



**Inspiring Science Education
Teacher Guide**

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Inspiring Science Education Consortium

	Angelos Lazoudis Eugenia Kypriotis Dimitris Rossis Manolis Chaniotakis Fani Stylianidou Sofoklis Sotiriou		Panagiotis Zervas Demetrios G. Sampson		Daniel Burgos Aurora Carrasco
	Nikitas Kastis Thomas Fischer		David Lee		Rosa Doran Maria Luísa Almeida
	Maximiliane Schumm Jessica Langheinrich Franz X. Bogner		Chris North Haley Gomez		Andrew MacPherson
	Rüdiger Tiemann		Lamprini Kolovou Antonis Ramfos		Yvonne Crotty Claire Kelly
	Thomas Kretschmer Christian M. Stracke		Radu Jugureanu Mihaela Garabet Ana-Maria Baldea		Constantin Brosda
	Angelos Papasakellariou Paraskevas Gialouris Georgios Skaliapas Katerina Marinagi Meropi Pantazidou Ioanna Katsouli		Augusto Chiocciariello		Christine Kourkoumeli Stylianios Vourakis George Vasileiadis
	Renata Ivankovic Jasna Tingle Ivana Vugdelija		Timotheos Kastrinogiannis Theodoros Michalareas		Nico Rutten Wouter van Joolingen
	Sally Reynolds Mathy Vanbuel		Petros Lameris Samantha Clarke		Vincent English
	Veera Pensala		Paula Havaste Jani Koivula		Dimitris Polymatidis

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SEARCH AND DISCOVER

Design your Lessons

SHARE

Resources and Tools

USE

Digital Resources
in your Classroom

ASSESS

Student's Performance
and Skills

Introduction

The Inspiring Science Education (ISE) project aims at contributing to the implementation of the 'Digital Agenda for Europe' and in particular to Action 68 "*Mainstream eLearning in national policies for the modernisation of education and training, including in curricula, assessment of learning outcomes and the professional development of teachers and trainers*", and to do so in line with the recommendations of the **Rocard Report** 'A new Pedagogy for the Future of Europe', that sets the basics for the introduction of the Inquiry Based approach in the science curricula of the Member States.

A central idea in the project is that teaching according to the inquiry-based approach can stimulate students' learning gains and their interest in science. Another premise is that digital, interactive tools can be effectively used to achieve these purposes. ISE set out to design, plan and implement large-scale pilots to stimulate and evaluate innovative use of existing eLearning tools and resources (e.g. interactive simulations, educational games, VR and AR applications, modelling and data analysis tools, eScience applications, as well as, digital resources from research centres, science centres and museums) for scientific disciplines and technology, enhancing science learning in 5,000 primary and secondary schools in 15 European Countries.

ISE innovation building methodology includes evaluation metrics and benchmarking activities, on the design and deployment of innovative science learning practice and school

organization change. The project's use of eLearning tools and resources is coupled with an evaluation framework, evaluating progress on learning achievements, based on the PISA 2012 framework for the assessment of students' problem solving competence of students. This approach offers the basis for validation of the introduction of technology-supported educational innovation in European schools, thus ensuring real impact and widespread uptake.

This Teacher Guide aims to support science teachers in navigating through ISE's methodology, tools and resources so as to create and deliver inquiry-based educational scenarios to use with students in their science classroom.

This chapter offers a brief introduction to the document. Chapter [2] summarises the main guidelines and background information for the implementation of inquiry-based inspiring science educational scenarios and the corresponding template used in ISE. Chapter [3] focuses on the ISE community environment, explaining how one can join or create a community and share –search and create–resources. Chapter [4] includes a ste-by-step tutorial about the most used functionalities of the ISE authoring and delivery environments: retrieving and sharing resources, creating and enriching scenarios and also viewing these scenarios. Finally, Chapter [5] focuses on the optional feature of creating and using formative assessment and problem solving questions as part of an educational scenario, providing the rationale behind and guidance for it.

SEARCH AND DISCOVER

Design your lessons

Contextualized model of learning

2.1 About Inquiry Based Science Education [IBSE]

Understanding science is essential in today's society. The public's understanding of science is largely influenced by its experiences in science classrooms. It is therefore important that science teachers understand science and give an accurate representation of it in their classrooms. Science is defined as a body of knowledge, a process of inquiry, and the people involved in the scientific enterprise. Science teachers usually concentrate on the body of knowledge that forms their discipline. Students should also understand the process of scientific inquiry; the understanding should come through their experiences with the process in the science classroom and outside school. Few definitions of science include the people who are involved in the enterprise. Yet the history of science has proven, time and again, to be a history of scientists. Recognising the individual qualities important to scientists and guarding against human shortcomings that may also influence scientific work are necessary in presenting a total picture of science. Different models of scientific inquiry have been developed and extensively validated in recent years. The accumulation of valid reliable knowledge was shown to be the aim of all the models. Science teachers should understand the strengths and weaknesses, the procedures, and the logical problems of the different models of inquiry. In the science classroom there should be a balance in emphasis on science as a body of knowledge, a process, and a human enterprise.

The idea of teaching science by inquiry has a long history in science education. There is an equally long history of confusion about what teaching science by inquiry means and,

regardless of the definition, its implementation in the classroom. Inquiry-based learning has been officially promoted as a pedagogy from improving science learning in many countries (Bybee et al., 2008; Hounsell & McCune, 2003; Minner et al., 2010), and since the publication of the 'Science Education Now: A renewed Pedagogy for the Future of Europe' report (Rocard et al., 2007) as one of the top educational goals for Europe (following similar actions in US by the National Research Council, 1996, 2000; Education Development Center, Center for Science Education, 2007).

'Inquiry' is referred to in the science education literature to designate at least three distinct but interlinked categories of activity: what scientists do (investigating scientific phenomena by using scientific methods in order to explain aspects of the physical world); how students learn (by pursuing scientific questions and engaging in scientific experiments by emulating the practices and processes used by scientists); and a pedagogy, or teaching strategy, adopted by science teachers (designing and facilitating learning activities that allow students to observe, experiment and review what is known in light of evidence) (Minner et al., 2010). This polysemy of the term explains partly the confusion associated with the implementation of 'inquiry-based science education' (IBSE), a term in itself used as an umbrella for various educational approaches, characterized by the differing emphasis they put on these three distinct 'inquiry' activities.

For example, Linn et al.'s (2004) definition of inquiry as *"the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning*

investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments". (p4)

seems to put the emphasis on what scientists do, whereas the US National Research Council's definition as

"a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models and theories...and learn science in a way that reflects how science actually works" (NRC, 1996: p214, cited by Krystyniak & Heikkinnen, 2007).

shifts the emphasis to how students learn, highlighting however the close connection between inquiry as scientific practice, and inquiry as student learning.

Inquiry-based science education has also been described as teaching and learning science as inquiry and by inquiry (Tamir, 1985; Chiappetta, 1997; Zion et al., 2004). Learning science as inquiry includes learning about the way in which the scientific endeavour progresses, and analyzing the inquiry process performed by others, sometimes using historical perspectives (Bybee, 2000; Schwab, 1962). Learning science by inquiry, on the other hand, involves the learner in raising research questions, generating a hypothesis, designing experiments to verify them, constructing and analyzing evidence-based arguments, recognizing alternative explanations, and communicating scientific arguments (Tamir, 1985). Teaching science by inquiry requires imparting not only scientific information but also the abilities to do inquiry and, more deeply, an understanding of what scientific inquiry is about.

The ISE approach acknowledges the need for science teachers to bestow their students with the knowledge and ability to engage in inquiry but also with an understanding of inquiry and of how inquiry results in scientific knowledge.

2.2 ISE's Instructional Model of IBSE

As mentioned in the introduction of this guide, ISE is also concerned with supporting teachers to organise and sequence inquiry-oriented and technology-enhanced learning experiences for their students effectively. One of the ways ISE pursued this concern, is by providing an instructional

model for teachers to help them organise their teaching sequences.

"An instructional model incorporates the features of inquiry into a sequence of experiences designed to challenge students' current conceptions and provide time and opportunities for reconstruction, or learning, to occur" (Bybee, 1997, cited by NRC, 2000).

Having said this, ISE does not perceive learning by inquiry as following specific step-by-step instructions in a linear sequence of activities, but rather as experiencing activities that blend and merge together. It moreover supports the prevailing view that inquiry is a flexible pedagogy that allows teachers to tailor their approaches to the desired learning outcomes and specific circumstances of different classroom contexts. And because these learning outcomes are diverse and vary according to the age of the learners, highly structured and more open-ended inquiries both have their place in science classrooms.

There is a variety of conceptualizations of the process of inquiry learning in the research literature. ISE's instructional model of IBSE consists of five learning activities: Orienting & Asking Questions; Hypothesis Generation & Design; Planning & Investigation; Analysis & Interpretation; and Conclusion & Evaluation. The following subsections provide explanations and suggestions of what these learning activities could consist of.

2.2.1 Orienting & Asking questions

Orienting: Provide contact with the content and/or provoke curiosity

These inquiry activities can be focused on answering a question, but also on investigating a controversial dilemma or solving a problem. Teachers may introduce this with a classroom discussion and support it, for example, with narratives, videos, or animations. They may provide a framework for the discussion and should monitor students' involvement in it. Formulating questions can be facilitated by structuring the question (problem/case) by identifying relevant limitations and variables. Students ask questions, discuss the issues involved and take notes of their ideas.

Define goals and/or questions from current knowledge

Knowing when the learning activity has been successfully completed necessitates clarifying the goals that should be

achieved, or the criteria that should be met. Therefore, together with their teachers students should identify learning goals, identify prior knowledge they have related to each issue, reflect on knowledge and skills they have for solving them. If appropriate, they should collect additional information and identify relevant variables.

2.2.2 Hypothesis generation & Design

Generation of hypotheses or preliminary explanations

Students based on their prior knowledge, the notes they have taken and the structure of the question (problem/case) formulate hypotheses, as supposed relations between measurable dependent and independent variables. It is difficult for students to formulate proper hypotheses on their own. This learning activity therefore necessitates appropriate support (de Jong & van Joolingen, 1998). Rules for generating hypotheses could serve this stage as resources.

Design/Model

Then students design an experiment that is appropriate for testing their hypotheses. Rules for planning experiments are resources that should be available in this stage. The difference between the experimental plan and planning of making the plan (a regulative process) should be understood and made explicit by the teachers.

Depending on the focus of the inquiry, the activities of generating hypotheses and designing can take several forms. An experiment can be set up to test hypotheses. For problem resolution, relating a hypothesis to the data allows for checking whether the hypothesis solves the problem. Another approach to investigating hypotheses is to design a model by building a physical or virtual artefact. For example, students can design a house to investigate influences on CO₂ emissions. The appropriateness of models can be evaluated by relating it to the notes that students take during the activity.

2.2.3 Planning & Investigation

Plan investigation

Clearly formulated hypotheses facilitate planning the work process. Planning includes determining the order of activities and intermediate goals, which tools and/or data to use, a clear time line, and how these activities can be

divided among the participants.

Perform investigation

Investigations may be performed by conducting experiments or designing artefacts, using physical, virtual or remote tools.

2.2.4 Analysis & Interpretation

Analysis and Interpretation: Gather result from data

Collected data will be analysed and interpreted. Data analysis and processing tools have to be used in this stage. Teachers should support the learners in the case of difficulties – sometimes they do not know where to start with searches in the data. Teachers may support students' process of data analysis by helping them organize the data collected and interpret them by identifying key issues. When solving problems, solutions found by experts can also be examined, and compared with students' own solutions for the same problem. For investigation of controversial cases, different perspectives on approaching the case should be analyzed, and the value of different information sources should be evaluated. These processes may generate new questions for further inquiry.

2.2.5 Conclusion & Evaluation

Conclude and communicate result/explanation:

Arriving at conclusions in the inquiry process can mean achieving consensus about a solution to a problem, producing a common artefact, or synthesizing views to arrive at a mutual decision. The evaluation process can be facilitated by presenting conclusions to a broader audience, as this allows for replication and/or endorsement of the presented results.

Evaluation/reflection

As it is important not only to arrive at a conclusion, e. g., solving a problem, but also to have actually learned something, reflection is necessary to allow for recognition of similar problems (questions/cases) in the future, transfer of knowledge to such situations, and the ability to apply the learned strategy. Besides evaluating one's own outcomes, it can also be interesting to evaluate others' outcomes and determine the extent to which they meet the criteria set. Comparing the collected data to such criteria can necessi-

tate subsequent refinement of the conceptual model. When determining whether learning goals are achieved, it can be valuable for future inquiry activities to identify what factors have been facilitators or barriers in attaining the goals.

Consider other explanations

For investigation of controversial cases, as before, the value of other explanations should be considered and evaluated. These processes may generate new questions for further inquiry.

The different information sources can be found by students themselves or provided by the teacher via links/documents/other materials.

2.3 ISE Educational Scenarios and the ‘Big Ideas’ of Science

To organize the ISE inquiry-based educational scenarios, so as to make them readily available to teachers and easy to use, it was decided that in addition to a number of other

more conventional metadata (e.g. school phase, science topic, age of students, etc.) they would be associated to one of the ‘Big Ideas’ of Science. These ‘Big Ideas’ represent overarching principles in the science curriculum and can also be looked at as ‘umbrellas’ where the content material from various science subjects can be brought under the same ‘umbrella’ in order to develop a common theme running through the science curricula over time. According to Harlen’s report (2010) the goals of science education should not be conceived “in terms of the knowledge of a body of facts and theories but a progression towards key ideas which together enable understanding of events and phenomena of relevance to students’ lives during and beyond their school years.” In this report 14 such ideas are identified and include ideas of science and ideas about science and its role in society. The former are adopted by ISE to be explicitly linked with its educational scenarios. Table 1, presents the proposed “Big Ideas” of Science Collection.

1	All material in the Universe is made of very small particles. Light in all different wavelengths permeates the Universe. (This idea is slightly changed from Harlen’s original)	6	The solar system is a very small part of one of millions of galaxies in the Universe.
2	Objects can affect other objects at a distance.	7	Organisms are organised on a cellular basis.
3	Changing the movement of an object requires a net force to be acting on it.	8	Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.
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.	9	Genetic information is passed down from one generation of organisms to another.
5	The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth’s surface and its climate.	10	The diversity of organisms, living and extinct, is the result of evolution.

SHARE

Resources and Tools

The ISE Community Environment

To achieve its objectives, ISE took into account emerging educational paradigms concerning access to learning (the once 'infrastructure equipment' mandate), the creation and sharing of knowledge (the once 'learning materials' availability) and the building of competences in learning communities (the teachers professional development quest). It thus hosts its portal under the umbrella of Open Discovery Space (ODS) (<http://portal.opendiscoveryspace.eu/>), an environment created with funding from the European Union to encourage educational communities to use and share eLearning resources, and exchange their experience and views on ease of use and quality of these resources. In the ISE Community Environment teachers can join existing communities or create new communities to discuss, share and swap ideas and resources in their own language or in

English, at a thematic (connected to a specific E-Learning tool or theme), school, national or international level. The following sections aim to be a step-by-step guide to how one can join or create a community and share –search and create- resources in the ISE Community Environment (or ISE portal) (<http://portal.opendiscoveryspace.eu/ise>).

3.1 Join ISE and one of its existing community of practice

The first thing any prospective ISE Community member ('you') should do in order to be able to take advantage of all the facilities of the ISE Community Environment is to 'Join' it, on the home page of the portal, by clicking on the corresponding link at the top right of the page (**Figure 1**),



Figure 1 – Joining ISE on the portal's home page

Then you are given two options (**Figure 2**):

- [1]. Only to 'Register in ISE portal', or
- [2]. To 'Register and join one of the ISE Communities'.



Figure 2 – Registering in ISE portal

In both cases you need to provide your Login information and you will receive an e-mail confirming that you have successfully registered. In the former case, you register first and then you decide whether you wish to join a community or create a new one yourself. In the latter case, you can search amongst the existing communities of practice, choose one and then both register to ISE and join this community at the same time.

As previously said the ISE portal aims at promoting a genuine collaborative approach to science education and teaching through building communities of practice. These communities are the heart of ISE, so as soon as you reg-

ister in ISE join a community and join other educators in searching, using, modifying and creating teaching materials for science education.

If you wish to join an already existing community of users, click on the Communities tab on the upper right side (**Figure 3 – [1]**) to look through all the already existing communities, sorted by 'Most Recent' or 'Most Popular', or limit your search by Title, School, Country, or Community Domain (Technology, ICT, Mathematics, Science) (**Figure 4 – [1]**). Alternatively, at the lower part of the first page you can easily find out the 'Most Popular', the 'Most Recent' or the 'International Communities' (Figure 3 – [2]).



Figure 3 – Looking for an ISE Community

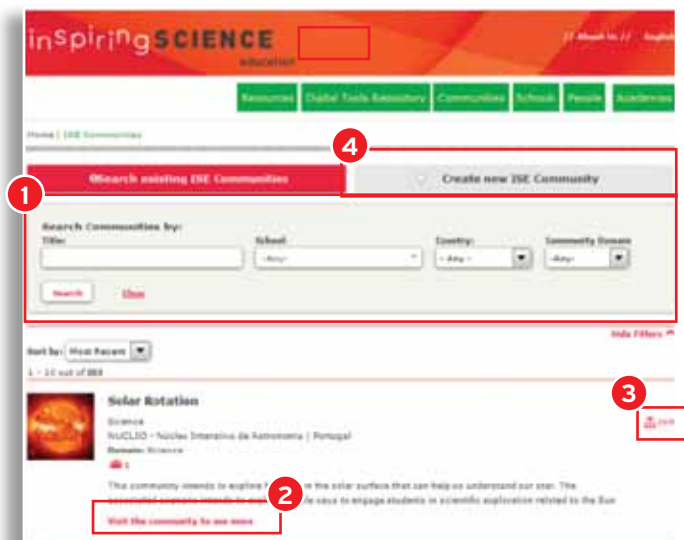


Figure 4 – Searching existing ISE Communities

Once you click on any of these options, you will be re-directed to the list of communities, demonstrating a name and a short description of each. You may want to 'Visit the community to see more' (**Figure 4 – [2]**) about it (**Figure**

5 – [1]). Once you have found a community that you would be interested to participate in, click on the 'Join' button (**Figure 4 – [3]** or **Figure 5 – [2]**) to request to join this community.

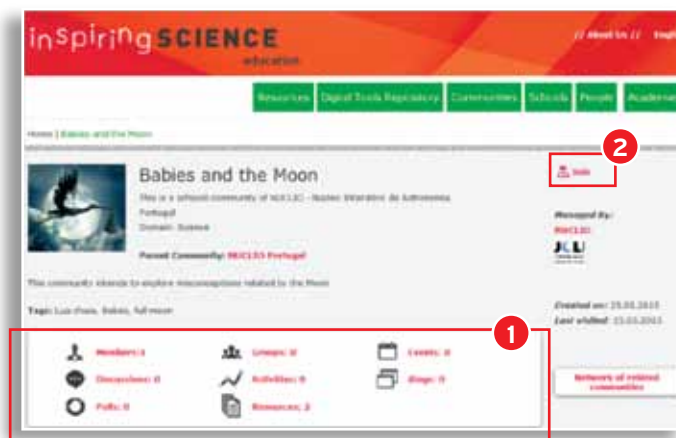


Figure 5 – Finding information about existing ISE Communities

You will then be asked to provide an explanation why you would like to join the community (**Figure 6**). Shortly after you submit this information an e-mail will be sent to you, stating whether your request has been approved. If this procedure is

completed successfully, you can then participate as an active member in your community, uploading resources, discussing with the other members and keeping track of various events in your region that may be of interest to you.



Figure 6 – Asking to join an existing ISE Community

3.2 Create your own ISE Community of practice

You can create a new community or a sub-community to an already existing one. Before creating a new community, please check whether any similar communities exist, that you could join. This would ensure that you can interact with more teachers, exchange views and gain access to an already existing pool of resources.

The creation of a sub-community would be a good idea if you found an already existing community that deals with

a large theme/topic [i.e. science education], and you were interested in narrowing it down [i.e. environmental education]. In the same context, you may be part of a specific school community but wish to create a sub-community for the English language teachers of your school.

If you wish to create a sub-community, providing that you are already a member of the parent community, click on the 'New sub-community' button on the home page of the parent community (**Figure 7**).

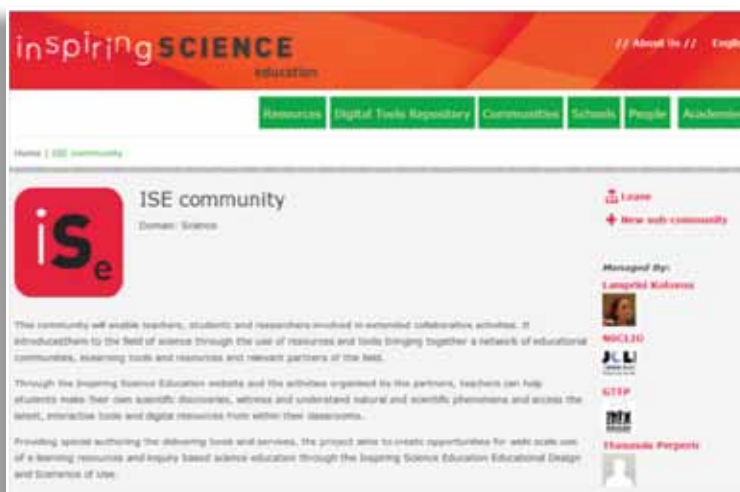


Figure 7 – Creating a sub-community in an existing ISE Community

If on the other hand, you wish to create a new community, you need to click on the 'Create new ISE Community' button (**Figure 4 – [4]** and **Figure 8 – [1]**).

In either case, you will be asked to submit some information about the community (or sub-community) you wish to create: a title, a brief description about it, the country of

the community and the name of your school (**Figure 8**). Shortly after you provide this information, an e-mail will be sent to you, stating whether your community has been approved. If this procedure is completed successfully, you will be the new community's manager and can edit its different settings.

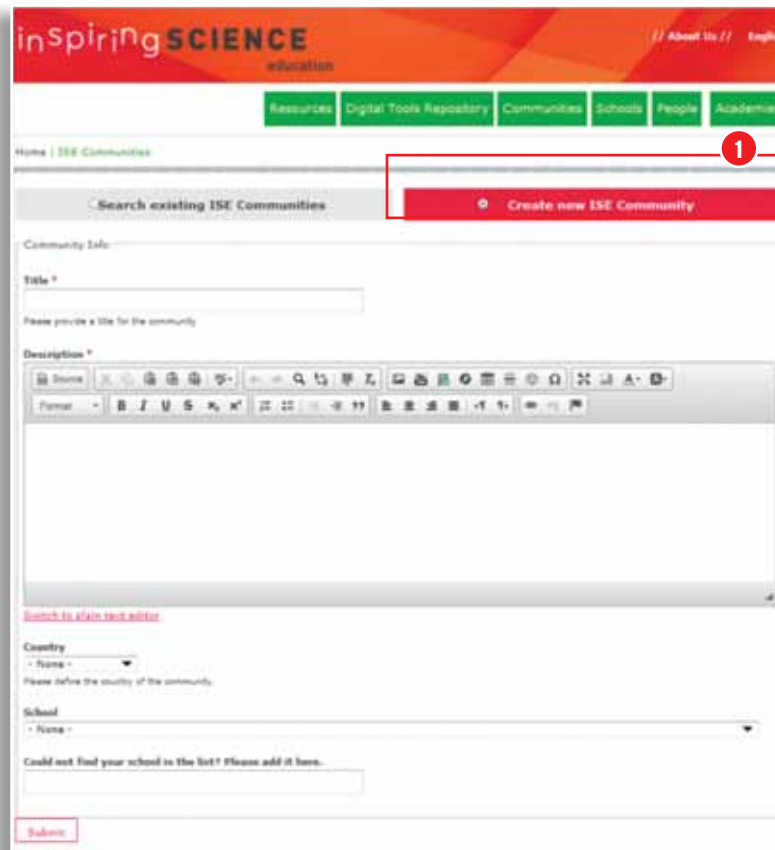
The screenshot shows the 'inspiring SCIENCE education' website. At the top, there are navigation tabs: Resources, Digital Tools Repository, Communities, Schools, People, and Academics. Below these, there's a search bar for 'Search existing ISE Communities' and a red button labeled 'Create new ISE Community' which is highlighted with a red box and the number 1. The form below the button includes fields for 'Title *', 'Description *' (with a rich text editor), 'Country' (a dropdown menu), and 'School' (a dropdown menu). There are also instructions like 'Please provide a title for the community' and 'Please define the country of the community'. At the bottom of the form is a 'Submit' button.

Figure 8 – Creating a new ISE Community

3.3 Use or Manage an ISE Community of practice

Once an ISE Community member or manager, you can share and/or use resources; and you can participate in and/or create Groups, Activities, Events, Blogs, Polls and Discussions (**Figure 9 – [1]**). As a manager of an ISE

Community you have additional functionalities to 'Invite' members to join the Community and to 'Customize the Community' (**Figure 9 – [2]**), that is to administer its members and their roles and to edit the settings of the community (e.g. its accessibility level, community domain, etc.).

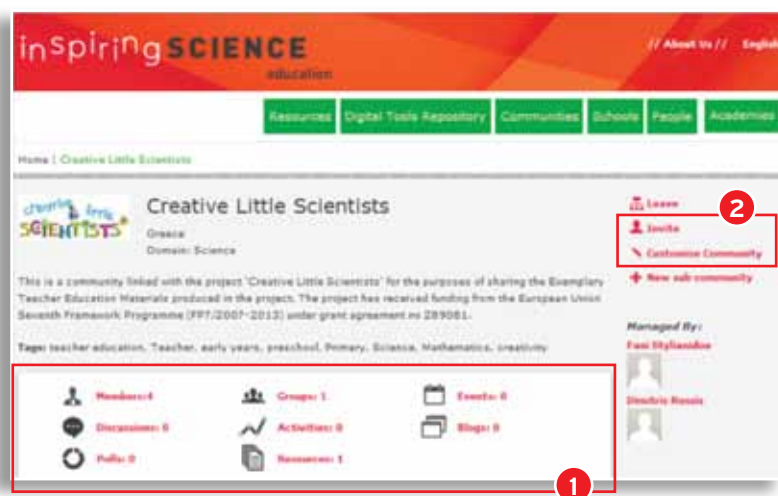


Figure 9 – Using and Managing a new ISE Community

USE

Digital Resources
in your Classroom

ISE Resources, ISE E-learning Tools and Usage scenarios

4.1 ISE E-Learning Tools

A second very significant intended use of the ISE Environment is to access a large number of e-learning tools through its 'Digital Tools Repository'. These can be either accessed and used independently of any other of ISE resources, or can be integrated in and used as part of Educational Scenarios created by Community members. The following section refers to how one can look for an ISE e-learning tool, whereas section 4.2.2.2 shows how users can incorporate such tools in their education resources.

4.1.1 Find an ISE E-Learning Tool

To look for an ISE e-learning tool you should click on the 'Digital Tools Repository' green button (**Figure 10 – [1]**) at the top of the page and then do one or more of the following:

1. a basic search of the tools on the basis of keywords in their Title (**Figure 10 – [2]**);
2. an advanced search (**Figure 10– [3]** and Figure 11)
3. browse using the Big Ideas (**Figure 10– [4]** and **Figure 12**)



Figure 10 – Searching for an ISE E-Learning Tool

4.1.1.1 Do an advanced search

Doing an advanced search for an ISE e-learning tool gives

you the opportunity to limit your search using the following criteria (**Figure 11**):

- Age range of learners you intend to use it with
- Language it uses
- Whether it is suitable for use with mobile devices
- Level of difficulty (*for the learners*)
- Level of interaction (*for the learners*)
- Teacher competency level (*based on the UNESCO ICT Competence Framework for Teachers*)
- Subject domain it addresses
- Big Ideas of Science the tool may be used to promote

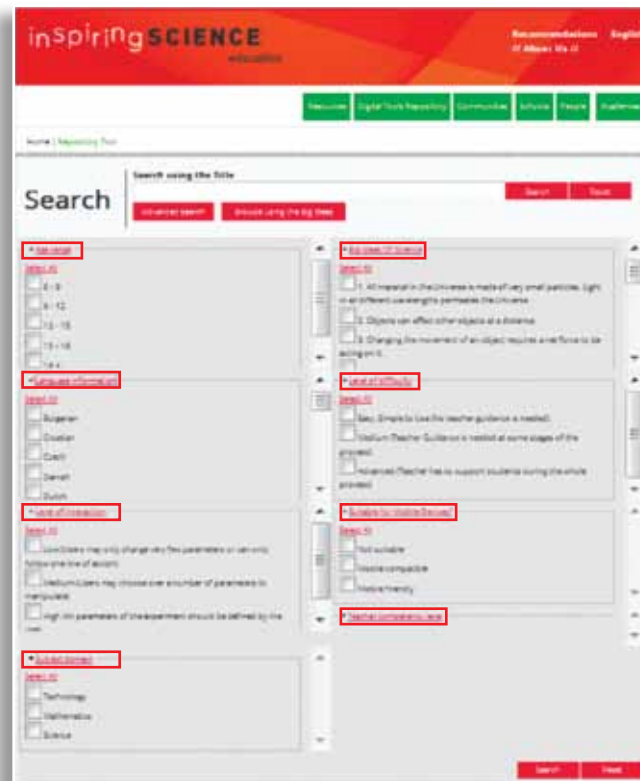


Figure 11 – Advanced search for an ISE E-Learning Tool

4.1.1.2 Browse using the Big Ideas

If on the other hand you have decided which Big Idea of Science you wish to address in your science teaching and you are looking for a suitable e-learning tool to use, you

click on 'Browse using the Big Ideas' red button (**Figure 10– [4]**), which takes you to a page presenting the Big Ideas of Science with links to the corresponding tools (**Figure 12**).



Figure 12 – Choosing ISE e-learning tools using the Big Ideas of Science

4.1.2 Use an ISE E-Learning Tool

Once you choose the ISE e-learning tool you would like to use, by clicking on it, you can see all the information re-

lating to it, including its pedagogical context of use and its technical information (**Figure 13**).



Figure 13 – Information about an ISE e-learning tool

4.2 ISE Resources

One of the main functions of an ISE Community of practice is to facilitate the exchange of resources amongst its members. More particularly, there are two categories of Resources one can share in the ISE Environment (or portal):

Educational Objects: They are typical digital materials, such as video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations and demonstrations.

Educational Scenarios: They are either shorter duration 'Lesson Plans' or longer duration learning 'Scenarios'. They provide teachers with guidelines for conducting an inquiry-based science lesson (or a series of lessons) using one of the digital tools in the ISE Repository, or any other digital tool. They typically contain information on their educational objectives and suggest assessment questions. Educational Scenarios can be (re) used by the same teacher, as well as

by other teachers.

There are also more than one way to share resources:

1. To use an existing resource either as it is or modified;
2. To create a new resource.

The following sections aim to be a step-by-step guide to how one can use and create resources in the ISE Environment.

4.2.1 Use an existing ISE Resource

The ISE Environment contains a vast number of resources, constantly updated and improved with new resources being added every day by the ISE users. Once logged in you can:

1. search through all the resources available, by clicking one of the green buttons at the top of the page (**Figure 14- [1]**) and then either doing free text

search, or limiting your by Title, Date, Contributor, Discipline, Context of use, Type of resource, Copy-right, etc.;

2. search the resources available within a community of practice that you are a member of (**Figure 14– [1]**), by title and type of resource and sorted either by 'Most Recent' or 'Most Popular'

In both cases if you find an educational resource that you are interested in, you can 'View Resource' (**Figure 15 – [1]**) and choose to 'Pin Resource' (**Figure 15– [2]**) in any of the communities you are an administrator of and thus make it part of its resources as well.

4.2.1.1 Use an existing Educational Scenario

If the resource is an Educational Scenario and you want

to use it, you need to 'Clone' (**Figure 15– [3]**) it first. By clicking on the 'Clone' button, you will be transferred onto another page, called 'Summary Page' (**Figure 16**), which gives summary information about the Educational Scenario, under the headings 'General Info', 'Educational Context', 'Educational Objective(s)', 'Subject Domain', 'Additional Information' (**Figure 16– [1]**). By clicking on the icon on the top left of the page to clone the resource (**Figure 16– [2]**), you will be given the opportunity to review and if you wish adapt to your needs, the summary information and meta-data about the resource under the above headings (**Figure 17– [1]**). At the end, you will be asked to 'Save' or 'Save and Edit Phases' (**Figure 17– [2]**). If you click on the latter option, you will be transferred to the authoring environment of the Educational Scenario where you will be able to modify it accordingly (see section 4.2.1.2).

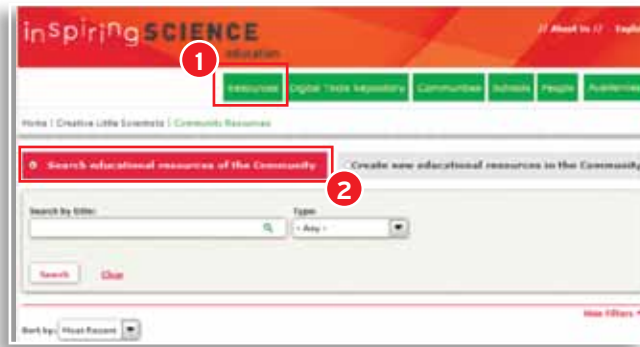


Figure 14 – Searching for educational resources

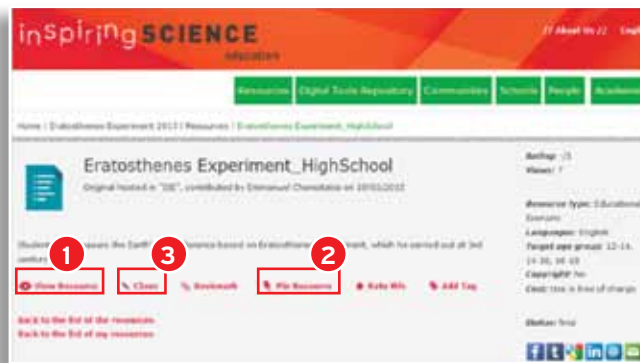


Figure 15 – Finding an educational resource: next steps

Summary Page - Eratosthenes Experiment_HighSchool

General Info.	
Title	Eratosthenes Experiment_HighSchool
Date Created	2019-05-19 18:33:37.0
Short Description	Students will measure the Earth's circumference based on Eratosthenes' experiment, which he carried out at 3rd century B.C.
Current status	Final
Author	Emmanuel Chaniotakis
Original Author	Eugenia Kyriots
Keyword(s)	eratosthenes,circumference,experiment
Language	English
License Level	Public, Allowing adaptations

Educational Context	
Context of use	Informal context
Level of Difficulty	Medium
Duration	3 hour(s)

Educational objective(s)	
Cognitive Objectives	Knowledge Types: Procedural Processes: To think critically and creatively Students learn about the innovative way Eratosthenes used to calculate Earth's circumference.
Affective	To respond and participate Students follow the guidelines given by the teacher and perform the measurement of Earth's circumference themselves.
Psychomotor	To imitate and try Learners follow the same procedure as Eratosthenes did and try to measure Earth's circumference exactly as he did.

Subject Domain	
Big Ideas of Science	1. All material in the Universe is made of very small particles. Light in all different wavelengths permeates the Universe.
Subject Domain	Physics

Additional Information	
General Structure	Linear
Interactivity Level	Very high
Cost	Use is free of charge

Figure 16 – Cloning an Educational Scenario

1

2

Figure 17 – Adapting the metadata of an Educational Scenario

4.2.1.2 Modify an existing Educational Scenario

By cloning an Educational Scenario, it then appears as an Educational Resource in your ISE Profile/Account (Figure 18). You can then use it in your classroom either as it is, or further modified. In both cases you need to click on it, and then click on the 'Edit' button (Figure 19). The Summary Page about the resource (Figure 20) is very similar in content to the one that appears when you 'Clone' an Educational Scenario (Figure 16), but also differs in two important ways: In it you now appear as the Author of the scenario (Figure 20 – [1]) and it also offers a number of new buttons at the top left of the page (Figure 20 – [2]).

These, from left to right allow you to:

- Edit the content of the Educational Scenario
- Edit its metadata
- Set its status to Draft or Final (only Educational Scenarios of Final Status can be used in the classroom)
- Deliver the Educational Scenario, by providing you with two delivery links (a 'Teacher Link' and a 'Class Link') to use in your lesson (Figure 21). Please note that every time you deliver the lesson in your classroom you will need a new set of delivery links.
- View the scenario's History
- Preview the scenario
- Clone the scenario
- Delete the scenario

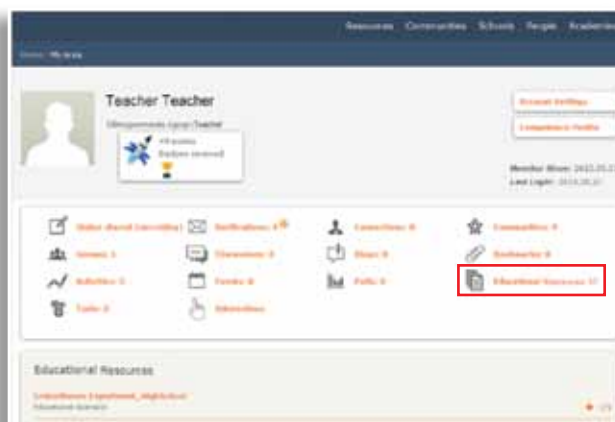


Figure 18 – My account in ISE

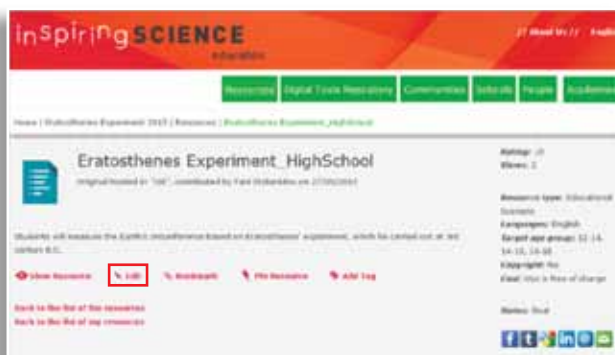


Figure 19 – Editing an Educational Scenario

2 Summary Page - Eratosthenes Experiment_HighSchool

1

General Info

Title	Eratosthenes Experiment_HighSchool
Date Created	2015-05-27 12:06:16.0
Short Description	Students will measure the Earth's circumference based on Eratosthenes' experiment, which he carried out at 3rd century B.C.
Current status	Draft
Author	Teacher Teacher
Original Author	Eugenia Kyriotis
Keyword(s)	eratosthenes, circumference, experiment
Language	English
License Level	Public, Allowing adaptations

Educational Context

Context of use	Informal context
Level of Difficulty	Medium
Duration	3 hour(s)

Educational objective(s)

Cognitive Objectives	Knowledge Types: Procedural Processes: To think critically and creatively Students learn about the innovative way Eratosthenes used to calculate Earth's
----------------------	--

Figure 20 – Using an Educational Scenario

Inspiring SCIENCE

Delivered Lessons and Scenarios

Showing 1 to 1 of 1 entries

Created Date	Teacher	Class
5/27/15 2:20:23 PM	Teacher Link	Class Link

Show 15 entries

First Previous Next Last

Figure 21 – Preparing to deliver an Educational Scenario

4.2.1.3 Deliver an existing Educational Scenario

By clicking on, or copying and pasting the 'Teacher Link'

in your browser you will be redirected to the delivery environment (**Figure 22**).



Figure 22 – Teacher delivery environment

By clicking on, or copying and pasting the 'Class Link' in the browser of the computers in your classroom each student will be directed to the delivery environment (**Figure 23**).



Figure 23 – Student delivery environment

In both views you will see the scenario divided in 5 tabs corresponding to the 5 inquiry-based learning activities presented in chapter 2: 'Orienting & Asking Questions', 'Hypothesis Generation & Design', 'Planning & Investigation', 'Analysis & Interpretation' and 'Conclusion & Evaluation' (**Figure 24 – [1]**). The difference between the 'Teacher Link' and 'Class Link' views is that the former includes grey boxes with direct suggestions/notes/reminders for the teacher for use in classroom (**Figure 24 – [2]**).



Figure 24 – Teacher view of an Educational Scenario

4.2.2 Create a new resource

If you wish to create a resource, depending on the type of resource there is a different path to follow. In the ISE Environment, all new resources can ONLY be created within the Communities you are a member of, by clicking on the 'Resources' link in the home page of the particular Community (see **Figure 9**) and then on the button 'Create new educational resources in the Community' (**Figure 25 – [1]**).

4.2.2.1 Add an Educational Object

If you wish to create an educational resource of the type 'Educational Object' select this option (**Figure 25 – [2]**) and then press 'Create New' (**Figure 25 – [3]**). In the next page you will need to provide a Title for the Educational Object, its Educational Context (i.e. whether it is aimed to be used in primary and/or secondary education and/or in an informal context) and its Content Type (i.e. whether it is a file containing the resource, or a link to the resource) (**Figure 26**).

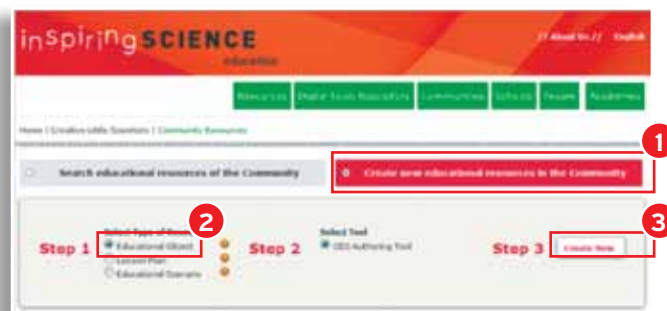


Figure 25 – Creating a new educational resource in the Community: an Educational Object

The screenshot shows the 'inspiringSCIENCE education' website. At the top, there are navigation links: Home, Creative Commons, Resources, Digital Tools Repository, Communities, Schools, People, and Academics. Below the navigation bar, there is a search bar and a language selector set to 'English'. The main form is titled 'Add New Educational Object'. It has a 'Title' field, a 'Language' dropdown set to 'English', a 'Content' dropdown set to 'Educational Content', and an 'Upload content type' dropdown set to 'Select'. A 'Save' button is at the bottom left of the form.

Figure 26 – Adding a new Educational Object

4.2.2.2 Create an Educational Scenario (incl. Lesson Plan)

If now you want to create an Educational Scenario (whether this is a Lesson Plan or a series of lesson plans),

select type of educational resource: 'Lesson Plan' or 'Educational Scenario', select tool: 'ISE Authoring Tool' and then press 'Create New' (**Figure 27**).

The screenshot shows the 'inspiringSCIENCE education' website. At the top, there are navigation links: Home, ISE Authoring Tool, Communities, Schools, People, and Academics. Below the navigation bar, there is a search bar and a language selector set to 'English'. The main form is titled 'Create new educational resources in the Community'. It has a 'Search educational resources of the Community' button and a 'Create new educational resources in the Community' button. The form is divided into three steps: Step 1 (Select Type of Resource), Step 2 (Select Tool), and Step 3 (Create New). Step 1 has radio buttons for Educational Object, Lesson Plan, and Educational Scenario. Step 2 has a radio button for ISE Authoring Tool. Step 3 has a 'Create New' button.

Figure 27 – Creating a new Lesson Plan / Educational Scenario

You will be re-directed to the ISE Authoring Tool, where the ISE Lessons/Scenarios created by you will be presented (**Figure 28**).



Figure 28 – ISE Authoring Tool – My Lesson Plans and Educational Scenarios

Press the 'Create new Lesson' button to start preparing your ISE Lesson/Scenario (**Figure 28**). Same as when cloning and adapting an Educational Scenario (see **Figures 12** and **13**), you will need to add educational metadata for your ISE Lesson/Scenario by following 5 simple steps of a metadata wizard (**Figure 29**).

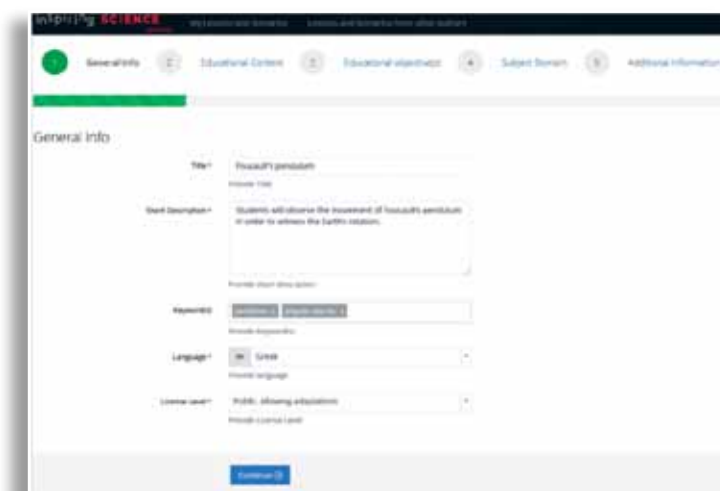


Figure 29 – ISE Authoring Tool – Add Metadata to my ISE Lesson/Scenario

You then have to add content (namely, text, images and videos) to the five (5) Inquiry Activities of your ISE Lesson/Scenario (**Figure 30 – [1]**). Moreover, you can add external digital tools (e.g. Google Sheets, Google Docs, PhET Simulations, Geogebra Worksheets, etc.) to the five (5) Inquiry Activities by selecting adding an iFrame via the rich text editor (**Figure 31**). More specifically, you have to add the URL of the external tool and the dimensions (namely, width and height) of the iFrame where the external tool will be presented.

Alternatively, you can press the Plus (+) button (**Figure 30– [2]**) and then choose to search the ISE Tools Repository and add eLearning Tools to your ISE Lesson/Scenario (**Figure 32– [1]** and **Figure 33**).

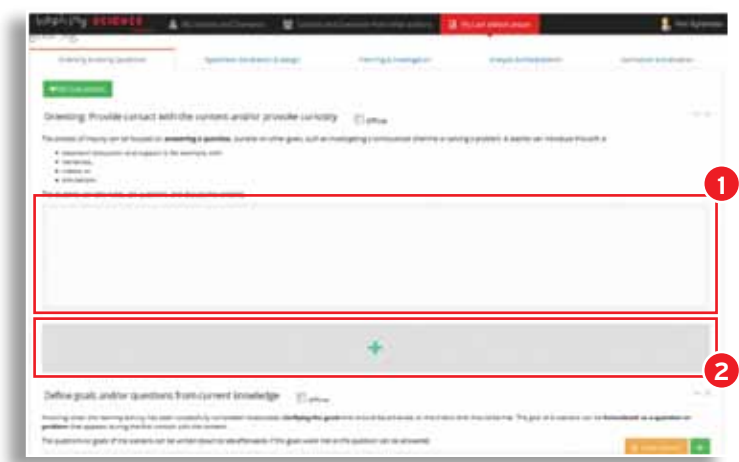


Figure 30 – ISE Authoring Tool – Add Content to the 5 Inquiry Activities

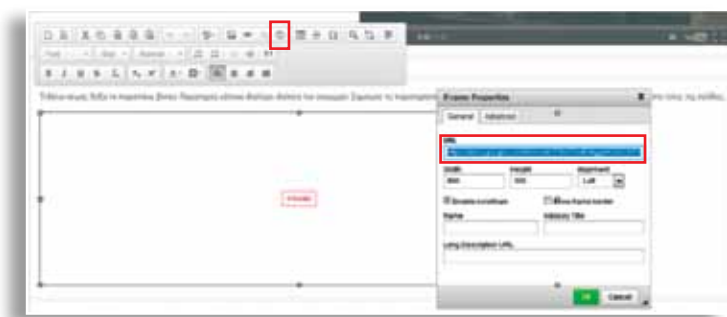


Figure 31 – ISE Authoring Tool - Add an External Tool as an iFrame

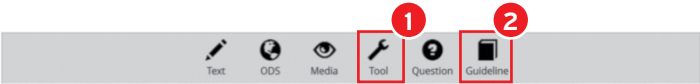


Figure 32 – ISE Authoring Tool – Add more features

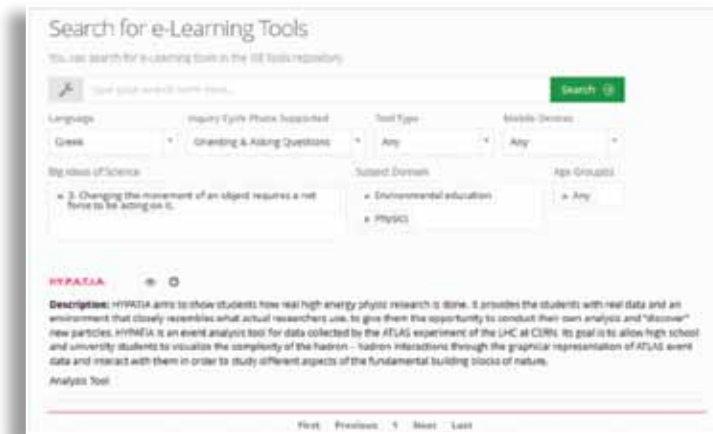


Figure 33 – ISE Authoring Tool – Add an eLearning Tool to my ISE Lesson/Scenario

Please address directly the students who will work with your lesson/scenario. If you want to give additional information or instruction to the teacher, please add an extra box for this called 'Guidelines' (**Figure 32-** [2] and **Figure 34**).



Figure 34 – Adding Guidelines only visible for the Teacher

You can save your ISE Lesson/Scenario any time by pressing the orange button at the bottom right ('Save Lesson'). You can also preview your ISE Lesson/Scenario by pressing the green button at the bottom right (see **Figure 34**). When saved, your ISE Lesson/Scenario will appear under 'My Lessons and Educational Scenarios' (see **Figure 28**).

After finishing adding the content of your ISE Lesson/Scenario for all Inquiry Activities, your Lesson/Scenario is ready to be delivered to a class with students (*please refer to sections 4.1.2 and 4.1.3*). However, it will keep the status 'draft' unless you press the 'Set Status to Final' option (**Figure 35**).

If the ISE Lesson/Scenario' status is set to 'Final' immediately the Lesson/Scenario will be posted to the ISE Community from where you started (see **Figure 9**). If you want

to keep the Lesson/Scenario as draft the Lesson/Scenario will be presented ONLY in your ISE Profile (**Figure 18**) and not in the ISE Community from where you started. Finally, it should be noted that if the license level of your Lesson/Scenario is 'Private' it will remain visible only in your profile at the ISE Portal (even if the status is 'Final'). In order to make it visible in an ISE Community, you have to set it as 'Final' but also to provide a public license level in Lesson's/Scenario's metadata (namely, public not allowing adaptations).



Figure 35 – ISE Authoring Tool – Finalize an ISE Lesson/Scenario and post it to an ISE Community

ASSESS

Student's Performance
and Skills

Assessment Questions in the ISE Environment

The ISE Authoring Tool offers teachers two additional features which they may use to enrich and support the delivery and assessment of a science lesson. These are:

1. The option of adding multiple-choice formative assessment questions at any point during an Educational Scenario
2. The option of adding problem solving questions at the end of four of the inquiry phases.

For both of these options teachers are also presented with a graphic analysis report of the results of this assessment for their students.

5.1 Create Formative Assessment Questions

By clicking on the 'Question' button on the extra tool bar that appears if you press the Plus (+) sign (see **Figure 30** – [2]) at any place within an Educational Scenario (**Figure 36**), you can add a multiple-choice question for your students, with up to 4 possible answers. You are also given the opportunity to choose the feedback text that will appear to students who choose each answer (**Figure 37**). You can add as many such questions you want.



Figure 36 – ISE Authoring Tool – Creating formative assessment questions

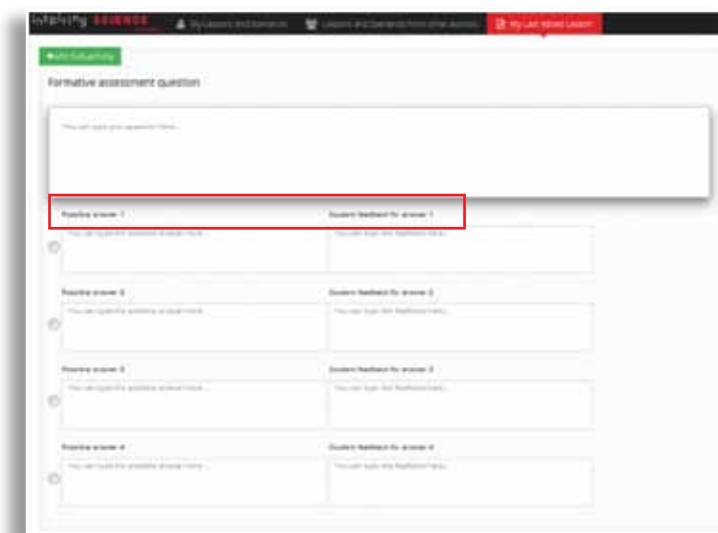


Figure 37 – ISE Authoring Tool – Writing formative assessment questions

5.2 Create Problem Solving Questions

One of the aims of ISE is to increase the problem solving competency of students in science classrooms. The following subsections explain the framework used in ISE for developing problem solving questions and provide support to teachers to create such questions in the ISE Environment.

5.2.1 Problem solving competency in ISE

The ISE concept of problem solving competency is based on the framework developed by OECD for use to assess the individual problem solving competency of 15-year olds in the Programme for International Student Assessment (PISA) 2012 (OECD, 2013). In it problem solving competency is defined as follows:

“Problem solving competency is an individual’s capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such solutions in order to achieve one’s potential as a constructive and reflective citizen.” (OECD 2013, p. 123)

According to this definition problem-solving competency includes “a mobilization of cognitive and practical skills, creative abilities and other psychosocial resources such as attitudes, motivation, and values.” (OECD 2013, p. 122)

PISA 2012 and consequently ISE focus more particularly on the cognitive processes required to solve real world problems. These can be described as four distinct processes: ‘Exploring and understanding’; ‘Representing and formulating’; ‘Planning and executing’; and ‘Monitoring and reflecting’ (OECD, 2013, p. 126). They are considered to be the steps to overcome when moving from a given situation to a target goal in problem solving.

Exploring and understanding. This task involves exploring the problem situation (observing it, interacting with it, searching for information and finding limitations or obstacles) as well as understanding the given information and the information discovered while interacting with the problem situation. However, the students should build mental representations of each of the pieces of information presented in the problem.

Representing and formulating. For building a coherent mental representation of the problem situation, the relevant information must be selected, mentally organized and integrated with relevant prior knowledge. This can be reached by representing the problem by constructing tabular, graphical, symbolic or verbal representations and shift-

ing between representations or formulating hypotheses by identifying the relevant factors in the problem and their interrelationships.

Planning and executing. The planning process of this task describes that the students have to set themselves a goal. This includes clarifying the overall goal and setting sub-goals (where necessary) as well as devising a plan or strategy to reach the goal state. After that, in the executing phase, the plan will be carried out.

Monitoring and reflecting. The students should monitor the progress towards reaching the goal at each stage including checking intermediate and final results, detecting unexpected events and taking remedial action when required. Finally they also should reflect on solutions from

different perspectives and critically evaluate assumptions and alternative solutions.

Not perhaps surprisingly these processes were thought to have significant similarities to the inquiry types of learning activities used by ISE in the design of Educational Scenarios, so ISE went a step further and matched the two, making the assumption that questions related to each of the cognitive processes may be best answered at the end of each of the inquiry phases. Given that the latter are five, **Table 2** shows the correspondence between the two sets, as well as suggestions about the possible foci of the assessment questions for each cognitive process.

Table 2: Correspondence between ISE inquiry model and the cognitive processes required to solve real world problems according to PISA 2012.

Orienting and Asking Questions		Hypothesis Generation and Design		Planning and Investigation		Analysis and Interpretation	Conclusion and Evaluation
↓		↓		↓		↓	
1		2		3		4	
Exploring and understanding		Exploring and understanding		Exploring and understanding		Exploring and understanding	
Questions		Questions		Questions		Questions	
- ...dealing with the representation of the problem		- ...concerning the exploration of correlations and dependencies		- ...concerning the correct strategies of experimentation		- ...about application or transfer of the tasks	
- ...about relevant information to understand the problem		- ...concerning a precise description of the focused problem		- ...concerning strategies of variable control		- ...about possible sources of experimental errors	
- ...dealing with different levels of understanding of content knowledge				- ...concerning strategies of data analysis		- ...about enhancement of experimental setting	

5.2.2 Levels of problem solving competency in ISE

The PISA 2012 framework recognises 6 levels of proficiency in problem solving (OECD 2014, p. 58-59) for students of 15 years old. ISE simplified these into 3 levels (**Figure 38**)

Students proficient at **high level** can

- develop complete, coherent mental models of different situations;
- find an answer through target exploration and a methodical execution of multi-step plans.
- To estimate the difficulty of the tasks for this level, an average of about 10% of 15-year-old students should be able to answer on this level.

Students proficient at **moderate level** can

- control moderately complex devices, but not always efficiently;
- handle multiple conditions or inter-related features by controlling the variables.
- To estimate the difficulty of the tasks for this level, an average of about 45% of 15-year-old students should be able to answer on this level.

Students proficient at **low level** can

- only answer if a single, specific constrain has to be

taken into account;

- only partially describe the behaviour of a simple, everyday topic.

To estimate the difficulty of the tasks for this level, an average of about 45% of 15-year-old students should be able to answer on this level.

5.2.3 Design problem solving questions in the ISE Environment

As previously mentioned the Problem Solving Questions are assigned to the four cognitive process of the problem solving competency ('Exploring and understanding'; 'Representing and formulating'; 'Planning and executing'; 'Monitoring and reflecting'). In the ISE Environment in particular, two individual problem solving questions should be created at the end of the corresponding inquiry phases (**Figure 38**)

These individual problem solving questions must be:

... multiple-choice (single-select), and

... with three possible answers all correct:

... one answer for a **low** performer on problem solving

... one answer for a **moderate** performer on problem solving

... one answer for a **high** performer on problem solving

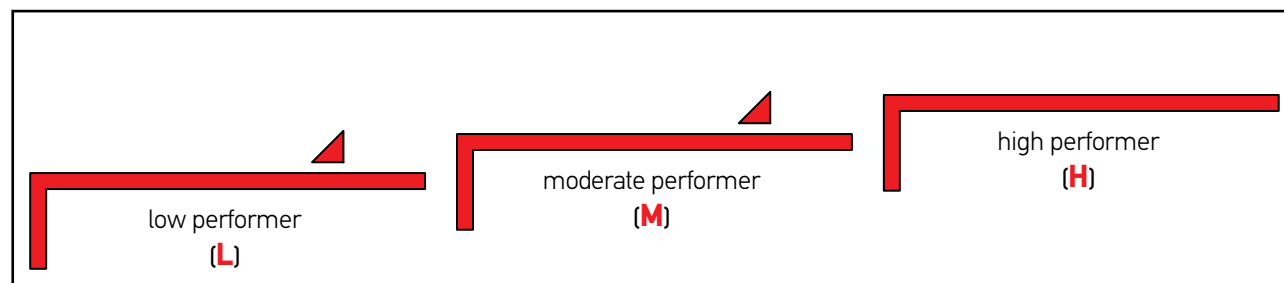


Figure 38 – Levels of problem solving competency in ISE

Figure 39 – ISE Authoring Tool – Add Problem Solving Questions to my ISE Lesson/Scenario

5.2.4 Example of Problem Solving Questions for an Educational Scenario on Renewable Sources of Energy

Level of problem solving	Exploring and understanding	Reepresenting and formulating	Planning and executing	Monitoring and reflecting
Question 1	Why do we need to think about renewable energies?	Which domains have to be taken into account for the change in energy supply to be successful?	Which consequences can the increase of the price for electricity have?	What advantages has the use of a simulation against the look at a whole real world scenario?
High level	Because we are responsible for our future	Because of interdependencies social, economical and ecological aspects have to be considered.	Government has to think about how to disencumber citizens and companies which can't afford higher prices.	Because of learning by trial and error I get a deeper understanding of the content.
Moderate level	Because as responsible citizens we have to be informed and able to discuss current issues	It's important that no jobs get lost or alternative jobs or retraining are offered to employees. Also investors have to be recruited.	Energy supply is an important economic factor. Companies may threaten with migration to a more cost-effective location.	Because it's not possible to manipulate the real world conditions in the same way as in a simulation.

Low level	Because it's very present in media	People have to be well prepared for the change in energy supply. So it's very important to promote the change and tell people why it is needed.	People become dissatisfied because they have to pay more money for electricity	Because it's funny to play with the simulation I'm more motivated to learn.
Question 2	CO2 is a problem, because...	What is the best way to start change in energy supply?	What happens if a power plant is switched off without substitution?	The discussion about renewable energies and also the simulation mostly ignore important factors. An important but ignored factor is:
High level	CO2 is accumulating in the atmosphere and reflecting thermal radiation from the earth so it can't leave the atmosphere. This contributes to the anthropogenic greenhouse effect.	Change in energy supply would be easier and faster when less energy has to be produced.	Energy supply is an important economic factor. Lack of reliable energy supply can lead to degeneration of a highly developed country.	Use of fossil fuels for transportation and heat production.
Moderate level	CO2 is jointly responsible for human made climate change	It's important to reduce energy consumption	Energy supply is not guaranteed	Importance of cogeneration of heat and electricity
Low level	CO2 is harmful to the environment	One first step is e.g. to switch of light when leaving a room.	Cities getting dark	Use of coal for barbeque

5.3 Results of Formative Assessment and Problem Solving Questions

To support teachers in the assessment of their class, the ISE Environment offers them the facility to view the assessment results of their students, both individually and as a whole.

5.3.1 Access Assessment student results

At any time after running an Educational Scenario you have created with your students you can access the results of their assessment, by clicking on the 'Teacher Link' of the particular run, log in using the same name and e-mail you used in delivering this lesson and pressing the 'Assessment' tab at the top of the page (**Figure 39**).

Four further tabs will appear giving you the opportunity to access both the problems solving and the formative assessment results of your class (**Figure 40**).

5.3.2 Problem Solving student results

There are two ways you can view the problem solving student results. The first tab from the left (**Figure 42**)– [1]) lets you view how many questions each of your students replied and at what level (e.g. **Figure 41**)– [2]).

The second tab from the left (**Figure 42** – [1]) shows you an analysis of the results for your whole class. The graph for example in **Figure 42** shows the percentage of answers at Low, Moderate and High levels completed by your class in relation to the equivalent average results in PISA 2012 for the whole of the country (where these exist) and for the whole of the OECD countries respectively.



Figure 40– ISE Authoring Tool – Accessing Assessment Results



Figure 41 – ISE Authoring Tool – Viewing Assessment Results

Student Name	LOW	MID/DATE	HIGH	DETAILS
A	0	0	0	
Neel/Ag Abipri	2	3	3	
Adhwa	4	2	2	
Arwa	1	3	4	
Shashidhar	3	2	3	

Figure 42 – ISE Authoring Tool – Problem Solving Results per student



Figure 43 – ISE Authoring Tool – Problem Solving Results per class in comparison to PISA

5.3.3 Formative Assessment class/student results

The third tab takes you to the Formative Assessment results, where you can see the percentage of correct/wrong answers per assessment question for both each individual student and the whole class.

Futhermore, each student is presented with the results of the formative assessment questions, both of his/her answers and of the class as a whole (**Figure 44**).



Figure 44 – Formative Assessment Results for the student

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