if the ILS is shared with other users) but it will be editable.
7	Keyword(s)	This metadata element refers to a set of terms that characterize the content of the ILS	Character String - Pre-Filled	-	Keywords will come from the keywords of the lab and they will be editable.
8	Subject Domain	This metadata element refers to the ILS subject domain	Vocabulary Term - Pre-Filled	See Annex C6	Subject Domain will come from ILS Platform. The default values will be available following the Subject Domains set for the labs that have been used. The element will remain editable.
9	Educational Objectives	This metadata element refers to the educational objectives that the ILS addresses	Vocabulary Term - Pre-Filled	See Annex C7	Educational Objectives will come from ILS Platform. The default values will be available following the

No	Element Name	Description	Datatype	Value Space	Input Details
					Educational Objectives set for the labs that have been used. The element will remain editable. The user will also be able to add an additional description for each objective.
10	Big Ideas of Science	This metadata element refers to the big ideas of science that the ILS addresses	Vocabulary Term - Pre-Filled	See page 60 chapter 4 paragraph 4.5	Big Ideas will initially come from ILS Platform. The default values will be available following the Big Ideas set for the labs that have been used. The element will remain editable.
11	Language(s)	This metadata element refers to the languages that the ILS is available in.	Vocabulary Term - Pre-Filled	EN (English) EL (Greek) FR (French) CA (Catalan) CS (Czech) DE (German) ES (Spanish) HU (Hungarian) IT (Italian) PT (Portuguese) Other	Language(s)* will come automatically from ILS Platform but it will not be editable.
12	Status	This metadata element provides information about the current status of the ILS.	Vocabulary Term - Pre-Filled	Go-lab reviewed/approved	The status will indicate if the ILS has been reviewed by the Go-Lab consortium or not.
13	Scenario	This metadata element indicates whether the ILS follows a specific scenario	Vocabulary Term - Pre-Filled	See Annex D	Scenario will come automatically from ILS Platform but it will not be editable.
14	Access Rights	This metadata element refers to the ILS access permissions	Vocabulary Term - Mandatory	Allow adaptations of your work to be shared? - Yes - Yes, as long as others share alike (under the same license as the original) - No (only share my work as is)	Access Rights (coming from creative commons) will be added manually by the contributor. A default value will be available.
15	Age Range	This metadata element refers to the age range for which the ILS can be used.	Vocabulary Term – Optional	<6 6-8 8-10 10-12	Age Range will be added manually by the contributor.

No	Element Name	Description	Datatype	Value Space	Input Details
				12-14 14-16 16-18 >18	
16	Organizational Requirements	This metadata element refers to the requirements that are needed in order to carry out the ILS without troubleshooting.	Character String – Optional	-	Organizational Requirements will be added manually by the contributor
17	Level of Difficulty	This metadata element refers to the level of difficulty of the ILS.	Vocabulary Term – Optional	Easy *(students can carry out the tasks on their own)* Medium *(students can carry out the tasks on themselves with little help from the teachers)* Advanced *(students can carry out the tasks on only with the help of the teacher)*	Level of Difficulty will be added manually by the contributor.
18	Level of Interaction	This metadata element refers to the level of interaction the ILS offers in terms of (a) variables manipulation during experimentation and (b) interaction and collaboration with peers	Vocabulary Term – Optional	Interaction with the lab Low *(Limited variables manipulation during experimentation – 1 variable, focusing more in observation)* Medium *(Average variables manipulation during experimentation – 2 or 3 variables)* High *(Numerous variables manipulation during experimentation – more than 3 variables)* Interaction with peers Low *(Limited or no interaction and collaboration with peers – students working individually)* Medium *(Average interaction and collaboration with peers – students working within groups but with distinct responsibilities)* High *(High interaction and collaboration with peers – students working in groups sharing common tasks)*	Level of Interaction will be added manually by the contributor.

No	Element Name	Description	Datatype	Value Space	Input Details
19	Additional materials included	This metadata element describes additional supportive material that can facilitate teachers to deliver the ILS and students to execute the ILS	Vocabulary Term – Optional	Exercise Answer Key(s) Related Theory Students' spreadsheets Other *(please specify)*	Additional materials will be added manually by the contributor.
20	Average learning time	This metadata element refers to the amount of time that the ILS requires in order to be completed	Vocabulary Term – Optional	1 didactical hour *(45 minutes)* 2 didactical hours 3 didactical hours More than 3 didactical hours	Average learning time will be added manually by the contributor.
21	Students' prior knowledge	This metadata element refers to students' prior knowledge in order to execute the ILS	Character String – Optional	- *(If there is another ILS that is a prerequisite for the present ILS please provide the URL)*	Students' prior knowledge will be added manually by the contributor.

As we can notice from Table 25, although the proposed ILS metadata model is very thorough with many metadata elements, most of them will be pre-filled by the ILS Platform (namely the Graasp) when a teacher is going to publish an ILS to the Go-Lab Repository. As a result, this process will not take much time for the teachers, who are going to develop their own ILSs and share them with other users via the Go-Lab Repository.

6.3 Validating the Metadata Model of the Go-Lab Inquiry Learning Spaces (ILSs) with teachers

The validation process of this metadata model will follow the same structure as the validation of the metadata elements set for the Go-lab online labs. Three different surveys are going to be used. Each survey will aim to collect teachers and teachers' trainers' opinions on the importance of metadata elements that describe the Go-Lab ILSs. As in the case of the online labs, the reason for having three different surveys is because we wish to investigate the importance of these elements in different contexts of use. Teachers will again be asked to rate each metadata element with a five-point like scale, where 1 denotes "low importance" and 5 denotes "high importance" for the following there same contexts of use:

1. Importance of Metadata Elements within the context of **making a general search for ILSs** in the Go-Lab repository.
2. Importance of Metadata Elements within the context of **filtering search results for ILS** in the Go-Lab repository.
3. Importance of Metadata Elements within the context of **viewing the preview page of an ILS** in the Go-Lab repository.

7 Conclusions and Next Steps

The Go-Lab inventory includes currently 48 online labs out of which 13 were integrated during the first year of the project and 35 during the second. The consortium has already set in place a mechanism to populate the Go-Lab repository with more online labs from the initial planned sample to support the large scale validation work. The consortium has already established cooperation with similar efforts across the globe (e.g. with PHET consortium in USA).

The consortium has performed an extended validation exercise with users in order to assess the potential impact of the proposed content organisation scheme of the Go-Lab repository. The main findings are:

- The Go-Lab set of Big Ideas is very close to teachers and teachers' trainers notion on Big Ideas and that they can be used in class in order to connect different subject domains. The proposed content organisation scheme facilitates Go-Lab users to retrieve and use a series of inquiry learning activities related to an online lab or a series of labs to further support the quite demanding process of integrating inquiry based approaches in the school curriculum.
- The Go-Lab metadata model was adapted according to users' (teachers' and lab owners' feedback. The Go-Lab metadata model for describing and classifying online labs includes 27 metadata fields.
- A similar metadata model was developed for describing and classifying ILSs. The proposed metadata model will be validated in the next pilot phase.

Next steps include the further extension of the Go-Lab inventory focusing especially on covering extensively all subject domains. In addition, the validation work will continue in the next pilot run phase and the necessary adaptations will be made following users feedback.

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Annex A: Invitation Letter for Potential Go-lab Providers

Dear [**Name**] [**Surname**],

We are contacting you on behalf of the consortium of the Go-Lab project (http://go-lab-project.eu/) which is funded by the European Union's Seventh Framework Programme. The Go-Lab Project aims to create a federation of online labs so as to increase their use by students and teachers as well as to provide the necessary facilities which will allow the embedding of the online labs in pedagogically structured learning spaces. The facilities and the federation of labs offered by Go-Lab will be extensively tested through a three-year pilot period which will involve 1.000 schools in total from 15 different European countries.

To this end we are conducting an internal review of existing virtual and remote labs as well as data sets from Europe and beyond and we have made a selection of labs based on their quality and usability which we would like to integrate in our federation.

Therefore we would like to invite you to be part of the Go-Lab federation of online labs by including the [**Name of Lab**] in our repository, along with the conditions we have to comply with.

If you accept our invitation to accommodate your Online Lab in our federation, as the lab-owner, you will have the following advantages:

- Increase the visibility and attraction of your Online Lab.
- Receive feedback and recommendations on improvements for your Online Lab from the schools participating in the Go-Lab pilots according to their needs and experience.
- Obtain educational activities designed based on your Online Lab by teachers across Europe, in multiple languages.
- • Online labs can be enriched with a set of scaffolds facilitating students to perform online experiments more efficiently. Moreover, they can make use of Go-Lab add-on services such as the booking service, the learning analytics and the bartering platform. Be part of a large community which stimulates dialog between scientists, instructors, students and other stakeholders on the use of Online Labs as a means to increase students' enthusiasm towards science.

We are looking forward to hearing from you.

Sincerely yours,

[**Name**] [**Surname**]

[**Go-Lab Partner**]

On behalf of the Go-Lab Consortium

Annex B: Questionnaires used in the validation workshops of the Big Ideas of Science

B1: Pre Questionnaire

Background information

Gender:
- ☐ Male
- ☐ Female

Years of teaching experience:
- ☐ 0 – 5 years
- ☐ 6 – 10 years
- ☐ 11 – 15 years
- ☐ >15 years

Education:
- ☐ BSc (bachelors degree)
- ☐ MSc (master degree)
- ☐ Phd (doctorate)
- ☐ Other…………………………………………………………………..

I am teaching students:
- ☐ Less than 6 years old
- ☐ 6-9 years old
- ☐ 9-12 years old
- ☐ 12-15 years old
- ☐ 15-18 years old
- ☐ Older than 18
- ☐ Other……………………………………………………………...

My teaching area is:
- ☐ Physics
- ☐ Biology
- ☐ Chemistry
- ☐ Geography
- ☐ Environmental Sciences
- ☐ Other…………………………………………

Are you a teachers' trainer?

☐ Yes
☐ No

1. Are you familiar with the concept of the “Big Ideas of Science”?
- ☐ Not familiar at all
- ☐ I have only heard a little about it
- ☐ I am quite familiar
- ☐ I am very well acquainted with the “Big Ideas of Science”

2. Which of the following definitions do you believe describes best the “Big Ideas of Science”?
- ☐ A set of ideas that briefly outline science’s greatest achievements and discoveries.
- ☐ 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 set of concepts that outline how science works and what principles (ethical, social, economic and political implications) it is submitted to.
- ☐ A set of proposals that demonstrate to teachers how to teach science in the most successful and efficient way.

3. When teaching any given science subject in your class; how often do you try to connect it to students’ everyday life and the world around us?
- ☐ Never
- ☐ Sometimes, but not very often
- ☐ As often as I can
- ☐ Always

4. When teaching any given science subject in your class; how often do you try to connect it to other subjects that students have been taught in the present year or past years?
- ☐ Never
- ☐ Sometimes, but not very often
- ☐ As often as I can
- ☐ Always

5. How important do you believe it is to connect the science subjects taught in school with everyday life and the world around us?
- ☐ Not important at all
- ☐ A little important
- ☐ Very important
- ☐ I think it is absolutely necessary

6. How important do you believe it is to connect the science subjects taught in school with other subjects that students have been taught in the present year or past years?
- ☐ Not important at all
- ☐ A little important
- ☐ Very important
- ☐ I think it is absolutely necessary

B2: Post Questionnaire

Are you a teachers' trainer?

☐ Yes
☐ No

1. **What are the Big Ideas of science according to you?**

   ____

   ____

2. **Which of the two sets is closer to the Big Ideas you thought?**[4]
   - ☐ Set A
   - ☐ Set B
   - ☐ None of the two
   - ☐ Both are very close

3. **Which of the two sets is more appropriate for your students according to your opinion?**
   - ☐ Set A
   - ☐ Set B
   - ☐ None of the two

   Please explain briefly why:

   ____

   ____

4. **Check again set A. Is there something missing, something unnecessary or something you don't like?**

   ____

   ____

5. **Do what degree do you find set A to be satisfying?**

	1	2	3	4	5	
Not satisfying at all						Very satisfying

6. **Do you have any other comments?**

   ____

   ____

7. **How important do you regard "Big Ideas of Science" to be when it comes to teaching science?**

	1	2	3	4	5	
Not important at all						Very important

[4] Set A corresponds to the Go-Lab set and Set B corresponds to Harlen's set. Sets were labeled A and B so as to avoid influencing participants' opinion.

Annex C: Questionnaires for Validating the Metadata Model for Go-Lab Online Labs

C1: Questionnaires' Common Part

Background Information

1. Gender: *[5]

☐ Male

☐ Female

2. Years of teaching experience *

☐ 0 – 5 years

☐ 6 – 10 years

☐ 11 – 15 years

☐ >15 years

3. Education: *

☐ BSc (bachelor's degree)

☐ MSc (master degree)

☐ Phd (doctorate)

☐ Other:

4. Computer knowledge: *

☐ YES

☐ NO

5. Computer usage during teaching: *

☐ YES

☐ NO

6. Have you ever used virtual labs during your teaching? *

☐ YES

☐ NO

7. Have you ever used remote labs during your teaching? *

☐ YES

☐ NO

[5] * Required

C2: Questionnaire 1: Importance of Metadata Elements within the context of viewing the preview page of a Go-Lab online lab.

Metadata elements are descriptions that characterise each lab and help users easily retrieve labs and activities from the Go-Lab repository according to their needs.

Imagine that you have made a search for online labs in the Go-Lab lab repository to be used in an ILS and you have found one you are interested in. Now, you want to see more details about the selected online lab so you go to its preview page.

Which of the following metadata elements would you consider them as important and you would like to be informed about in the preview page of the lab?

Notes:

- The tables in the following pages present metadata elements that can be used to facilitate organizing, searching and retrieving the Go-Lab Online Labs. They are categories organizing the information that can be attached to each Online Lab.

- The metadata information may be added to an Online Lab either by choosing between entries in pre-defined vocabulary lists, or by filling open-ended text fields. Please note that we will ask for your opinion on the vocabularies for some of these elements in the next section of the questionnaire.

- Users will only be able to search or filter with these metadata provide that they are available.

*- In the following table, please state the importance that you assign to each metadata element by putting an "**X**" into the relevant box.*

General Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
1	Keywords *(A set of terms that characterize the content of the lab.)*					
2	Available Languages					
3	Type of the lab *(virtual lab, remote lab, dataset/analysis tool)*					
4	Access permissions					
5	Information about the provider(s) *(publishers)*					
6	Contact details of the lab's owners					
7	Availability of the lab					
8	Booking requirement					
9	Current version of the lab					
10	Information on the contributors of the lab					
11	Critical dates related to the lab's lifecycle					
Pedagogical Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
12	The big ideas of science that the lab addresses *(see Annex B5)*					

13	Subject domain *(see Annex B6)*					
14	Grade levels covered					
15	Educational objectives addressed *(see Annex B7)*					
16	The phases of the Go-Lab inquiry cycle supported					
17	Level of difficulty *(Students are able to use it easily on their own; with little help from the teacher; only following step-by-step guidelines)*					
18	Level of interaction *(low, medium, high; depending on the number of variables the students has to handle in the lab)*					
19	The ICT competence level that a teacher should possess. *(see Annex B8)*					
20	Support of students with disabilities					
21	The principal users for whom the lab was designed.					
22	Information about how the use of the lab can support students in developing different skills					
Additional Resources and Apps						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
23	URL(s) for accessing student's material					
24	URL(s) for accessing relative Inquiry Learning Spaces					
25	URL(s) for accessing any supportive app(s)					
Technical Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
26	Technical requirements needed					
27	Technical format *(e.g. javascript, java, flash, applet)*					

Your opinion on some of the proposed vocabularies for the metadata elements used for searching Go-Lab Online Labs

Note:
In the present section, we would like to focus on some of the vocabularies to be used for some elements presented in the above table. For this purpose, we would like to ask for your opinion and suggestions.

4.1 For the metadata element that characterizes the ***Grade Level*** [Element 14] for which an Online Lab can be used, a proposed vocabulary is the following:

- **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**

• Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	*appropriate to some extent – sufficient*	*I have no opinion*	*appropriate to some extent – deficient*	*not appropriate*

Comments/suggestions for improvement:

4.2 For the metadata element that characterizes whether an online lab ***Supports Students with Disabilities*** [Element 20], a proposed vocabulary is the following:

- **Physical impairments**
- **Visual impairments**
- **Hearing impairments**
- **Learning disabilities**
- **No specific provisions**

- Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	*appropriate to some extent – sufficient*	*I have no opinion*	*appropriate to some extent – deficient*	*not appropriate*

Comments/suggestions for improvement:

4.3 For the metadata element that characterizes the "**Big Ideas of Science**" [Element 12], a proposed list is presented in Annex B5.

- Do you regard the above list appropriate for this element?

appropriate	*appropriate to some extent – sufficient*	*I have no opinion*	*appropriate to some extent – deficient*	*not appropriate*

Comments/suggestions for improvement:

- The characterization of labs, following the big ideas, will provide teachers with suggested activities that interconnect different subject domains. Do you find this feature useful?

very useful	*useful to some extent – sufficient*	*I have no opinion*	*useful to some extent – deficient*	*not useful*

Comments/suggestions for improvement:

C3: Questionnaire 2: Importance of Metadata Elements within the context of making a general search for labs in the Go-Lab repository.

Metadata elements are descriptions that characterise each lab and help users easily retrieve labs and activities from the Go-Lab repository according to their needs.

Imagine you are in the Go-Lab repository and you wish to make a search for labs. This general search will be about retrieving labs that you can use in your class within a specific learning activity.

Which of the elements mentioned in the table below would you use to perform your initial search? Please indicate how important you believe each element is in the context of such a search.

Note:

- The tables in the following pages present metadata elements that can be used to facilitate organizing, searching and retrieving the Go-Lab Online Labs. They are categories organizing the information that can be attached to each Online Lab.

- The metadata information may be added to an Online Lab either by choosing between entries in pre-defined vocabulary lists, or by filling open-ended text fields. Please note that we will ask for your opinion on the vocabularies for some of these elements in the next section of the questionnaire.

- Users will only be able to search or filter with these metadata provide that they are available.

*- In the following table, please state the importance that you assign to each metadata element by putting an "**X**" into the relevant box.*

General Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
1	Keywords *(A set of terms that characterize the content of the lab.)*					
2	Available Languages					
3	Type of the lab *(virtual lab, remote lab, dataset/analysis tool)*					
4	Access permissions					
5	Information about the provider(s) *(publishers)*					
6	Contact details of the lab's owners					
7	Availability of the lab					
8	Booking requirement					
Pedagogical Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
9	The big ideas of science that the lab addresses (see Annex B5)					
10	Subject domain (see Annex B6)					
11	Grade levels covered					

12	Educational objectives addressed (see Annex B7)					
13	The phases of the Go-Lab inquiry cycle supported					
14	Level of difficulty (Students are able to use it easily on their own; with little help from the teacher; only following step-by-step guidelines)					
15	Level of interaction (low, medium, high; depending on the number of variables the students has to handle in the lab)					
16	The ICT competence level that a teacher should possess. (see Annex B8)					
17	Support of students with disabilities					
Additional Resources and Apps						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
18	URL(s) and availability of students' material					
19	URL(s) for accessing relative Inquiry Learning Spaces					
20	URL(s) for accessing any supportive app(s)					

Your opinion on some of the proposed vocabularies for the metadata elements used for searching Go-Lab Online Labs

Note:
In the present section, we would like to focus on some of the vocabularies to be used for some elements presented in the above table. For this purpose, we would like to ask for your opinion and suggestions.

4.1 For the metadata element that characterizes the ***Grade Level*** [Element 11] for which an Online Lab can be used, a proposed vocabulary is the following:

- **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**

• Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	***appropriate to some extent – sufficient***	***I have no opinion***	***appropriate to some extent – deficient***	***not appropriate***

Comments/suggestions for improvement:

4.2 For the metadata element that characterizes whether an online lab ***Supports Students with Disabilities*** [Element 17], a proposed vocabulary is the following:

- **Physical impairments**
- **Visual impairments**
- **Hearing impairments**
- **Learning disabilities**
- **No specific provisions**

• Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	***appropriate to some extent – sufficient***	***I have no opinion***	***appropriate to some extent – deficient***	***not appropriate***

Comments/suggestions for improvement:

4.3 For the metadata element that characterizes the "**Big Ideas of Science**" [Element 9], a proposed list is presented in Annex B5.

• Do you regard the above list appropriate for this element?

appropriate	***appropriate to some extent – sufficient***	***I have no opinion***	***appropriate to some extent – deficient***	***not appropriate***

Comments/suggestions for improvement:

• The characterization of labs, following the big ideas, will provide teachers with suggested activities that interconnect different subject domains. Do you find this feature useful?

very useful	***useful to some extent – sufficient***	***I have no opinion***	***useful to some extent – deficient***	***not useful***

Comments/suggestions for improvement:

C4: Questionnaire 3: Importance of Metadata Elements within the context of filtering search results for labs in the Go-Lab repository.

Metadata elements are descriptions that characterise each lab and help users easily retrieve labs and activities from the Go-Lab repository according to their needs.

Imagine that you have searched for an online lab in the Go-Lab lab repository, but there are many search results returned. Because there are many irrelevant results, you would like to trim the list down by filtering on specific fields.

Which of the following metadata elements would you use to filter in search results? Please, indicate how important each element is in context of such a search.

Note:

- The tables in the following pages present metadata elements that can be used to facilitate organizing, searching and retrieving the Go-Lab Online Labs. They are categories organizing the information that can be attached to each Online Lab.

- The metadata information may be added to an Online Lab either by choosing between entries in pre-defined vocabulary lists, or by filling open-ended text fields. Please note that we will ask for your opinion on the vocabularies for some of these elements in the next section of the questionnaire.

- Users will only be able to search or filter with these metadata provide that they are available.

*- In the following table, please state the importance that you assign to each metadata element by putting an "**X**" into the relevant box.*

General Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
1	Keywords *(A set of terms that characterize the content of the lab.)*					
2	Available Languages					
3	Type of the lab *(virtual lab, remote lab, dataset/analysis tool)*					
4	Access permissions					
5	Information about the provider(s) *(publishers)*					
6	Contact details of the lab's owners					
7	Availability of the lab					
8	Booking requirement					
Pedagogical Metadata						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
9	The big ideas of science that the lab addresses *(see Annex B5)*					
10	Subject domain *(see Annex B6)*					
11	Grade levels covered					
12	Educational objectives addressed *(see Annex B7)*					

13	The phases of the Go-Lab inquiry cycle supported					
14	Level of difficulty *(Students are able to use it easily on their own; with little help from the teacher; only following step-by-step guidelines)*					
15	Level of interaction *(low, medium, high; depending on the number of variables the students has to handle in the lab)*					
16	The ICT competence level that a teacher should possess. *(see Annex B8)*					
17	Support of students with disabilities					
18	The principal users for whom the lab was designed.					
Additional Resources and Apps						
No	**Metadata Element**	**1 (Low Importance)**	**2**	**3**	**4**	**5 (High Importance)**
19	Availability of students' material					

Your opinion on some of the proposed vocabularies for the metadata elements used for searching Go-Lab Online Labs

Note:
In the present section, we would like to focus on some of the vocabularies to be used for some elements presented in the above table. For this purpose, we would like to ask for your opinion and suggestions.

4.1 For the metadata element that characterizes the ***Grade Level*** [Element 11] for which an Online Lab can be used, a proposed vocabulary is the following:

- **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**

- Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	*appropriate to some extent – sufficient*	*I have no opinion*	*appropriate to some extent – deficient*	*not appropriate*

Comments/suggestions for improvement:

4.2 For the metadata element that characterizes whether an online lab ***Supports Students with Disabilities*** [Element 17], a proposed vocabulary is the following:

- **Physical impairments**
- **Visual impairments**
- **Hearing impairments**
- **Learning disabilities**
- **No specific provisions**

- Do you regard the above vocabulary as an appropriate vocabulary for this element?

appropriate	appropriate to some extent – sufficient	I have no opinion	appropriate to some extent – deficient	not appropriate

Comments/suggestions for improvement:

4.3 For the metadata element that characterizes the "**Big Ideas of Science**" [Element 9], a proposed list is presented in Annex B5.

- Do you regard the above list appropriate for this element?

appropriate	appropriate to some extent – sufficient	I have no opinion	appropriate to some extent – deficient	not appropriate

Comments/suggestions for improvement:

- The characterization of labs, following the big ideas, will provide teachers with suggested activities that interconnect different subject domains. Do you find this feature useful?

very useful	useful to some extent – sufficient	I have no opinion	useful to some extent – deficient	not useful

Comments/suggestions for improvement:

C5: Questionnaires' Annex: 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.
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.
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.

C6: Questionnaires' Annex: Primary Terms of the Science Curriculum Vocabulary

Analytical Chemistry	Solids, liquids and gases
Anatomy	Sound
Astronomy	Technological applications
Botany	Tools for science
Chemical Reactions	Useful materials and products
Climate	Variation, inheritance and evolution
Earth science	Waves
Ecology	
Electricity and magnetism	
Energy	
Environment	
Environmental protection	
Fields	
Forces and motion	
Geography	
High Energy Physics	
History of Science and Technology	
Humans and animals	
Inorganic chemistry	
Life processes	
Light	
Natural resources	
Obtaining and using materials	
Organic chemistry	
Radioactivity	

C7: Questionnaires' Annex: 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
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 remember	To help the learner recognize or recall information
To understand	To help the learner organize and arrange information mentally
To apply	To help the learner apply information to reach an answer
To think critically and creatively	To help the learner think on causes, predict, make judgments, 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.

Affective Objectives

Process	Description
To pay attention	To help the learner focus and pay attention to stimuli, passively
To respond and participate	To help the learner react to stimuli and actively participate in the learning process
To recognize values	To help the learner attach values to stimuli
To form and follow a system of values	To help the learner build a consistent system of values and behave accordingly

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.

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

C8: Questionnaires' Annex: Teachers' ICT Competences

	Technology Literacy	Knowledge Deepening	Knowledge Creation
Understanding ICT in Education	**Policy Awareness** [Teachers must be aware of the current policies and be capable of describing how their own practices support and correspond to them]	**Policy Understanding** [Teachers must be knowledgeable of the national policies and be able to design practices to support them]	**Policy innovation** [Teachers must be able to critically assess national policies and engage in the creation and implementation of programmes aimed at realizing them]
Curriculum and Assessment	**Basic knowledge** [Teachers must have an excellent understanding of the curriculum and assessment standards in their subject domain, and utilize ICT in the curriculum]	**Knowledge Application** [Teachers must have a firm understanding of the knowledge of their subject domain and be able to utilize it in a flexible manner to create complex problems]	**Knowledge society skills** [Teachers must be knowledgeable about complex human development and the specific manners in which this process is optimized]
Pedagogy	**Integrate Technology** [Teachers must have a thorough understanding of the appropriate time, place, target and manner of using ICT]	**Complex problem solving** [Teachers must design, monitor and assess student's project plans with the focus of enhancing their understanding and their collaboration]	**Self-management** [Teachers must be able to explicitly model their learning processes and to create situations for their students to apply developmental skills]
ICT	**Basic Tools** [Teachers must be competent in the use of basic hardware, software and productivity tools]	**Complex tools** [Teachers must be able to use a number of subject-specific tools and adapt their use in diverse problem- and project- based scenarios. Moreover, external collaborations should be performed with the use of ICT]	**Pervasive tools** [Teachers must be competent in creating ICT-based knowledge communities to foster their students' development of knowledge creation skills and reflective skills]
Organization and Administration	**Standard Classroom** [Teachers must be able to use ICT to provide equitable access to their classroom as a whole and as separate groups]	**Collaborative groups** [Teachers must be adept in creating flexible learning environments which foster student collaboration]	**Learning Organizations** [Teachers must be able to perform leadership tasks in terms of supporting their colleagues' training and promoting a vision of continuous learning for their school]
Teacher Professional Learning	**Digital literacy** [Teachers must be able to utilize ICT resources for enhancing their own professional learning and competences]	**Manage and guide** [Teachers must be competent in creating complex projects, collaborating with external colleagues and accessing networked information with the aim of enhancing their professional learning]	**Teacher as model learner** [Teachers must express the ability and motivation to experiment and continuously pursue their professional learning through the creation of and participation in ICT-powered professional learning communities]

Annex D: Inquiry Learning Space (ILS) Scenario

1. Go-Lab basic inquiry cycle scenario
2. The jigsaw approach
3. Changing hats
4. Learning by critiquing