Next-Lab

Next Generation Stakeholders and Next Level Ecosystem for Collaborative Science Education with Online Labs

Innovation Action in European Union's 2020 research and innovation programme

Grant Agreement no. 731685

Deliverable 2.6

Releases of learning spaces (40) for primary and secondary (20) education

Editor	Henny Leemkuil (UT)
Date	29-09-2018
Dissemination Level	Public
Status	Final

The Next-Lab Consortium

Beneficiary Number	Beneficiary name	Beneficiary short name	Country
1	University Twente	UT	The Netherlands
2	École Polytechnique Fédérale de Lausanne	EPFL	Switzerland
3	IMC Information Multimedia Communication AG	IMC	Germany
4	EUN Partnership AISBL	EUN	Belgium
5	Ellinogermaniki Agogi Scholi Panagea Savva AE	EA	Greece
6	University of Cyprus	UCY	Cyprus
7	Universidad de la Iglesia de Deusto	UD	Spain
8	Tartu Ülikool	UTE	Estonia
9	Núcleo Interactivo de Astronomia Associacao	NUCLIO	Portugal
10	Ecole Normale Superieure de Lyon	ENS de Lyon	France
11	Turun Yliopisto	UTU	Finland
12	University of Leicester	ULEIC	United Kingdom

Contributors

Name	Institution
Henny Leemkuil, Joep van der Graaf, Ton de Jong	UT
Eleftheria Tsourlidaki, Eugenia Kypriotis, Jens Koslowsky	EA
Nikoletta Xenofontos, Marios Papaevripidou, Tasos Hovardas, Maria Irakleous	UCY
Olga Dziabenko	UD
Leo Siiman, Meeli Rannastu, Mario Mäeots, Äli Leijen, Margus Pedaste	UTE
Maria Luísa Almeida, Rosa Doran	NUCLIO
Gérard Vidal	ENS
Miikka Korventausta	UTU

Legal Notices

Executive Summary

In this deliverable a set of exemplary learning spaces is presented which are co-created between teachers and experts from the Next-Lab consortium. These ILSs are meant as examples to inspire teachers to develop their own ILSs but also as off the shelf ILSs that can easily be implemented in class.

To support the development teams a checklist was developed based on learning theories. These theories and some other important topics can be found in Chapter 1. The checklist is in Chapter 2. A description of the 33 exemplary ILSs for primary education can be found in Chapter 3 and a description of 27 ILSs for secondary education is given in Chapter 4.

Table of Contents

1. What makes an exemplary ILS? 9

1.1 Theoretical basis 9
1.1.1 Phases in Inquiry based learning 9
1.1.2 Gagné's nine events of instruction 10
1.1.3 Motivational theories 11
1.1.4 Cognitive load theory 12
1.1.5 Experiential learning 13
1.2 Copyright and privacy 13
1.3 Gender 14

2. Checklist 15

3. Exemplary ILSs for primary education (students from 6-12 years) 17

3.1 De kleur van licht; The colour of light 17
3.2 Lichtbreking 1; Refraction of light 1 17
3.3 Lichtbreking 2; Refraction of light 2 18
3.4 Drijven en zinken (Groep 5-6); Sinking and floating (Age 8-9) 19
3.5 Electriciteit; Electricity 19
3.6 Vast, vloeibaar, gas. How werkt dat?; Solid, liquid, gas. How does this work? 20
3.7 Tandwielen ontdekken; Discovering Gears 20
3.8 Planten en groei; Plants and growth 21
3.9 Bouw een tuinhuis voor Stephen en Marie; Build a garden house for Stephen and Marie 22
3.10 Free Fall on the Earth and on the Moon 22
3.11 Kuidas mõjutavad valgustugevus ja temperatuur fotosünteesi?; How do light and temperature affect photosynthesis in plants? 23
3.12 Veeringe; The Water Cycle 24
3.13 Staatiline elekter; Static Electricity 24
3.14 Elektrivool; Electric Current 25
3.15 Toitumine; Healthy Eating 26
3.16 Ακαδημία Αστροναυτών; Astronauts' Academy 26
3.17 A Journey to Space 27
3.18 Παιχνίδια Προσανατολισμού; Navigation games 28
3.19 Reasons for the seasons 28
3.20 Skeittaaja Osa 1: Energia; Skater Part 1: Energy 29
3.21 Skeittaaja Osa 2: Kitka; Skater Part 2: Friction 29
3.22 Kelluuko vai uppoaako?; Does it float or sink? 30
3.23 Sähköiset synttärit; Electric Birthday Party 30
3.24 Johde vai eriste?; Conductor or non-conductor? 31
3.25 Τριβή; Friction 31
3.26 Παράγοντες που επηρεάζουν τον ρυθμό της φωτοσύνθεσης; Factors that affect the rate of photosynthesis 32
3.27 Η εξαφάνιση των δεινοσαύρων; The extinction of dinosaurs… 33
3.28 Φαινόμενο του θερμοκηπίου: Αλήθεια ή μύθος; Greenhouse effect: Fact or myth 34
3.29 As Estações do Ano; The Seasons 35

3.30 C'est chaud ou c'est froid; Is it warm or is it cold ? 35
3.31 Visibilité de Mercure et Vénus; Mercury and Venus visibility 36
3.32 Visibilité des planètes Mercure et Vénus (Allophones); Mercury and Venus planets visibility (Allophones) 37
3.33 Mekanismoak; Mechanisms 38

4. Exemplary ILSs for secondary education (students from 12-18 years) 39

4.1 Ρυθμός μεταφοράς θερμότητας; Rate of heat transfer 39
4.2 Μεταγραφή και μετάφραση του DNA; Transcription and translation of DNA 40
4.3 The sound of music: An interactive lesson on standing waves 40
4.4 Kas On Hea Olla Ilus?; Is It Good To Be Beautiful? 41
4.5 Leeromgeving De Meent; Tragedy of the commons 42
4.6 Ευθύγραμμες Κινήσεις; Linear Motions 42
4.7 Από το κύτταρο στους ...εξωγήινους; From the cell to…aliens 43
4.8 Ευτυχώς υπάρχει και η άνωση; Thankfully, there is buoyancy 44
4.9 Εύρηκα!; Eureka! 44
4.10 Παράγοντες που επηρεάζουν την φωτοσύνθεση; Factors that affect photosynthesis 45
4.11 Astronaut's Job = Cool! 45
4.12 Elektrische circuits; Electrical Circuits 46
4.13 Arraunean; Rowing 46
4.14 Contaminación ambiental; Environmental pollution 47
4.15 Arquimedesen printzipioa; Archimedes Principle 47
4.16 Plano Inklinatua; Inclined Plane 48
4.17 Viajando num raio de luz à descoberta das reações fotoquímicas; Travelling in a light ray to unveil the photochemical reactions 48
4.18 Propriétés thermiques de la Terre et géothermie; Thermal properties of the Earth and geothermal 49
4.19 Globulozobot; Globulozobot 50
4.20 Dihybridisme en terminale S; Dihybridism in final year 51
4.21 Visibilité des planètes_Master; Planets visibility_Master 52
4.22 Raconte-moi le ciel étoilé; Tell me the starry sky 52
4.23 Les conditions de germination des graines (DIPHTERIC); Seed germination conditions 53
4.24 Datation d'une roche au rubidium strontium; Rock dating with rubidium strontium method 54
4.25 Enrichissement de l'atmosphère en O2; Enrichment of the atmosphere in O2 54
4.26 Les conditions nécessaires à la nutrition des végétaux verts; The conditions necessary for the nutrition of green plants 55
4.27 Dérive génétique; Genetic drift 55

Introduction

Most of the learning spaces in Go-Lab and the ones published on Golabz, have been developed by teachers themselves. Additionally, in Next-Lab we now have designed a set of exemplary learning spaces co-created between teachers and experts from the Next-Lab consortium. These ILSs are meant as examples to inspire teachers to develop their own ILSs but also as off the shelf ILSs that can easily be implemented in class.

This deliverable presents exemplary ILSs for primary and secondary education. For secondary school teachers, the initiatives to co-create learning spaces was mainly driven by the teachers themselves. Here, we planned around 20 exemplary learning spaces to be co-created, this deliverable presents 27 exemplary ILSs for secondary education. For primary school teachers situation is different. These teachers are often not trained as science teachers and most probably have less confidence in initiating the creation of learning spaces themselves. Therefore, the Next-Lab team initiated the design and creation of these exemplary learning spaces targeting curriculum topics that were identified as common in primary education in Europe (see Deliverable 1.2 and Appendix A and B from Deliverable 3.2). Also for these primary education learning spaces co-creation with teachers took place. For primary education we planned 40 exemplary ILSs, this deliverable presents 33 ILSs. All of these learning spaces are, with the use of the Next-Lab authoring tools, still fully configurable (including the language) to local circumstances.

To support the development teams a checklist is developed with guidelines based on learning theories. These theories and some other important topics can be found in Chapter 1. The checklist is in Chapter 2. A description of the exemplary ILSs can be found in Chapters 3 and 4.

The work on developing exemplary ILSs will be continued after the delivery of this deliverable; exemplary ILSs are published at Golabz and indicated with a dedicated badge.

1. What makes an exemplary ILS?

To support development teams in creating exemplary ILSs a checklist was developed that lists a series of concrete characteristics of a well-designed ILS. This checklist is presented in Chapter 2 of this deliverable, in the current chapter a short description is give of theories about learning and instructional design that have formed the basis for the criteria in the checklist. Furthermore, three aspects not related to these theories will be introduced: copyright, privacy and gender.

1.1 Theoretical basis

Several theories about learning and motivation are the basis for a checklist that can be used to develop an ILS and to assess whether an ILS is an exemplary ILS. These will be introduced briefly in the next sections.

1.1.1 Phases in Inquiry based learning

Inquiry-based learning is most of the time organized into inquiry phases that together form an inquiry cycle. However, different variations of this cycle can be found throughout the literature. Pedaste et al. (2015) made an analysis of a large set of articles describing inquiry phases and developed a synthesized inquiry cycle that combines the strengths of existing inquiry-based learning frameworks. Figure 1 gives a general description of the phases and sub-phases.

General phases	Definition	Sub-phases	Definition
Orientation	The process of stimulating curiosity about a topic and addressing a learning challenge through a problem statement		
Conceptualization	The process of stating theory-based questions and/or hypotheses.	*Questioning*	The process of generating research questions based on the stated problem.
		Hypothesis Generation	The process of generating hypotheses regarding the stated problem.
Investigation	The process of planning exploration or experimentation, collecting and analysing data based on the experimental design or exploration.	*Exploration*	The process of systematic and planned data generation on the basis of a research question.
		Experimentation	The process of designing and conducting an experiment in order to test a hypothesis.
		Data Interpretation	The process of making meaning out of collected data and synthesizing new knowledge.
Conclusion	The process of drawing conclusions from the data. Comparing inferences made based on data with hypotheses or research questions.		
Discussion	The process of presenting findings of particular phases or the whole inquiry cycle by communicating with others and/or controlling the whole learning process or its phases by engaging in reflective activities.	*Communication*	The process of presenting outcomes of an inquiry phase or of the whole inquiry cycle to others (peers, teachers) and collecting feedback from them. Discussion with others.
		Reflection	The process of describing, critiquing, evaluating and discussing the whole inquiry cycle or a specific phase. Inner discussion.

Figure 1: Phases and sub-phases of the synthesized inquiry-based learning framework of Pedaste et al. (2015)

Although every inquiry process starts with an orientation the following (sub)phases may be different and several routes are possible through these phases (see Figure 2). An inquiry process (and thus an ILS) doesn't necessarily needs to cover all the (sub)phases. ILSs focusing on primary education in many cases will not be hypothesis driven but more explorative. They follow a path that is in the left side of Figure 2.

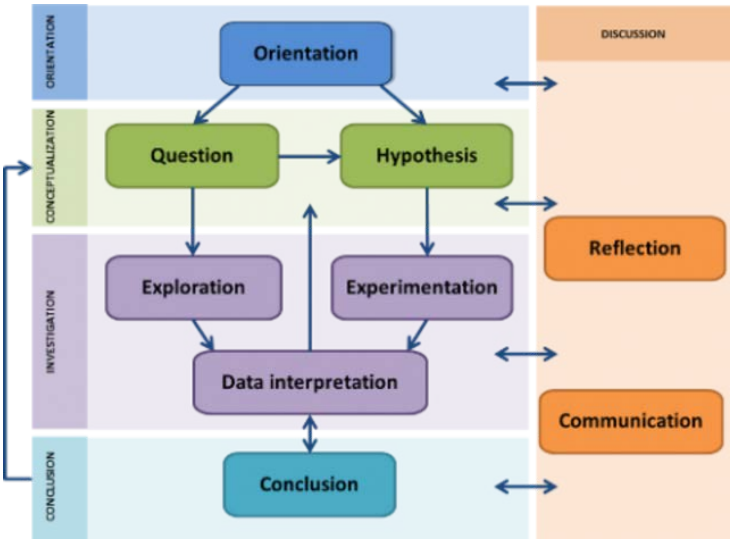

Figure 2: The Go-Lab inquiry circle

1.1.2 Gagné's nine events of instruction

There are many theories focusing on the design of engaging and meaningful instruction based on the work of Merrill, Reigeluth, and Gagné. The latter published "The Conditions of Learning" already in 1965. In this book he described a series of events which should be part of a systematic instructional design process (Gagné, Briggs, & Wager, 1992).

Figure 3: Gagné's Nine Events of Instruction (by CourseArc licensed under CC BY 4.0).

The nine events are:

1. Gaining attention;
2. Informing learners of objectives;
3. Stimulating recall of prior learning;
4. Presenting the stimulus;
5. Providing learning guidance;
6. Eliciting performance;
7. Providing feedback;
8. Enhancing retention and transfer.

These general events could also be the basis for designing an engaging ILS. For inquiry learning with online labs, event #3 deserves special attention, stimulating recall of prior knowledge. In inquiry learning, students generate knowledge themselves by performing experiments and finding “new” relations, but in order to be able to do that they need the right starting knowledge. This idea is backed up from the literature. Hattie and Donoghue (2016), based on a large series of meta-analyses indicate that there are less favourable effect sizes for forms of active learning (like inquiry learning) when they are introduced in the curriculum when the necessary surface knowledge has not yet been acquired. Schneider and Preckel (2017), also presenting a meta-synthesis, found that prior instruction is a moderator variable for the effectiveness of engaged forms of learning such as problem-based learning and inquiry learning. It seems, therefore, a fact that inquiry learning needs to be preceded (or accompanied) by direct instruction.

1.1.3 Motivational theories

Offering information and activities is not enough to initiate a learning process. An important element is how to design learning materials that motivate learners to engage in the learning process. A model dealing with this aspect is John Keller's “ARCS” model (Keller, 1987). ARCS is an acronym that represents four categories: Attention, Relevance, Confidence and Satisfaction. Years later he expanded this with a fifth category: volition and self-regulation (Keller, 2008). These are especially important when the learners are facing distractions and obstacles in the learning process.

Attention	Relevance	Confidence	Satisfaction
Perceptual Arousal Provide novelty and surprise	***Goal Orientation*** Present objectives and useful purpose of instruction and specific methods for successful achievement	***Learning Requirements*** Inform students about learning and performance requirements and assessment criteria	***Intrinsic Reinforcement*** Encourage and support intrinsic enjoyment of the learning experience
Inquiry Arousal Stimulate curiosity by posing questions or problems to solve	***Motive Matching*** Match objectives to student needs and motives	***Successful Opportunities*** Provide challenging and meaningful opportunities for successful learning	***Extrinsic Rewards*** Provide positive reinforcement and motivational feedback
Variability Incorporate a range of methods and media to meet students' varying needs	***Familiarity*** Present content in ways that are understandable and that related to the learners' experiences and values	***Personal Responsibility*** Link learning success to students' personal effort and ability	***Equity*** Maintain consistent standards and consequences for success

Figure 3. Main strategies based on Keller's ARCS model (source: https://en.wikipedia.org/wiki/File:ARCS_Model_Components_Table.jpg)

Grabbing attention is important because it motivates learners. Once learners are interested in a topic, they are willing to invest their time, pay attention, and find out more. According to Keller a learner's curiosity is aroused when (s)he perceives a gap in current knowledge. Even if curiosity is aroused, motivation is lost if the content has no perceived value to the learner. Therefore, it is important to make learning relevant by connecting the content of the lesson to important goals of the learners, their interests and prior knowledge. Furthermore, learners will be motivated if they have confidence and believe they can succeed in the task. The fourth category, satisfaction, is necessary to to promote positive feelings about the learning experience.

1.1.4 Cognitive load theory

Although students may be motivated and the learning materials and events are engaging often the learning process is not optimal because of the limitations of our memory. Main idea behind the "Cognitive load theory" (Sweller, 1994) is that working memory capacity is limited. In many cases during the learning process working memory might be overloaded which hinders learning. Based on this idea Clark and Mayer (2016) developed a set of principles and guidelines for multimedia learning to free working memory capacity. The main ones that are applicable for ILS design are summarised below.

- Multimedia principle:
    - Include both words and graphics
- Contiguity principles:
    - Place printed words near corresponding graphics.
    - Place elements that belong together conceptually together in space or time.
- Modality principle:

    - Present words as speech rather than on-screen text.
- Redundancy principle:
    - Do not repeat information; this needs double processing.
- Coherence principle:
    - Do not use irrelevant visual or auditory information – eliminate non-essential material
- Personalization principle:
    - Use a conversational style and virtual coaches
- Segmenting principle:
    - Break a long segment into smaller segments. E.g. divide a phase in which students have to scroll a lot into two phases.
- Pre-training principle:
    - Ensure that learners know the names and characteristics of key concepts.
- Worked Example principles:
    - Include instructional explanations of worked examples in some situations.
    - Promote self-explanations.
- Practice Principle:
    - Provide explanatory feedback instead of corrective feedback.
- Learner Control Principle:
    - Offer navigational support.
- Thinking Skills Principle:
    - Make thinking processes explicit.

The modality principle is not well suited for designing ILSs because having a lot of spoken words will not be handy in most cases unless all students have earphones. Most of the other principles are applicable and might help to prevent cognitive overload.

1.1.5 Experiential learning

Experiential learning is the process of learning from experience. It is related to other forms of active learning like inquiry based learning. A well-known model of experiential learning is the four stage model of Kolb (1984). Miettinen (2010) points out that the basic ideas of experiential learning go back to the first phase of the 20th century and were formulated by Dewey. Dewey made a distinction between primary and secondary experience. Primary experience is based on the interaction with the physical or social environment. Secondary experience is a reflective experience. So reflection on action is an important element of the learning process. Stimulating reflection in an ILS or after an ILS has been worked through therefore is very important.

1.2 Copyright and privacy

Pictures or videos used in ILSs should be created by the author(s) or be available on the Internet under a *Creative Commons* license. In the “About” section of the ILS references should be available to the original sources where the videos or pictures can be found.

Pictures with copyright shouldn't be used unless the author has the permission of the owner. This permission should be explicitly mentioned in the ILS.

Respecting privacy is also an important aspect in ILS design. It is advised to not include pictures of students in an ILS.

1.3 Gender

One of the objectives of Next-Lab is to support a positive attitude towards science and technology especially with younger students. Good ILSs can contribute to this. However, data show that more men are studying and working in science fields than women. According to Kerkhoven et al. (2016), this could be an effect of the prevalence of gender stereotypes in science education resources. They investigated the content (especially visuals) in online education resources for the primary education level using the databases of Scientix and OER commons. They concluded that the largest proportion of people in visuals were boys and that more men were shown in science professions and more women were depicted as teachers. According to them it is important that there is a balance in the number of men and women in visualisations in educational resources (as well as in text).

In the next chapter a checklist will be presented that is based on the insights given in the previous sections.

2. Checklist

Based on the theories mentioned and other topics mentioned in Chapter 1 a checklist has been developed which can be used to assess whether an ILS can be labelled as an exemplary ILS. Such an ILS doesn't have to cover all of the attention points listed in the checklist. In fact, this is not possible because in some cases (for instance in grabbing the attention) an ILS could satisfy either one or another point of the checklist. An exemplary ILS should cover about 75% of the checklist.

Table 1: Checklist

An ILS doesn't have to cover the whole Inquiry circle. It can be focused on certain elements of the circle, however, every ILS should center around investigations	
1. Use at least one lab activity.	
Grabbing attention is important because it motivates learners. Once learners are interested in a topic, they are willing to invest their time, pay attention, and find out more.	
2. Use surprise or uncertainty to gain interest or introduce incongruity or conflict.	
3. Stimulate curiosity by posing challenging questions or problems to be solved.	
4. Stimulate curiosity by using multimedia (video, visuals) to introduce a new topic and review what connections it has to previous learning or to real world applications.	
Keeping the attention throughout the ILS	
5. Regularly pose questions or present problems to solve or introduce new lines of thought to keep the attention.	
6. Regularly check for student understanding. For example, the ILS could include quiz questions that give automatic feedback or a teacher could use intermediate classroom discussions to check for misconceptions.	
Even if curiosity is aroused, motivation is lost if the content has no perceived value to the learner. Make learning relevant by connecting the content of the lesson to important goals of the learners, their interests, and prior knowledge.	
7. Activate prior knowledge, or explain (with text or video) to students the names and characteristics of key necessary prior concepts. Ensure that learners know the names and characteristics of key concepts, symbols etc.	
8. Show where the new knowledge/skills can be applied.	
9. Relate the content of the ILS to a context that is well known to the students.	
10. Use a conversational style and/or virtual coaches.	
Help students establish positive expectations for success	
11. Make sure that students feel that they will be successful. Start with simple problems and gradually increase the difficulty level.	
12. Give hints about what to do or worked examples on how to do it. Students (especially the younger ones) need more instructions (guidance) than you would expect. Things that might seem obvious for a (more) experienced user (pressing a button or tab, clicking on an item to change its appearance or characteristics) are often not clear to new users. Anticipate on commonly made errors.	

13. Give support by adjusting the content of the apps to students' age/knowledge level. - For students with little prior knowledge partially filled hypotheses or concept maps could be included	
14. Give extensive and positive feedback. Provide explanatory feedback instead of corrective feedback. Don't just say that an answer is right or wrong but explain why.	
15. Provide opportunities to the learner to apply the knowledge/skill just gained.	
Working memory capacity is limited. Don't overload working memory	
16. Help students focus on the important elements. Use signalling (e.g. bold words, arrows etc.) to attract the attention to certain parts of a text or picture.	
17. Give meaningful titles to the inquiry phases.	
18. Videos shouldn't be too long. Maximum 6 minutes, preferably 3 minutes or shorter.	
19. Demonstrate the use of a lab or guide students to get familiar with it.	
20. Include both words and pictures that complement each other. The content of the text and the picture should not be the same.	
21. Place elements that belong together conceptually together in space or time - Place words near corresponding graphics.	
22. Do not use irrelevant visual or auditory information - eliminate non-essential material.	
23. Break long segments into smaller segments. E.g. divide a phase in which students have to scroll a lot into two phases.	
24. Make ILSs that are mainly sequential. Try to avoid students having to unnecessarily go back and forth between phases. - Use the viewer to repeat the content of apps so that students do not need to go back and forth.	
25. Offer navigational support. Give hints how students should proceed after completing a task and/or phase.	
26. Use the "Hints" functionality to give additional support for those who need it and to limit scrolling.	
27. Make thinking processes explicit.	
Actively processing information/reflection. ***Reflection is an important part of the learning process. The educational reformer John Dewey said "We do not learn from experience... we learn from reflecting on experience."***	
28. Promote self-explanations and reflection. - Learning analytics apps could be helpful	
29. Include checkpoints for discussion on personal level, group level or on the whole class level.	
Pictures or videos used in ILSs should be created by the author(s) or be available on the Internet under a *Creative Commons* license.	
30. In the "About" section of the ILS references should be available to the original sources where the videos or pictures can be found.	
31. Because of privacy reasons do not include pictures of your students in an ILS.	
Gender	
32. Use visuals including both genders. Avoid stereotypes.	

3. Exemplary ILSs for primary education (students from 6-12 years)

Descriptions of the content of the ILS and justification why this is an exemplary ILS.

3.1 De kleur van licht; The colour of light

Topic: White light actually consists of a spectrum of colours

Age group: 9-10 years

Link to the ILS: https://www.golabz.eu/ils/de-kleur-van-licht (Dutch) and https://www.golabz.eu/ils/the-colour-of-light (English)

Short description of the content

This is the first of three ILSs about light. In this ILS the HTML5 PhET lab "Color vision" is used. A female avatar guides the students during the ILS. The first part is about the fact that we can only see things when light is shining on them. This light is reflected by the object and comes in our eyes. In the second part the avatar tells the students that a friend of her told her that white light actually is a mixture of colours. The students are stimulated to reflect on this. In the next part the students use the lab in which they can use the three basic colours (red, green and blue) to create other colours. They will discover that when they mix the three basic colours they will get white light. At the end of the ILS it is explicated that light consists of waves and that every colour has a different wavelength.

The knowledge gained in this ILS is used in the ILSs: Refraction of light 1 and 2.

Justification why this is an exemplary ILS

In this ILS curiosity is triggered by the avatar, attention is kept by posing questions regularly, the phases have meaningful names and hints are given about what to do. The students don't need to do a lot of scrolling. The ILS is sequential and the viewer is used to show the content of an app in a next phase so students don't have go back and forth in the ILS. At the end there is a kind of reflection and new information is introduced to raise curiosity into the topic (and a next ILS).

The following criteria from checklist are met in this ILS: 1-3,5-6, 9-10, 12, 14-15, 17, 20, 22-25, 27-28, 30-31, 32 (no stereotypes).

3.2 Lichtbreking 1; Refraction of light 1

Topic: Light rays/waves sometimes refract when they go from one transparent material to another transparent material

Age group: 9-10 years

Link to the ILS: https://www.golabz.eu/ils/lichtbreking-1 (Dutch) and https://www.golabz.eu/ils/refraction-of-light-1-1 (English)

Short description of the content

This is the second of three ILSs about light. In this ILS the HTML5 PhET lab "Bending light - Intro" is used. The same female avatar as in the Colour of light guides the students during the ILS. In the beginning of the ILS the students are confronted with two pictures of glasses with a pencil it. In one of the glasses is water. In this glass the pencil seems broken. That's strange! The students are asked to think why this could be? In the Investigation students can experiment with a light ray shining through two transparent

materials. They can discover that sometimes the light ray refracts when going from one transparent material to another. At the end of the ILS the students are confronted with fact that objects don't seem to be broken when we see them through a window. Why?

The knowledge gained in this ILS is used in the ILS: Refraction of light 2 about the rainbow.

Justification why this is an exemplary ILS

In this ILS curiosity is triggered by presenting a strange phenomenon, prior knowledge is activated, attention is kept by posing questions regularly, the phases have meaningful names and hints are given about what to do. The students don't need to do a lot of scrolling. The ILS is sequential and the viewer is used to show the content of an app in a next phase so students don't have go back and forth in the ILS. Thought processes are made explicit, At the end there is a kind of reflection and new information is introduced to raise curiosity into the topic (and a next ILS).

The following criteria from checklist are met in this ILS: 1-3,5-10, 12, 14-17, 19, 20, 22-25, 27, 29-32 (no stereotypes).

3.3 Lichtbreking 2; Refraction of light 2

Topic: Light rays/waves sometimes refract, and light with different wavelengths refracts in a different way. This is why we sometimes can see a rainbow.

Age group: 9-10 years

Link to the ILS: https://www.golabz.eu/ils/lichtbreking-2 (Dutch) and https://www.golabz.eu/ils/refraction-of-light-2 (English)

Short description of the content

This is the third of three ILSs about light. In this ILS the HTML5 PhET lab "Bending light - Prisms" is used. The same female avatar as in the previous ILSs about the Colour of light and Refraction 1 guides the students during the ILS. In the first part students are stimulated to think about the conditions under which we can see a rainbow. Furthermore, a reference is made to the knowledge gained in the ILS "The colour of light" and in the ILS "Refraction of light 1". After that two rounds of investigation are introduced. In the first one the students use a light ray with one colour which shines through a prism. In the second one they use white light. They will discover that the different colours in white light refract in a different way. At the end there is a video explaining how a rainbow exists and a quiz.

Justification why this is an exemplary ILS

In this ILS curiosity is triggered by referring to a common phenomenon (the rainbow) and asking students to think when and why this phenomenon can be seen. A conversational style is used. Prior knowledge is activated, attention is kept by giving assignments regularly. The phases have meaningful names and hints are given about what to do. The students don't need to do a lot of scrolling. The ILS is sequential. Thought processes are made explicit. A short video is used at the end to give more information followed by some questions.

The following criteria from checklist are met in this ILS: 1, 3-5, 7-12, 15-25, 27, 30-32 (no stereotypes).

3.4 Drijven en zinken (Groep 5-6); Sinking and floating (Age 8-9)

Topic: The pupils learn which of the materials wood, brick, styrofoam, and aluminium will float or sink, and whether size and weight are of influence.

Age group: 8-9 years

Link to the ILS: https://www.golabz.eu/ils/drijven-en-zinken-groep-5-6 (Dutch) https://www.golabz.eu/ils/floating-and-sinking-age-8-9 (English)

Short description of the content

Through the use of a story (a message in a bottle of somebody washed ashore on a deserted island who wants help with designing a raft), and a helping professor, the interest of the pupils will be aroused. The students will do experiments using the (Flash) Phet lab “Density”. Besides, they run through the process of inquiry learning: formulating questions, formulating hypotheses, experimenting, writing down observations, concluding, reflecting. In the end they apply what they've learned through designing a raft (this is also possible via Padlet, there is an option to choose this within the ILS).

There are 2 videos which are in Dutch. They could be replaced by videos matching the content.

Video 1: “Heavy materials will sink; light materials will float”. But think about this: heavy tree trunks float, a light paper clips sinks. How is this possible?

Video 2: Things with a similar size are not per se similar when it comes to floating or sinking.

Justification why this is an exemplary ILS

The authors place the content in an appealing context and use a message in a bottle to attract attention. They use a conversational style with a virtual coach. They include both text and graphics (which complement each other). Meaningful titles are given to the phases. Apps are partially filled already so students have to complete hypotheses. Hints about what to do/ navigational support is provided. There is no irrelevant information. The ILS is sequential and the viewer is used to show the content of an app in a next phase so students don’t have go back and forth in the ILS. Videos are not too long. They regularly pose questions or give assignments.

The following criteria from checklist are met in this ILS: 1-3, 5-10, 12-19, 22, 24-27, 29-31.

3.5 Electriciteit; Electricity

Topic: Students learn to build a functioning electrical circuit and learn if everyday objects are conductors or insulators.

Age group: 11-12

Link to the ILS: https://www.golabz.eu/ils/elektriciteit

Short description of the content

The interest for the topic is raised by an avatar who shows a news video about a teenager who died because her cell phone fell in the bathtub while the phone was loading. After an introduction about electrical circuits students will formulate hypotheses about when an electrical circuit is working and about whether everyday objects are conductors. Students use the HTML5 PhET Lab “Circuit Construction Kit: DC” to do experiments.

Justification why this is an exemplary ILS

Curiosity is raised by presenting a news video at the beginning. Prior knowledge is activated by means of another video. The videos are not too long (0.27 and 2.36). A conversational style and an avatar is used. Meaningful titles are given to the phases. Hints and navigational support are provided. At the end students are asked to reflect on the activity.

The following criteria from checklist are met in this ILS: 1, 2, 4, 5, 7, 9-13, 16-19, 22, 24, 25, 29, 31.

3.6 Vast, vloeibaar, gas. How werkt dat?; Solid, liquid, gas. How does this work?

Topic: In this ILS students learn about the states of matter.

Age group: 9-12

Link to the ILS: https://www.golabz.eu/ils/vast-vloeibaar-gas-hoe-werkt-dat

Short description of the content

An investigator named Jack guides the students through the ILS. This ILS is designed as an assimilation assignment for chapter 5 of a schoolbook (Wijzer! Natuur en Techniek).

1. The students create hypotheses about how the movement of atoms differs when temperature changes, with the help of the information from the videos.
2. The students test their hypotheses in the virtual laboratory.
3. The students can change the different states of matter by regulating the temperature in the lab.
4. The students can observe and report how the movement of atoms differs across the different states of matter.
5. The students can relate the differences in movements (slow/stagnant, moderate, and fast) to the different states of matter (solid, liquid, and gas) and specific changes in temperature (heating and cooling down).

Students do experiments by using the HTML5 PhET Lab “States of matter-basics”.

Justification why this is an exemplary ILS

The authors use a conversational style with a virtual coach. They include both text and graphics (which complement each other). Meaningful titles are given to the phases (What do you already know?, What are you going to research? Time for an experiment! What have you discovered?).There are links to prior knowledge in first phase by means of questions. Hints about what to do/ navigational support is provided. The apps are adjusted to the audience. There is no irrelevant information. Videos are not too long (2.49 and 1.15). They regularly pose questions or give assignments.

The following criteria from checklist are met in this ILS: 1, 3-5, 7, 9, 10, 12, 13, 16-22, 24-26, 31.

3.7 Tandwielen ontdekken; Discovering Gears

Topic: In this ILS students learn about which side gears turn and acceleration using gears.

Age group: 9-14

Link to the ILS: https://www.golabz.eu/ils/discover-gears and the Dutch one: https://www.golabz.eu/ils/tandwielen-ontdekken

Short description of the content

This ILS is about gears. By helping Stef to design his bicycle, you will learn which side gears turn and how you can use them to accelerate.

The ILS starts with an introduction of Stef's bicycle. Thereafter, hypotheses (expectations) will be created. The hypotheses will be tested in an online lab in which you can draw gears. Finally, it will be concluded that gears turn in opposite direction when they are placed directly to each other, but in the same direction when they are connected by a chain. The other conclusions is that you can use a combination of large and small gears to accelerate. These conclusions will be used to give Stef advice.

Justification why this is an exemplary ILS

In this ILS, the first problems are easy to solve; it starts with the assignment to put together some gears and let them turn. Starting with success motivates the learner. In addition, the problem is contextualised, as a character is presented that want to reach some goals. At the end, knowledge can be applied to help this character design a bicycle. Another feature that helps the learner is that two distinct problems are solved and they are provided in two distinct inquiry cycles, instead of one in which both are addressed. This structures the ILS and helps to understand the relevant variables.

The following criteria are met in this ILS: 1-5, 7-13, 15-27, 31

3.8 Planten en groei; Plants and growth

Topic: In this ILS students learn about what plants need to grow.

Age group: 7-12

Link to the ILS: https://www.golabz.eu/ils/planten-en-groei (Dutch) https://www.golabz.eu/ils/plants-and-growth (English)

Short description of the content

This ILS is about plants and growth. By helping Sofia with her school garden, you will learn what plants need to grow.

The ILS starts with an introduction of Sofia and the school garden. Thereafter, hypotheses (expectations) will be created. The hypotheses will be tested in an online lab in which you can change the light intensity and temperature. Finally, it will be concluded that plants grow well when they get light and when the temperature is not too high or too low. These conclusions will be used to give Sofia advice.

Justification why this is an exemplary ILS

In this ILS, curiosity is stimulated by posing challenging questions and a short quiz. Before going into detail, the lab is explored. This way relevant variables and their settings can be represented mentally. In the next phase, they can immediately use it to create hypotheses. Due to the apps that are used, inquiry is supported extensively, from partially filled in hypotheses in the Hypothesis Scratchpad, and partially filled in experimental design in the Experiment Design Tool, to an easy-to-use Observation Tool, which all culminates in the Conclusion Tool at the end. Therefore, this ILS can be used to train inquiry skills.

The following criteria are met in this ILS: 1-10, 12-13, 15-19, 21-28, 31.

3.9 Bouw een tuinhuis voor Stephen en Marie; Build a garden house for Stephen and Marie

Topic: In this ILS students learn about area and perimeter

Age group: 7-12

Link to the ILS: https://www.golabz.eu/ils/build-a-garden-house-for-stephen-and-marie and the Dutch one: https://www.golabz.eu/ils/bouw-een-tuinhuis-voor-stephen-en-marie

Short description of the content

This ILS is about area and perimeter. By helping Stephen and Marie design and build a garden house, you will learn to calculate area and perimeter.

The ILS starts with an introduction of Stephen and Marie. Afterwards, hypotheses (expectations) will be made about how long/how large the garden house can be that they want to build. The hypothesis is tested in an online lab about area and perimeter. Finally, it will be concluded how long Stephen's garden house can be and how large Marie's garden house can be.

Justification why this is an exemplary ILS

This ILS contains a context that is related to everyday life of the students. First of all, they understand that a piece of ground is limited, which makes it relevant to calculate its area and perimeter. Also, they understand that how much money you have determine the possibilities. Finally, there are two characters in this ILS and each has their own hobby, which affects what they want to build on the piece of ground. The problem is, thus, presented as a story. This is also common in tests at schools, where problems often are presented as stories and children have to read carefully and extract the relevant information to solve the problem at hand.

The following criteria are met in this ILS: 1-5, 7-10, 12-13, 15, 18, 20-21, 23-27, 31-32.

3.10 Free Fall on the Earth and on the Moon

Topic: Students explore the concept of atmosphere on the example of the Gravitational Force and Gravity on the Earth and Moon

Age group: 11-12 years

Link to the ILS: https://www.golabz.eu/ils/free-fall-on-the-earth-and-on-the-moon

Short description of the content

In this ILSs the study of an atmosphere concept is based on the falling objects contrasting the cases on the Earth and Moon. The ILS is starting with a bet between father and daughter “if we dive into water together”. In the phase of ideas and hypothesis, students should figure out which characteristics of the objects can affect the falling process. The Gravity Drop Lab is applied. The students explore the time that is required by objects with different weights and shapes to reach the surface of Earth or Moon. Students behaving as investigators can create graphs that describe a correlation between mass and time, and take the observation notes. Students are encouraged to evaluate their hypothesis and to reflect on their new experience. The new "Another bet daddy?" is the best way to inspire kids, teens, and adults to gain new experience and knowledge.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1-4, 7, 10, 11, 16-22, 24, 25, 31-32 (no stereotypes). The bet and meaningful images are the form to pick up the attention of students to a topic. The teacher regularly presents a problem, introduces reflection tools for students. Concept Mapper and Hypothesis tools are employed to activate prior knowledge and connect the ILS content to a real-life context. Conversational style, wise formulated titles of inquiry phases, short videos are addressed to motivate and encourage students to the subject.

3.11 Kuidas mõjutavad valgustugevus ja temperatuur fotosünteesi?; How do light and temperature affect photosynthesis in plants?

Topic: Students collaboratively explore how light intensity and season of the year affect photosynthesis in aquarium plants using a collaborative lab, and then individually explore how light intensity and temperature affect photosynthesis using another lab.

Age group: 12-13

Link to the ILS:

Estonian links:

https://www.golabz.eu/ils/kuidas-mõjutavad-valgustugevus-ja-temperatuur-fotosünteesi-versioon-a (Version A)

https://www.golabz.eu/ils/kuidas-mõjutavad-valgustugevus-ja-temperatuur-fotosüteesi-versioon-b (Version B)

English links:

https://www.golabz.eu/ils/how-do-light-and-temperature-affect-photosynthesis-in-plants-version-a (Version A)

https://www.golabz.eu/ils/how-do-light-and-temperature-affect-photosynthesis-in-plants-version-b (Version B)

Short description of the content

This ILS requires at least two lesson periods to complete. In addition to supporting the development of students' inquiry skills it also focuses on building students' collaboration skills.

The ILS begins with a Demo phase in which the instructor should demonstrate to students how to formulate a hypothesis using the hypothesis scratchpad, how to get started with a collaborative simulation and how to use the SpeakUP app for text communication. Pairs of students should be assigned different room numbers so that there chat room discussion and actions in the collaborative simulation are independent from other students. After students get familiar with how to solve a collaborative simulation in the Demo phase, the next phase of ILS begins the lesson of photosynthesis in plants. Another collaborative simulation is used in the Explore phase, after which the students can reflect on their collaborative experience. Then in the Predict, Investigation and Conclusion phases the students work individually to complete the rest of the ILS.

Justification why this is an exemplary ILS

The ILS stimulates curiosity by requiring students to work collaboratively to answer questions. In a collaborative simulation, any one student does not have control over all the relevant variables of interest and therefore must communicate with their partner to successfully complete their assignment.

From the checklist, several criteria are met in this ILS. The ILS uses a lab (1), grabs attention by dividing control over a lab to collaborating partners and asking them to answer challenging questions (2-3), regularly checks for understanding with quiz questions (6), activates prior knowledge in the “Explore” phase (7), relates to concepts of light intensity and temperature that are familiar to students (9), gives hints about collaboration (12), gives meaningful titles to inquiry phases (17), begins with a demo phase to introduce students to using a collaborative simulation (19), interleaves words and pictures appropriately throughout the ILS (20-24), includes a reflection phase (27-28) and respects privacy (31).

3.12 Veeringe; The Water Cycle

Topic: Understanding different processes of the water cycle.

Age group: 8-9

Link to the ILS:

Estonian link: https://www.golabz.eu/ils/veeringe English link: https://www.golabz.eu/ils/the-water-cycle

Short description of the content

This ILS uses a lab created in the Scratch programming environment (see https://www.golabz.eu/lab/water-cycle-lab) to allow students to choose one of three weather conditions (sunny, partly cloudy or cloudy) and then run a simulation of the four main stages of the water cycle (evaporation, condensation, precipitation, infiltration). In the simulation, the sunny condition results in the most precipitation whereas the cloudy condition does not result in any precipitation because not enough evaporation occurred for large water droplets to form during the condensation stage.

In the ILS students are guided to use their observations of the simulation to identify the different stages of the water cycle and explain why they think different weather conditions result in different outcomes.

Justification why this is an exemplary ILS

From the checklist, several criteria are met in this ILS. The ILS uses a lab (1), grabs attention with an initial task to contribute to a collaborative Padlet wall (2-3), includes a video to review what was learnt (4), provides necessary background knowledge (7), relates to weather conditions that are well known to students (9), gives a hint to help with the lab (12, 26), focuses attention on important elements (16), includes a short video (18), mixes words with pictures (20-21), keeps inquiry phases compact and relevant (22-23) and respects privacy (31).

3.13 Staatiline elekter; Static Electricity

Topic: Understanding static electricity and an imbalance of electric charges within a material.

Age group: 9-10

Link to the ILS: https://www.golabz.eu/ils/staatiline-elekter

Short description of the content

This ILS introduces the concept of static electricity to third grade students. It begins with real-life examples of static electricity and a video showing a person rubbing a balloon against hair and the balloon causing small pieces of paper to stick to it. Then the second phase asks students to think of a prediction of when static electricity is large or small depending on how a balloon is rubbed against a woollen sweater. The third phase, investigate, guides students to interact with a PhET lab about static electricity and discover that after rubbing a balloon against a woollen sweater there is an exchange of electric charges, the balloon has excess negative charges and will be attracted to objects having an excess of positive charges. The conclusion phase has several open-ended questions for students to answer. The discussion phase asks students to reflect on their inquiry learning experience.

Justification why this is an exemplary ILS

From the checklist, several criteria are met in this ILS. The ILS uses a PhET lab (1), grabs attention with an interesting video (2-4), poses a question to prompt students to make a prediction (5), relates the content to a well-known phenomenon (9), adjusts the hypothesis scratchpad to provide a comprehensive list of well-defined terms (13), gives meaningful titles to the inquiry phases (17), includes brief videos (18), appropriately integrates words and pictures (20-22), concludes with a discussion phase for reflection (28), respects privacy (31) and includes visuals with both genders (32).

3.14 Elektrivool; Electric Current

Topic: Understanding electric current in a material and the consequences of a short circuit.

Age group: 9-10

Link to the ILS: https://www.golabz.eu/ils/elektrivool

Short description of the content

This ILS introduces the concept of electric current to third grade students. It begins with a phase called ‘What will do today?’ in which students are introduced to the main features of the lesson: learning to put a simple circuit together, exploring the way electricity flows in a circuit and what happens when inappropriate materials are connected to a circuit. The second phase, labelled ‘What happens if…’, demonstrates to students two videos - one where a metal wire is connected in a circuit and the other where a LED lamp is connected to a circuit. The metal wire is shown to glow red and burn up. The LED lamp is shown is light up and remain illuminated. This phase ends with students making hypotheses about why the two examples gave different results. The next phase, called ‘What happened?’, guides students to build circuits representing the two examples using a PhET lab. The final phase, ‘What did you learn?’, asks students to explain the way electrons flowed in the circuit for the two example cases discussed.

Justification why this is an exemplary ILS

From the checklist, several criteria are met in this ILS. The ILS uses a PhET lab (1), grabs attention with an interesting video (2-4), poses a question to prompt students to make a prediction (5), relates the content to a well-known phenomenon (9), adjusts the hypothesis

scratchpad to provide a comprehensive list of well-defined terms (13), gives meaningful titles to the inquiry phases (17), includes brief videos (18), is structured sequentially (24), offers navigational guidance (25) and respects privacy (31).

3.15 Toitumine; Healthy Eating

Topic: Understanding food calories and food consumption for healthy eating.

Age group: 9-10

Link to the ILS: https://www.golabz.eu/ils/toitumine

Short description of the content

This ILS is about exploring the effects of nutrition and movement on human health and body weight. First, the lesson structure and aim is introduced, and then the first engagement exercise has to be solved using an application to match pictures to words (from https://learningapps.org). An extra possibility is to make the interactive exercise full screen - main aim is to track amounts - how much is one slice, glass, or different spoonful. Students have to remember or write down everything they eat and drink in their previous day, and put all the data into a Food Journal. The Food Journal is located at the Health Department Institute webpage, that is embedded in the ILS. The lesson continues with students analysing their diet. After students fill in their own Food Journal, they complete a table about what is their consumed count of calories, and what is the suggested amount of calories they should be consuming. Then they have to calculate if they exceed or have a deficit of calories. This phase also includes a Discussion module, where students can ask from others about recording foods in the diary and get help from classmates and teacher. The next step is background information reading and theory. With simple examples there is a text for students to read. And after reading text the students do quiz. Next phase is formulated research question: What is the relation between daily diet/energy and body weight? And according to question students need to create hypothesis with hypothesis app. To solve the question, students have a hypothetical case study where they need to insert data of foods about similar age group boy. The final assignment is to compare in a table the personal and case study data and bring out the amount of energy consumed per day, three important indicators and foods that they need to consume the next day and which foods to avoid.

Justification why this is an exemplary ILS

From the checklist, several criteria are met in this ILS. The ILS grabs attention with an interesting app to match pictures and words (2-4), poses a question to prompt students to make a prediction (5), checks for understanding using a quiz (6), activates background knowledge (7), relates to the well-known phenomena of eating and consuming calories (9), adjusts the hypothesis scratchpad to provide a comprehensive list of well-defined terms (13), gives meaningful titles to the inquiry phases (17), includes brief videos (18), is structured sequentially (24), offers navigational guidance (25) and respects privacy (31).

3.16 Ακαδημία Αστροναυτών; Astronauts' Academy

Topic: Astronomy, Geography and Earth Science

Age group: 9-10, 10-11

Link to the ILS: https://goo.gl/7YQAAR

Short description of the content

This is an ILS for teachers whose students are intrigued by the night sky, exploration, astronauts and aliens. Students are involved in an adventure through which they reach the learning objectives set by the author. The content is focusing on succeeding and surviving relying on orientation depending on the sky and its celestial objects. It has been designed for students between 9-12 years old, curious, creative and eager to learn based on inquiry and interdisciplinary.

Justification why this is an exemplary ILS

This ILS contains lab activities and a key adventure game, enriched with multimedia material, that students need to follow in order to complete the activity. Prior knowledge is brought up and questions are popping up through the whole body of the ILS encouraging students' understanding of the concepts presented. Very clear guidelines are suggested by the author offering a sense of confidence to the students to work by themselves, with labs' instructions included as hints. Even in the case of apps, their functions have been customized in order to be easily addressed to primary school students (e.g. hypothesis scratchpad). The titles of the phases have been personalized in order to be applied in the adventure set by the author, which makes it look like a game to the students and the whole body of the ILS is enriched with graphic features and pictures to make it even more appealing to the students.

3.17 A Journey to Space

Topic: Astronomy

Age group: 7-8, 9-10, 11-12

Link to the ILS: https://goo.gl/a2K4wq

Short description of the content

Following this ILS, students will be exposed to the Solar Systems and its secrets and they will get familiarized with its key concepts. Through a training to be an astronaut challenge they will gain relevant knowledge sharing the feeling of participating in a game. The lab activities and the simulation will help them to clear any misconceptions they may have about space, the Solar System and the lives of the astronauts. This ILS can be matched with the ILS Astronaut's Job = Cool! presented in this document.

Justification why this is an exemplary ILS

This is an ILS that follows the inquiry cycle in a serial form covering the experimental part with a lab activity and simulations. Its content is very vibrant and keeps the students' attention throughout the ILS. The author has picked attractive multimedia elements to ensure the interactivity with the students and along with questions set it is as if the participants are invited to take part in a learning game, where their prior knowledge is very important. Investing on the "game" approach, the titles of the phases have been altered in a way that suits the general concept of the ILS and so does the casual languages of the narration and last the concept of activities (3) within the ILS involves the students in specific tasks. At the same time, the author manages to examine the understanding of the students through the wise use of apps which can provide the teacher with feedback. Nonetheless, the inquiry part is not more complicated than expected and as a result the young students can share a feeling of accomplishment amongst them once they complete it. Even the practical part is covered by the author, as the author is providing guidelines

when necessary. Last, the participants have the opportunity to reflect the gained knowledge through an interesting activity.

3.18 Παιχνίδια Προσανατολισμού; Navigation games

Topic: Environmental Education, Geography and Earth Science

Age group: Before 7, 7-8, 9-10

Link to the ILS: https://goo.gl/ZBg8Ec

Short description of the content

This ILS is mostly targeting young ages and the main objectives are to familiarize the students with the key concept of navigation and to enable them to develop their navigation skills through a game set by the author. Students have to follow the story of four children and with the help of a lab to solve the mystery of being navigated without the use of any instrument.

Justification why this is an exemplary ILS

“Navigation games” describes a game happening through the inquiry cycle and with the use of a lab. It is actually a sequential ILS which navigates the students by following easy steps and by raising challenging questions to form their hypotheses based on their prior experience. Interesting pictures and videos are used to attract students’ attention and in combination with the narration of the story told by the author, students can enjoy their participation in a game. Key concepts and relevant terms are appearing in every phase for the best familiarization of the students with the topic and, at the same time, apps are easing the learning process for the students. Text styling is supporting the challenge of presenting an ongoing story in Graasp. Detailed guidelines are used, taking into consideration the young age of its audience and especially for the use of the lab there are directions under the function of hint. Reflection of the procedure is covered by the specially designed use of a Go lab app.

3.19 Reasons for the seasons

Topic: Environmental Education, Geography and Earth Science

Age group: 11-12

Link to the ILS: https://goo.gl/rqPGY5

Short description of the content

People living on the Earth sometimes have a narrow perspective of things and often do not realize that in nature all things are part of a system. Earth is not just a huge rock wandering around in space. Earth is part of the Solar System and like all other planets is orbiting the Sun, day after day and season after season. Following the inquiry cycle, this ILS will help students to look closer into the Earth’s orbit, position and distance from the Sun, and to find out what are the reasons for the seasons.

Justification why this is an exemplary ILS

This is a very interesting ILS which makes full use of the Inquiry Cycle in the usual sequence, underlying the significance of experimentation by including two investigations on the same topic. Many questions throughout the ILS stimulate students’ curiosity over the issue and at the same time to follow the comprehension status of the participating students throughout the activity. The author also relies a lot on prior knowledge and in

students' everyday experience in order to encourage them to relate with the topics and with the key concepts. The author suggests two phases of investigation with increasing difficulty and by giving very clear guidelines so that students will have a good ground to achieve the learning goals. Last, there is a phase in the end which includes a discussion-game involving students not only to reflect what they have learned, but also to apply the knowledge they have gained.

3.20 Skeittaaja Osa 1: Energia; Skater Part 1: Energy

Topic: Students explore how the mass of a skateboarder relates to energy levels while skateboarding

Age group: 11-14

Link to the ILS: https://www.golabz.eu/ils/skeittaaja-osa-1-energia

Short description of the content

This ILS is the first of the two ILSs based on a virtual laboratory Energy Skate Park: Basics (PhET). The objectives of the ILS include learning of the energy principles: kinetic and potential energy. The ILS is divided into four phases. The first, introduction phase, begins with a video about skateboarding on a ramp and continues with three questions based on the video. The second, experiment phase, includes testing on how the mass of the skater effects on the skater's energy levels in the skate park. The third, conclusion phase, includes a questionnaire about how the skater's mass is related to the energy levels while skating on the ramp. After this, student forms a hypothesis using a hypothesis scratchpad application. The fourth, self-assessment phase, includes student's reflection of the activity and forming of ideas how to continue research of the topic.

Justification why this is an exemplary ILS

This ILS is based around of a practical and interesting simulation Energy Skate Park Basics (PhET) which is well-suited for students aged 11-14. Since forming of a hypothesis can be difficult for primary school students, this ILS follows a modified inquiry cycle where hypothesis is formed after the experiment. The objective of this is to scaffold the learning process of how to form a hypothesis. The following criteria are met in this ILS: 1-13, 15, 17-28, 31.

3.21 Skeittaaja Osa 2: Kitka; Skater Part 2: Friction

Topic: Students explore how the amount of friction is related to the motion of the skateboarder

Age group: 11-14

Link to the ILS: https://www.golabz.eu/ils/skeittaaja-osa-2-kitka

Short description of the content

This ILS is the second of the two ILSs based on a virtual laboratory Energy Skate Park: Basics (PhET). The objectives of the ILS include learning of the concepts of friction and conservation of the energy. The ILS is divided into five phases. The first, introduction phase, begins with a video about skateboarding on different ground materials and continues with three questions based on the video. The second, conceptualization phase, introduces the concept of friction. After this, the student forms hypotheses based on readily given variables. The third, experiment phase 1, includes experimenting with friction in a virtual laboratory Forces and Motion: Basics. The fourth, experiment phase 2, is

carried out in a virtual laboratory Energy Skate Park: Basics. It includes experimenting on how the amount of friction is related to the moving of a skateboarder on a ramp. Additionally, the student explores the conservation of the energy. The last, reflection phase, includes the self-assessment and contemplating how to study the topic further.

Justification why this is an exemplary ILS

This ILS activates prior knowledge learnt during the first part of the Skater series. Forming of the hypothesis is scaffolded by giving partially filled variables. Further, the experiment is guided by giving step by step instructions to work in a laboratory. In a self-reflection phase, students plan ways how to further research the topic in a classroom environment. This provides opportunities for follow-up studies.

The following criteria are met in this ILS: 1-13, 15, 17-28, 31.

3.22 Kelluuko vai uppoaako?; Does it float or sink?

Topic: Students explore what kind of elements sink and float

Age group: 9-12

Link to the ILS: https://www.golabz.eu/ils/kelluuko-vai-uppoaako

Short description of the content

This ILS is about experimenting what kind of elements sink and float. The objectives of the ILS include learning of the concepts of mass and volume. The ILS is divided into five phases. The first, introduction phase, includes a video about a tanker that catches the students' attention. The second, experiment 1, is about testing how plastic, ice and a small rock react when they are dropped in water. Students measure how much the level of water increases after the dropping of these elements into a water cup. On a third phase, students report their results for their peers. The fourth phase, experiment 2, includes a virtual laboratory Density and Buoyancy (PhET). In the laboratory, the students experiment with different elements and find out that if the density of the element is smaller than the density of water, the element floats. On the last phase, students conclude their findings and reflect on their work during the inquiry.

Justification why this is an exemplary ILS

This ILS is well-suited for students aged 9-12. It includes both, virtual simulation and an easy experiment to be done in a classroom. This approach makes the inquiry practical for the student. The ILS includes various different apps and a checkpoint where the students can share their results to their peers. The following criteria are met in this ILS: 1-25, 27-29, 31.

3.23 Sähköiset synttärit; Electric Birthday Party

Topic: Students explore static electricity

Age group: 7-12

Link to the ILS: https://www.golabz.eu/ils/*Sähköiset-synttärit*

Short description of the content

The ILS is about experimenting static electricity in a context of a birthday party. The objectives of the ILS include learning of the concepts *static electricity, positive charge,* and *negative charge*. The ILS is divided into five phases. The first, introduction phase, includes a video about science tricks using static electricity which raises student's

curiosity. The second phase includes background information about static electricity and electric charges. After this, the student forms a hypothesis: in which situation materials attract and repulse each other? In the third phase, the student tests the hypothesis using a Balloons and Static Electricity virtual laboratory (PhET). The fourth phase includes student's conclusion and a discussion to reflect on what did the students learn during the inquiry. On the last phase, students self-reflect on the inquiry.

Justification why this is an exemplary ILS

The ILS is framed around a narrative of birthday party which makes it interesting for students aged 7-12. The abstract topic of static electricity is studied in a concrete way by using a virtual simulation Balloons and Static Electricity (PhET) and instructions to do an inquiry step by step. The following criteria are met in this ILS: 1-13, 15-25, 28, 31.

3.24 Johde vai eriste?; Conductor or non-conductor?

Topic: Students experiment with conductors and non-conductors using electrical circuit

Age group: 7-12

Link to the ILS: https://www.golabz.eu/ils/johde-vai-eriste

Short description of the content

This ILS is about experimenting with electricity. The objectives of the ILS include learning of the concepts *electrical circuit*, *conductor*, and *non-conductor*. The ILS is divided into five phases. The first phase introduces the topic of the activity. In the second phase, students form a hypothesis about the conductivity of different materials. The third phase includes a virtual laboratory Circuit Construction Kit: DC (PhET) and the students conduct research where the conductivity of different materials are tested. In the fourth phase, students make conclusions about their experiments. In the last phase, they reflect on the activity with their peers.

Justification why this is an exemplary ILS

The laboratory setting in the ILS is practical for students on the age group 7-12 since the objects used are familiar from everyday life (e.g. paper clips, pencils, coins). Forming of the hypotheses is scaffolded by partially filled variables and the context is well known for the students. The key concepts are repeated through the activity to emphasize them.

The following criteria are met in this ILS: 1, 3-5, 7-13, 16-17, 19-25, 27-28, 31

3.25 Τριβή; Friction

Topic: Friction is the force that resists the sliding or rolling of one object over another. The friction can cause attrition, heat and sound.

Age group: 8-7, 9-10, 11-12

Link to the ILS: https://goo.gl/6ne47j (Greek) https://www.golabz.eu/ils/friction-2 (English)

Short description of the content

In this ILS students are introduced to the concept of friction and they conduct guided experimentation to learn more about this phenomenon. At the end, they apply the new knowledge about friction to explain everyday situations where friction plays an important role. In this way they discuss about the outcomes of friction, namely attrition, heat and sound.

Justification why this is an exemplary ILS

Alex is the main character of the ILS and together with his friend Sofia, guide students through the activities of the ILS (10, 32), provide navigational support (25), introduce new lines of thoughts (5), provide clear instructions and hints (12) and encourage students before a challenging task, to increase their confidence that they be successful. Moreover, titles of the phases have been renamed to become meaningful for students (17), throughout the ILS the thinking process is explicit (27), bold text and signalling are used to help students focus on key elements (16), students do not have to unnecessarily go back and forth between phases (24) and videos that are included are short (18) and relevant (22). In the introduction, students are provided with challenging questions (3, 5) and the images that accompany the questions stimulate their curiosity (4, 20, 21) and help them activate their prior knowledge (7). In order to check students' understanding of the key elements, quizzes and group discussions are included 6). Explanatory feedback is provided (14), especially in the activities before experimentation. The PhET Interactive Simulation Forces and Motion: Basics is used for experimentation, specifically, the learning environment about friction (1). Before using the Lab, students are guided to get familiar with it (19) and during the experimentation they receive enough support from the apps that have been adjusted to their knowledge level (13). The level of difficulty increases from the first experiment to the second (11) and at the end of the ILS, students have the opportunity to discuss on everyday activities that can be explained using the concept of friction (9, 15, 29).

Note: Pictures of students are not included in the ILS (31).

3.26 Παράγοντες που επηρεάζουν τον ρυθμό της φωτοσύνθεσης; Factors that affect the rate of photosynthesis

Topic: The concentration of carbon dioxide, the temperature and the light intensity are factors that affect the rate of photosynthesis.

Age group: 11-12

Link to the ILS: https://goo.gl/48ZLo1

Short description of the content

This ILS introduces the concept of photosynthesis and students investigate the effect of three factors on the rate of photosynthesis. By watching some images, students first identify some factors related to the phenomenon and then try to represent their initial ideas on a concept map. In the next steps, students receive support to formulate hypotheses that can be examined in the virtual lab. It is expected that students will examine all the possible variables that are provided in the virtual lab.

Justification why this is an exemplary ILS

This ILS stimulates students' curiosity through challenging questions (3) and images (4) related to the plants' growth. Particularly, the example of plane tree, which can grow up to 30-50 meters height is considered as very exciting. Later, students are asked to create a concept map with the given concepts to activate their prior knowledge about plant growth (7). Thought the ILS, both text and images are included (20), elements that belong together conceptually are together in space and time (21) and new lines of thoughts are introduced (5), allowing students to identify some of the variables they are going to work with, during the experimentation in the virtual lab included in the ILS, called Photolab (1). In addition, to ensure that students will get familiar with the key concepts they watch a

short video (18) explaining in details the process of photosynthesis. At the beginning and the end of each phase, a conversational style of writing is used (10), while, throughout the ILS, the thinking process is explicit (27). The names of the phases have been changed to be more meaningful for students, however their titles imply the processes of inquiry (17). Bold text, at the end of each phase, informs students about the next steps (25) or, elsewhere, helps students focus on important elements (16), while italics provide hints and support for the completion of some activities (12). Instructions before an activity are clear and the apps included were configured properly to the students' age (13). However, very often students are reminded that the teacher can support them at any time (6). Moreover, there are specific calls for discussion (29), either with the teacher or peers, to ensure that students can check their understanding and be able to move to the next steps without any misconceptions. The "Hints" functionality is used to give additional support to those who need it and to limit scrolling into phases (26). The content and the overall structure of the ILS (9, 11, 20, 22, 24) ensures that students feel that they will be successful.

Note: Pictures of students are not included in the ILS (31).

3.27 Η εξαφάνιση των δεινοσαύρων; The extinction of dinosaurs…

Topic: Students investigate what factors affect the size of a crater created from a crash of an asteroid on Earth.

Age group: 9-10, 11-12

Link to the ILS: https://goo.gl/nd336M

Short description of the content

The main goal of this ILS is to help students develop inquiry skills, namely, question and hypothesis formulation, experiment design, data collection, graph creation and data interpretation, communication, etc. The topic of the extinction of dinosaurs stimulates students' interest and they are supported to undertake the lab activity about the crash of asteroids on Earth.

Justification why this is an exemplary ILS

A virtual coach guides student at the beginning of each phase (10), by posing challenging questions (3) and by providing explanations and information about the processes of inquiry that students have to undertake. In this way, new lines of thought are introduced (5) and the thinking processes are becoming explicit (27). For the introduction of the topic of the extinction of dinosaurs, both text and images are included (20) in order to activate students' prior knowledge (7). In the second phase of the ILS, the "Hints" functionality is used (26) to provide definitions of the key concepts for those need it, and a short video (18) simulates the crash of the asteroid that scientists believed it caused the extinction of dinosaurs (4). In addition, "Hints" are used throughout the ILS to offer support during the inquiry processes and anticipate commonly made errors (12). Students receive navigational support at the end of each phase (25) and other signalling throughout the ILS is used to help students focus on important elements (16). The names of the inquiry phases have been changed to make more sense for young students (17), however their titles imply the processes of inquiry. The lab used in this ILS is the Crater on Earth and Other Planets (1). Before students start using the lab for their investigations, they are supported to get familiar with it (19). Throughout the ILS, students are given clear instructions and the apps used were adjusted properly to their age (13). However, the

difficulty level increases during the experimentation, where gradually students receive less support in the apps used (11). At the end of the ILS, students respond to reflection questions (28) regarding the importance of the results of their inquiry and they complete a questionnaire to apply the knowledge they gained (15). Overall, the general structure (21, 22, 23, 24) of the ILS ensures that students feel that they will be successful.

Note: Pictures of students are not included in the ILS (31).

3.28 Φαινόμενο του θερμοκηπίου: Αλήθεια ή μύθος; Greenhouse effect: Fact or myth

Topic: Students investigate the effect of three factors (greenhouse gases concentration, number of clouds and atmosphere; e.g. ice age, today) on Earth's temperature.

Age group: 11-12 years

Link to the ILS: https://goo.gl/jaizdV

Short description of the content

In this ILS students elaborate on information and undertake a lab activity regarding the Greenhouse Effect to argue if they agree that this phenomenon is amongst the biggest environmental problems of our age. At the beginning, students' prior knowledge is activated and then several sources (e.g. video, images) are given to help them get familiar with the key concepts of the phenomenon under study. Later, students conduct experiments, collect and analyse data, draw conclusions and create a concept map including all the information learned from the lesson.

Justification why this is an exemplary ILS

In this ILS, a Java PhET simulation is used, named The Greenhouse Effect (1). The software requirements for the use of this simulation are for Windows: Microsoft Windows XP/Vista/7/8.1/10 and latest version of Java, for Macintosh: OS X 10.9.5 or later and latest version of Java and for Linux: latest version of Java. The ILS stimulates student curiosity with a driving question in the title of the ILS (3) and an image (4) and introduces an incongruity and conflict regarding the Greenhouse Effect (2). After this introduction, students answer a short quiz to activate their prior knowledge and the second phase of the ILS help students to get familiar with the names and characteristics of the key concepts. For this purpose, a video is used which is divided in four separate episodes (18, 23). Before each episode a question is given, and students should answer it after they watch the episode (5). Each episode introduces a new line of thought. At the end of the second phase, students complete a very short assignment in the virtual lab to get familiar with it (19). In the next two phases, students are supported to formulate hypotheses, design and execute experiments, write observations and draw conclusions. Throughout the ILS, they are given clear instructions (12) and the apps included were adjusted properly to their age (13). In the next phase students create a concept map to provide an answer to the driving question of the ILS, thus this is an opportunity for them to apply the knowledge they gained (15). In the last phase of the ILS, students have the opportunity to discuss with the teacher and peers (29) and reflect on the aggregated map that is created (28). Some other elements that consider this ILS an exemplary one is the use a virtual coach (10), who informs students about the next steps (25), the several checkpoints included in the ILS that allow teacher to check for misconceptions (6), the name of the inquiry phases have been changed to make more sense for young students (17), and the structure and activities of the ILS (20, 21, 22, 24, 27) help students stay focused on important elements (16).

Note: Pictures of students are not included in the ILS (31).

3.29 As Estações do Ano; The Seasons

Topic: Students explore why there are seasons on Earth, why not all places have the same seasons and why the northern and southern hemisphere have opposite seasons.

Age group: 9-12

Link to the ILS: http://graasp.eu/s/h3ss8g

Short description of the content

This ILS starts by letting the students choose their favourite season and talk about the seasons they know and some of their characteristics. They are confronted with the fact that Christmas is during summer on the southern hemisphere, while it is winter on the northern hemisphere. They investigate if the distance Earth-Sun can be the cause of the seasons – which is one of the most common misconceptions – and conclude that it cannot be so. Then they are led to establish a relation between the inclination of the solar beam and the temperature of the illuminated surface. With this understanding, they are challenged to relate the temperature with the latitude of different places. Using the online lab “Seasons and the Ecliptic Simulator” they investigate how the sun’s altitude and solar beam inclination change along the Earth’s orbit and what causes these changes. They acquire data for different latitudes and using the relation they have found between temperature and inclination of the beam, they conclude the causes of the seasons, why not all places have the same seasons and why the northern and southern hemisphere have opposite seasons. Finally, they are invited to explore a little more the simulator.

Justification why this is an exemplary ILS

This is an exemplary ILS because it takes a topic well known to the children, from their everyday experience - the seasons - and leads them to understand why they occur, clarifying usual misconceptions. It grabs their attention with some visual curiosities - Santa Claus on the beach in Australia and in Brazil(!) - and poses challenging questions to activate prior knowledge. To assure success, the investigation is done in small steps: there is some help in formulating hypotheses through examples and keywords, there are detailed instructions to use the online lab, there are tables prepared to collect data and questions guiding them to obtain conclusions. The last section challenges them to explore more the online lab and poses interesting questions for them to look for the answer.

The following criteria are met in this ILS: 1-15, 17-19, 22-24, 27-31

3.30 C’est chaud ou c’est froid; Is it warm or is it cold?

Topic: Students explore the difference between feeling and measurement of water temperature

Age group: 6-7

Link to the ILS: http://graasp.eu/ils/5b0bcf7302e852fe996153fd/?lang=fr

Short description of the content

This ILS has a double target: scientific and methodological. On the scientific point of view it is build to guide the students on a path to discover what is a temperature and the difference between a feeling, that may lead to wrong interpretations and a measurement that gives a numerical value shared and understood by everybody. Students have first to

identify cold and warm weather, clothes for such environments then they experiment by plunging their hands in three buckets of hot warm and cold water and finally discover how a tool can measure temperatures. On the methodological point of view this ILS introduces audio files associated with the assignments, recorded by the teacher with its own voice reading the assignments. This strategy enables to erase reading difficulties of some students and puts them in a successful path by removing the fear of not understanding the assignments.

Justification why this is an exemplary ILS

This ILS targets young primary students. Reading is hard for some of them and is a cause of failure or dropping out. This ILS is exemplary because the teacher has taped his voice reading all instructions and for each step all instructions are written and proposed as a voice file erasing almost totally the reading difficulty to enable the student concentrate on science topics.

The ILS proposes a mix between real life experimentation (required by French ministry instructions) and digital investigation. There is continuity and complementarity between the use of the computer and real-life observations. Traces of the students' activity in the class are incorporated in the ILS facilitating the appropriation of the digital tool.

The following criteria are met in this ILS: 1-4, 6, 7, 9-10, 11, 14-15,17-18, 20-22, 24, 26 (orientation and discussion phases), 27, 29, 31 (students' faces are blurred on the pictures), 32.

3.31 Visibilité de Mercure et Vénus; Mercury and Venus visibility

Topic: student explore the parameters that control the visibility of planets to be able to choose when will be the best moment to observe Venus and Mercury.

Age group: 11-12 (13-16+)

Link to the ILS: https://www.golabz.eu/ils/mercure-vénus-visibilité

Short description of the content

The lower planets (Venus and Mercury) have similar characteristic positions that enable to understand their periods of visibility. The objective of this ILS is to explore what their significant positions are and to find out which are the best periods of visibility for the coming months / years using graphs extracted from ephemeris and "Planets" Lab included in Golabz as well as Stellarium software which allows to have at the same time an heliocentric and a geocentric simulation of the phenomena.

Justification why this is an exemplary ILS

Venus is probably the easiest planet to observe and the most famous of our sky to the opposite Mercury is difficult to see but both are inner planets (their orbits have smaller radius than earth orbit). The ILS takes advantages of this property to make students understand when and where they will find both planets. The ILS makes a clear link between real observations of the sky and "Planets" lab that enable to build the situation at a given date and observe it in 3 dimensions. The ILS helps first to understand the theory then enables to use the lab to predict the planets position. An interesting point is the

assessment that calls on another software (stellarium) to check if the concepts and physics laws are understood and mastered.

The following criteria are met in this ILS: 1 (Lab Planets), 3, 8 (use a second lab to apply skills acquired with Planets)11, 14(frequent use of teacher feedback), 19, 20, 22, 24, 26, 27, 31.

3.32 Visibilité des planètes Mercure et Vénus (Allophones); Mercury and Venus planets visibility (Allophones)

Topic: This ILS is an adaptation of the previous one for allophone students It enables to improve French language by learning astronomy for allophone students

Age group: 11-12 (13-16+)

Link to the ILS: http://graasp.eu/ils/5b2e24e002e852fe99c88cd5/?lang=fr

Short description of the content

This ILS is an adaptation of the previous one to allophone students, it aims to develop comprehension and production of language skills in science domains for a successful inclusion of NAAS (newly arrived allophone students). It also aims to set up support tracks. The disciplinary objective of this sequence is to understand what are the significant positions of the lower planets (Venus and Mercury) and to identify which are the best periods of visibility for the months / years to come but it is also a learning medium French as a Second Language.

On the scientific point of view the lower planets (Venus and Mercury) have similar characteristic positions that enable to understand their periods of visibility. The objective of this ILS is to explore what their significant positions are and to find out which are the best periods of visibility for the coming months / years using graphs extracted from ephemeris and “Planets” Lab included in Golabz as well as Stellarium software which allows to have at the same time a heliocentric and a geocentric simulation of the phenomena.

Justification why this is an exemplary ILS

This ILS demonstrates the flexibility of ILSs and the efficiency of Go-Lab ecosystem. With few work allophone student’s teachers, whose speciality is not sciences, have duplicated and modified an existent ILS dealing with a scientific question to use it as a springboard to teach French to NAAS (newly arrived allophone students). The scientific content is identical to the previous one.

Venus is probably the easiest planet to observe and the most famous of our sky, to the opposite Mercury is difficult to see but both are inner planets (their orbits have smaller radius than earth orbit). The ILS takes advantages of this property to make students understand when and where they will find both planets. The ILS makes a clear link between real observations of the sky and “Planets” lab that enable to build the situation at a given date and observe it in 3 dimensions. The ILS helps first to understand the theory then enables to use the lab to predict the planets position. An interesting point is the assessment that calls on another software (stellarium) to check if the concepts and physics laws are understood and mastered.

The following criteria are met in this ILS: 1 (Lab Planets), 3(using scientific topic brings motivation to learn the language for NAAS who like sciences), 8 (use a second lab to apply skills acquired with Planets), 11, 14(frequent use of teacher feedback for scientific

and linguistic purposes), 19, 20(special attention is paid to readability of text and images), 22, 24, 26, 27, 31.

3.33 Mekanismoak; Mechanisms

Topic: Fundamental Forces, Reductive Transmission; Rotary change mechanisms

Age group: 11-12, 12-13

Link to the ILS: https://www.golabz.eu/ils/mekanismoak

Short description of the content

A 13-second video introduces the principle of the reductive transmission. 3 clocks and 2 straps demonstrate a rotary speed reduction mechanism. Students create three hypothesis that can build the understanding and knowledge about the topic. The GearSketch virtual laboratory built by University of Twente team helps to prove students' hypotheses. The information is collected for each hypothesis. The designed with the virtual laboratory mechanisms should be submitted on teacher's feedback. The Observation tool, Quiz, and Progress bar are employed to exercise students' self-reflection and self-evaluation.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1,2,4, 6, 10,13, 17,18, 22-24, 28-32. The short video, virtual laboratory, carefully chosen Apps, reflection instruments make this ILS exemplary.

4. Exemplary ILSs for secondary education (students from 12-18 years)

Descriptions of the content of the ILS and justification why this is an exemplary ILS.

4.1 Ρυθμός μεταφοράς θερμότητας; Rate of heat transfer

Topic: The rate of heat transfer, when two gases are separated through a barrier, is affected by the material, the depth, the height and the thickness of the barrier and the type and the temperature of the gases.

Age group: 13-14 and 15-16

Link to the ILS: https://goo.gl/srnJU9

Short description of the content

Students conduct a scientific inquiry to investigate what variables affect how quickly heat is transferred from one element to another. They first activate their prior knowledge and then perform three investigations. For each investigation they have to make predictions, formulate hypotheses, design and conduct valid experiments, create graphs and finally draw conclusions by rejecting or confirming the hypotheses.

Justification why this is an exemplary ILS

The virtual lab used in this ILS is the HTML Heat Transfer Lab (1). At the beginning of the ILS, students are asked to use the time planner app to read about the activities they would complete and to estimate the time needed to complete each phase of the ILS. At the end of the ILS, students use the time checker app to reflect on the time spent in each phase of the ILS by comparing the estimated with the real time and explaining any difference between the two (28). After the time planning activity, the ILS introduces a well-known context (9) and students try to explain it by answering some questions (3). Then, the process of the heat transfer is presented through a diagram (4, 21), helping students activate their prior knowledge (7) and students have to respond to a quiz in order to explain it (5). Then, they are asked to classify variables that might affect the rate of heat transfer and variables that might not affect it. In the next step, they access the virtual lab to explore it (19) and get familiar with the key concepts that are involved in the phenomenon. Moreover, they create a concept map to indicate how these variables are related. The Investigation phase of this ILS is separated into three different phases (23) and each one introduces a new line of thought for investigation. Therefore, students make assumptions, formulate hypotheses, design and execute experiments in the virtual lab, create graphs and justify their conclusions by confirming or rejecting their hypotheses. In order to complete their investigations students are provided with clear instructions and hints (12, 26), the apps that are used are adjusted to help them be successful (13) and there is a checkpoint for discussion with the teacher (6 and 29) at the end of the second investigation. Finally, the ILS is mainly sequential (24), both words and pictures are included (20, 21, 22), difficulty level increase gradually (11), thinking process is explicit (27) and students receive navigational support at the end of each phase (25) and other signalling throughout the ILS (16).

Note: Pictures of students are not included in the ILS (31).

4.2 Μεταγραφή και μετάφραση του DNA; Transcription and translation of DNA

Topic: This ILS is about the transcription and translation of DNA. Students learn about DNA and nucleotides, ribosomes and amino acids

Age group: 13-14, 15-16

Link to the ILS: https://goo.gl/8WTm3V (Greek) https://www.golabz.eu/ils/transcription-and-translation-of-dna (English)

Short description of the content

In this ILS, students explore the processes of transcription and translation of DNA using simulations. The main objectives of the ILS are to enable students to describe and explain the two processes, as well as to explain the difference between the transcribed DNA strand and the non-transcribed DNA strand. The prior knowledge requirements for the completion of this ILS are the DNA structure and the replication of DNA.

Justification why this is an exemplary ILS

This ILS uses two simulations developed by the Concord Consortium, the Modeling Transcription and Modeling Translation (1). The names of the phases were changed into meaningful titles (17) and often challenging questions are used to stimulate the curiosity of students (3, 9) and maintain their attention to the task at hand (5). At the beginning of the ILS, a video and a diagram are used (4, 20, 21) to introduce the topic. The video lasts approximately 5 minutes (18); however, it is separated into three episodes (23) to introduce new lines of thoughts and activate students' prior knowledge. In certain points of the ILS, basic information related to the new and prior knowledge is provided to students to ensure that they know key terms and concepts (7). The apps that are used are adjusted properly (13) and the instructions on how to use them are very clear (12). The whole design of the ILS (16, 22, 24, 25, 27), the support that is provided to students, the controversial style (10) of presenting new lines of thoughts, and the explanations given are the key elements that make students feel that they will be successful (11). After students reach their conclusions, they are given the opportunity to apply the new knowledge by completing two small assignments (15). In the last phase of the ILS, students have the opportunity to reflect (28) if the ILS was interesting, if they learnt something new, if they could do better in the ILS, etc.

Note: Pictures of students are not included in the ILS (31).

4.3 The sound of music: An interactive lesson on standing waves

Topic: Standing waves and their properties

Age group: 13-14, Above 16

Link to the ILS:

https://www.golabz.eu/ils/the-sound-of-music-an-interactive-lesson-on-standing-waves

Short description of the content

In this ILS, students learn about standing waves and explore their properties. At the beginning, their attention is stimulated by a video in which two musicians produce melodic sound with glasses. Then, they watch animations and read about types of waves and their properties to refresh their prior knowledge. The investigation phase includes both the exploration and experimentation processes, and thus students first get familiar with

standing waves and their properties and then investigate the relation between their properties in order to conclude to the mathematical equation that describes the phenomenon. At the end, knowledge gained from the previous phases is used to explain the phenomenon at the beginning, namely, the creation of sound with the different glasses.

Justification why this is an exemplary ILS

The introduction of this ILS stimulates students' curiosity by posing challenging questions (3) and using an attractive video (4). The purpose of the second phase of the ILS is to activate students' prior knowledge on the types of waves (7) and, throughout the ILS, new lines of thoughts are introduced (5) basically about the standing waves, which is the main topic under study. This is to ensure that students will become familiar with the main concepts. In the next phase, students are introduced to simple problems and gradually the difficulty level increases (11), however hints and clear instructions are given (12) so that students feel that they will be successful. Moreover, the apps that are used in the ILS have been configured to support students complete the activities successfully (13). The videos used in the ILS are not too long (18, 22), both images and texts are included (20), elements that refer to the same thing are together in space and time (21), bold text is used to help students focus on important elements (16) and navigational support is offered (25). For the purpose of the exploration three virtual labs are used, the Wave on a String PhET Interactive Simulation and the HTML5 apps, Standing Wave (Explanation by Superposition with Reflected Wave) and Standing Longitudinal Waves, while for experimentation the Standing Waves lab is used (1). At the end students are asked to explain what they saw in the first video by applying the new knowledge on standing waves gained in the previous phases (15). Overall, the content of the ILS is related to music (9), instructions and explanations are written in a conversational style of writing (10), the names of phases have meaningful titles (17), the ILS is mainly sequential (24), and the "Hints" functionality is used often to give additional support for those who need it and to limit scrolling (26).

Note: Pictures of students are not included in the ILS (31).

4.4 Kas On Hea Olla Ilus?; Is It Good To Be Beautiful?

Topic: Evolution, Natural Selection

Age group: 15-16, above 16

Link to the ILS:

Estonian link: https://www.golabz.eu/ils/kas-on-hea-olla-ilus

English link: https://www.golabz.eu/ils/is-it-good-to-be-beautiful

Short description of the content

This ILS guides students through a real-life experiment done by the biologist John Endler in the 1970s in which he investigated the balance of natural and sexual selection in guppy fish. The ILS begins with the question 'Is it always good for a person or an animal to look beautiful?' and provides background information in the orientation phase to think about this question. Then in the conceptualization phase it introduces the puzzling observation John Endler made regarding guppy fish: namely, male guppies in one part of a stream had many colourful spots on their sides whereas male guppies in another location were relatively dull and showed only a few spots. Students are guided to make hypotheses to explain these observations. In the investigation phase, the Sexual Selection In Guppies (Html5) lab is

provided so that students can make experiments to test their hypotheses. The conclusion phase instructs students to finalize their conclusions based on evidence they collected in the lab. Finally, the discussion phase asks student to look back on their work and reflect on what they would do differently the next time they had to conduct a similar inquiry investigation.

Justification why this is an exemplary ILS

From the checklist, several criteria are met in this ILS. The ILS uses a lab (1), grabs attention by relating the activity to an authentic case study in science (2-3), activates background knowledge in the Orientation phase (7), relates to concepts that are familiar to students (9), adjusts the scratchpad tools to provide predefined terms (13), gives meaningful titles to inquiry phases (17), interleaves words and pictures appropriately throughout the ILS (20-24), includes a reflection phase (27-28) and respects privacy (31).

4.5 Leeromgeving De Meent; Tragedy of the commons

Topic: Students will learn that multiple individuals acting in their own interests, while exploiting a common resource, will inevitably overexploit the resource

Age group: 15-16

Link to the ILS: https://www.golabz.eu/ils/leeromgeving-de-meent

Short description of the content

To make students familiar with the topic, a short introductory video about the subject was developed specifically for this orientation phase. The lab 'Tragedy of the Commons' (from http://virtualbiologylab.org) is used and the students are asked to experiment with the sliders and to try to answer their hypothesis. Due to the high amount of novel information, an extra (recap) phase is added in order to explain the concepts behind the 'Tragedy of the Commons'. This was done in a instruction video in order to give the students the needed theoretical (conceptual) knowledge, without interrupting the inquiry process. In the discussion phase, the goal is to stimulate reflective activities. The students are stimulated to transfer (i.e., apply) their newly acquired knowledge to another social (economical) example of the "Tragedy of the Commons', namely that of overfishing.

Justification why this is an exemplary ILS

Curiosity is raised by means of a short video. Hints are provided on what to do. Questions are added to stimulate discovery with the lab. A list with the definitions of the main concepts is included as a Hint. The students don't have to do a lot of scrolling. The thinking process that is at the basis of the tragedy of the commons is explained in an animated video. At the end students are stimulated to reflect on what they have learned and to think of other contexts in which these ideas could also be of use.

The following criteria from checklist are met in this ILS: 1, 4, 5, 8-10, 12, 13, 15-19, 21-24, 26, 27, 29-31.

4.6 Ευθύγραμμες Κινήσεις; Linear Motions

Topic: Physics

Age group: 15-16

Link to the ILS: https://goo.gl/T4og48

Short description of the content

In the Linear Motions learning environment, students have the opportunity to experience the linear motions of bodies with the help of exploratory components. It successfully combines the conduction of a real experiments using simple materials and the use of a simulation provided by Golabz. This ILS can be used in high school and it includes both an experiential and a virtual workshop.

Justification why this is an exemplary ILS

“Linear motions” is a sequential ILS that is based a lot on challenging questions in order both to attract the attention of the students, but also to uncover their pre-existing knowledge about the examined topic. Investigation is initially approached by experimentation with everyday materials and in a later stage of the activity with a simulation. Participating students are also asked to compare the two methods of research, through the use of an app, getting involved even more actively in the inquiry method followed by the author. However, titles of phases have neem customized to fit the concept of the ILS and multimedia material has been added to make the material even more appealing to the students. Key concepts are exposed through simple problems and questions and students receive detailed guidelines on how to use apps and labs included in the ILS. Last, students are asked in the final phase to reflect their experience again with the use of a Go lab app.

4.7 Από το κύτταρο στους ...εξωγήινους; From the cell to…aliens

Topic: Astronomy, Biology, Environmental Education, Physics

Age group: 9-10, 11-12, 13-14

Link to the ILS: https://goo.gl/6Ah6pc

Short description of the content

This ILS is dealing with the origins of the creation of life on Earth through very simplistic manners. Students are navigated through fundamental scientific issues in a very smart way. Apart from Earth, space will also be explored along with Sun and forces applied. After this activity, students will be able to respond to questions regarding space and the microcosm, too.

Justification why this is an exemplary ILS

“Alien Evolution” is a very extensive ILS following the Inquiry Cycle with meaningful titles instead of just the names of the phases. The author is using many multimedia elements, not only to ease visually the comprehension of key concepts of the examined topic, but even for the guidance of the students to the next phase each time with customized avatars. From the very beginning the author takes advantage of the prior knowledge and experience of the participants through quizzes and challenging questions, which at the same time request the involvement of the students. For the experimentation more than one lab activities are included approaching the same issue from different angels providing students a broad impression of the topic to be taught. Thorough guidelines are offered to the students and apps are used to ease even more students’ work. As for the reflection, the author invests a lot in getting feedback from the participants as there are three phases including different apps to facilitate students to reflect what they have learnt and even to apply and test their newly obtained knowledge through a quick quiz.

4.8 Ευτυχώς υπάρχει και η άνωση; Thankfully, there is buoyancy

Topic: Physics, Forces and Motion, Pressure Weight Tools for Science, Dynamometers Sensors (Tools for Science)

Age group: 13-14, 15-16

Link to the ILS: https://goo.gl/dz42A8

Short description of the content

“Thankfully, there is buoyancy” ILS encourages students to get to know the force applied to all bodies that are submerged in a liquid. The content is counting a lot on the experimentation requesting the active involvement of the students. This ILS can be matched with the ILS Eureka! presented in this document, but it can also be taught independently.

Justification why this is an exemplary ILS

This is a very complete ILS covering a specific topic from various points of view, which follow sequentially the Inquiry cycle, with extensive experimentation. Multimedia is used to attract students’ attention, but the author is mostly using apps to keep the attention of the students, giving the impression of a challenge to be completed. This is also supported by the story-mystery narrated by the author from the very first phase. Prior knowledge of the students is also asked to be applied and key concepts are introduced quite early to help students to get familiarized. Participating students get very clear instructions through all the experiments suggested and especially for the use of the labs and relating apps are also contributing to ease students’ effort. Titles have been customized in order to follow the flow of the mystery and reflection is achieved by the use of apps again which help them to either confirm or not their initially hypotheses set in previous phase.

4.9 Εύρηκα!; Eureka!

Topic: Physics, Forces and Motion, Pressure, Weight, Solids, Liquids and Gases, Density Tools for Science Online Laboratories Sensors (Tools for Science)

Age group: 13-14, 15-16

Link to the ILS: https://goo.gl/YWD1Jf

Short description of the content

In ILS "Eureka!" students will verify the "Archimedes Principle". They will be familiarized with the history behind Archimedes scientific innovation and they will comprehend its significance even up to today. It can be matched with the ILS Thankfully, there is buoyancy presented in this document.

Justification why this is an exemplary ILS

Eureka is a quick and enjoyable ILS for students to understand very basic key concepts of science and to familiarize with science through its history. It is a sequential ILS that follows the Inquiry Cycle, although the names of the phases have been altered in order to fit the concept of the ILS. The author has used multimedia material, such as videos and pictures to make it look more appealing for the students and there are regular questions posed through apps, which help the teacher to understand the comprehension progress of the students. Students get very thorough instructions of how to use the lab in the investigation phase and through the simple problem set they can feel they have achieved what they have been assigned to complete. In the last phase, there is also some extra

content and apps are used in order to make the students apply what they have learned in this ILS.

4.10 Παράγοντες που επηρεάζουν την φωτοσύνθεση; Factors that affect photosynthesis

Topic: Biology, Physics

Age group: 12-13, 14-15, 16-17

Link to the ILS: https://goo.gl/7bdxsZ

Short description of the content

In this ILS students will study the factors on which the photosynthesis process depends. Students will be involved into two experimentations which follow the inquiry cycle. The content is aimed at high school students who have basic knowledge about the phenotype of photosynthesis.

Justification why this is an exemplary ILS

This ILS follows the inquiry cycle sequentially including the core of inquiry two experimentations with lab activities. Moreover, apps are supporting the inquiry by supporting students to set the hypotheses and to test them and to organise most efficiently the design of their experiments. Even form the very beginning, the authors are putting forward questions to attract the attention of students and to explore their existing knowledge. As this ILS is addressed to older students it takes for granted knowledge they have been taught in earlier grades according to the national curriculum and failing to confirm that fact may risk the success of its implementation; thus, the smart choice of the author to pick the questioning tool to avoid that probability. Key concepts are introduced and terms that are vital for the understanding of the topic. Detailed guidelines support the use both of apps, which are customized to the level of the student, and labs providing backing to the participating students. As for the reflection of the knowledge gained, the authors have selected to use one questionnaire and one quiz from the apps provided by Go Lab.

4.11 Astronaut's Job = Cool!

Topic: Physics Forces and Motion, Gravitational force and Gravity, Weight

Age group: 11-12, 13-14

Link to the ILS: https://goo.gl/pKas7q

Short description of the content

Following this ILS, students have the opportunity to have a thorough insight in the training and the preparation of astronauts. They are taught fundamental science in a very enjoyable way and they solve all the misconception they may have regarding spaces and its laws. This ILS can be matched with the ILS A Journey to Space presented in this document.

Justification why this is an exemplary ILS

This is a very unique ILS that draws the attention of the students straight away in a very enjoyable manner, as from the very first phase the approach is very interactive. On the whole the multimedia used is rich in quantity and quality and students' interest is kept alive through the ILS also through questions addresses to them not only checking their

knowledge, but also for examining their understanding. Key concepts are presented as a game and the inquiry suggested through the lab activity helps the students to feel successful leaving them with a sense of security. Very clear guidelines are provided to the students in every phase with apps that ease the process. The language used is very casual and is presented in an attractive way. Last, the author gives the chance to students to test the knowledge they have gained and to apply it through a very interactive activity.

4.12 Elektrische circuits; Electrical Circuits

Topic: In this ILS students learn about electrical energy in relation to electric current and tension, as well as about serial and parallel circuits.

Age group: 11-16

Link to the ILS: https://www.golabz.eu/ils/electrical-circuits and the Dutch one: https://www.golabz.eu/ils/elektrische-circuits

Short description of the content

This lesson is about electrical circuits. In this online lesson you learn what electrical circuits are, how to create them, how to conduct investigations using them, how electrical energy affects electric current and tension, and what the difference is between serial and parallel circuits.

After a short introduction, you will create hypotheses about electric current and tension and you will investigate them. You will then create hypotheses about serial and parallel circuits and investigate them. Finally, you will draw conclusions and think of other research questions.

Justification why this is an exemplary ILS

This ILS introduces all concepts that are relevant to conduct investigations in the lab. Moreover, the concepts are directly connected to the corresponding symbols in the lab. The first assignment was designed to be easy, because the learner recreates an example. The example was created in the same lab, which makes it easier to use. Subsequently, specific instructions are given to manipulate settings as an exploration of the lab. Specific and concrete instructions are given throughout the ILS.

The following criteria are met in this ILS: 1, 4-5, 7, 9-13, 16-27, 31.

4.13 Arraunean; Rowing

Topic: On the example of the rowing students study Fundamental Forces/ Forces and Motion topic of the physics

Age group: 13-16

Link to the ILS: https://www.golabz.eu/ils/arraunean

Short description of the content

Rowing is a very popular sport in Bilbao and great Area, Basque Country. The ILS allows to understand the scientific components behind this famous sport activity. A teacher suggests to evaluate what variables could impact a speed of a racing boat. Students are invited to provide their hypothesis for these variables influences. The Graphing Motion Lab allows exploring the variable influence. With Data Viewer students visually present the results of the experiments performed. During the Conclusion, students compare their

hypothesis with the results of their measurements. At the end, they should describe the most effective training strategy for the racing boat crew in case if they will be a team coach.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1, 4, 7-9, 12, 13, 16, 18-22, 24, 25, 31-32 (no stereotypes). A teacher connects the ILS theme to a context which is already known by and very popular between students. The formulated questions help to rise curiosity, in addition to designing hypothesis. Carefully chosen Apps and provided instruction to the virtual experiment make the research experience exciting. Students use the observation tool reflecting the gaining knowledge and skills. In last phase the ILS author encourages students to play a role of a trainer (element of the game-based learning and leadership), as well as self-explanation and reflection by providing their opinion on the improvement of the training protocol.

4.14 Contaminación ambiental; Environmental pollution

Topic: Planet Earth: with this activity students will discover how environmental pollution works, its accumulation and dispersion

Age group: 13-14, 15-16, above 16

Link to the ILS: https://www.golabz.eu/ils/contaminación-ambiental

Short description of the content

A short movie explains the negative impact of a human on the Earth environment. In the phase of the hypothesis the teacher introduces possible factors that can influence on the pollution. The students should think for both atmospheric and anthropological factors. Investigation with the virtual laboratory “Factors that Affect Air Quality” created by The Concord Consortium, includes following activities: “change, search, touch, increase or decrease ... but above all, observe”. The students analyse their observation, and compare them with the hypothesis and questions created. Finally, on the discussion stage students should provide their opinion on the pollution in Madrid.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1-5, 7, 9, 10,12, 16-19, 25, 29, 31, 32. Teacher provides clear instruction to work that should be performed and, at the same time, encourages student to explore various aspects that influenced on the environmental pollution. The good balance between 2"I"s: inquiry and instruction is settled. With questions the author guides students over the inquiry path. The memory capacity was taken into an account when this ILS was built. The privacy of learners is respected and ensured.

4.15 Arquimedesen printzipioa; Archimedes Principle

Topic: Fundamental Forces: students explore the floating principle of the objects in the liquids

Age group: 13-14, 15-16

Link to the ILS: https://www.golabz.eu/ils/arquimedesen-printzipioa

Short description of the content

In the water our weight “reduces”. Why? In 3rd century BC Archimedes made his first scientific research on this theme. Students build their hypothesis using the previous knowledge. The description of the remote laboratory is provided before the experiment. That allow students to create their experiment with respect to the available parameters.

After performing the research students analyse the results using the Data Viewer and Observation Apps. On the Conclusion stage they compare the hypothesis drafted with the results obtained.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1,3-5, 12,13,18-23, 31-32. The core of the ILS is a remote experiment provided by University of Deusto in a cooperation with LabsLand. The detailed description of the laboratory in connection with possible parameters and variables that could be studied and modified makes this ILS easy for usage by young students. The author actively applies the criteria to keep working capacity not overloaded allowing students to concentrate on the research topic. The privacy of learners is respected and ensured.

4.16 Plano Inklinatua; Inclined Plane

Topic: Fundamental Forces: using the inclined plane, one of the six classical simple machines defined by Renaissance scientists, students will analyse an acceleration that a body has on a water slide

Age group: 15-16

Link to the ILS: https://www.golabz.eu/ils/plano-inklinatua

Short description of the content

The main idea of the ILS is to study mechanics of motion such as an acceleration that a body has during the high speed drop on a water slide. The ILS consists of 4 phases: Orientation (What will we do?), Conceptualisation (Basics), Investigation (Laboratory work), and Conclusion. On the first stage the attention of students are getting picked up with a video shot in the Kansas City water attraction. Based on the previous knowledge and information provided, students should create their own hypothesis that they will check on the 3rd stage - Investigation. The remote laboratory of the Universidad Federal de Santa Catalina, Brazil, uses for the performance of the experiment. Students are asking to compare the results achieved with their hypothesis formulated.

Justification why this is an exemplary ILS

The following criteria from checklist are met in this ILS: 1,3,4, 7-9, 16,18, 20, 22, 31, 32. The remote laboratory activity is applied. The nontrivial question is posing what is stimulate the curiosity. The visual tools such as short video, image are used. Activation of prior knowledge is employed. The privacy of learners is respected and ensured.

4.17 Viajando num raio de luz à descoberta das reações fotoquímicas; Travelling in a light ray to unveil the photochemical reactions

Topic: Students will work with concepts of energy, electromagnetic radiation, photochemical reactions, greenhouse effect, stratospheric ozone, photosynthesis, autotrophic organisms, photosynthetic pigments

Age group: 15-18

Link to the ILS:

https://www.golabz.eu/ils/viajando-num-raio-de-luz-à-descoberta-das-reações-fotoquímicas

Short description of the content

Students will encounter the following situations: what happens when electromagnetic radiation interacts with particles? All living organisms need energy to live – heterotrophs get their energy feeding themselves of other living organisms, but where do autotrophs get their energy from?

This is an interdisciplinary ILS co-created by two Physics-Chemistry teachers and one Biology/Geology teacher. The contents of the ILS covers several units of the Chemistry and Biology Portuguese curriculum of the 10th grade and is conceived to be used during spaced moments of the school year, both in Physics-Chemistry classes and Biology/Geology classes. The ILS begins with revisions and curiosities about electromagnetic radiation, photochemical reactions and photosynthesis. It follows with an experimental activity which is based on the online lab “Importance of Light in Photosynthesis”. Next they study the formation and destruction of ozone and use the online lab “Molecules and Light” to explore the greenhouse effect. The next part of the ILS includes going to real laboratories and execute three activities about photochemical reactions, the importance of light in the growth of plants and extraction and separation of photosynthetic pigments. These activities are mandatory experiments of the curriculum. To conclude, there is a quiz and a presentation to the class, with discussion. The ILS includes a “Go further” section with related topics they can pursue.

Justification why this is an exemplary ILS

The interdisciplinarity of this ILS is exemplary on how to explore topics through different subjects within the curriculum, making students understand how different fields of study are interconnected. It grabs the attention with interesting short videos about light, each one related with a different subject: physics, chemistry and biology. Previous knowledge is activated through video, questions and an interactive animated quiz. There are several investigations throughout the ILS, using not only online labs, but also real laboratory experiments, showing how both can be included in an ILS. Student understanding is checked regularly with the teacher feedback app. In the end, there are challenging topics students can proceed to explore and a short reflection on how they perceived the activity.

The following criteria are met in this ILS : 1-7, 9-15, 17-18, 22-24, 27-32

4.18 Propriétés thermiques de la Terre et géothermie; Thermal properties of the Earth and geothermal

Topic: Geology earth internal heat geothermal activity and applications

Age group: 15-16+

Link to the ILS: https://www.golabz.eu/ils/propri%C3%A9t%C3%A9s-thermiques-de-la-terre-et-g%C3%A9othermie

Short description of the content

This ILS is built to be used in a flipped classroom strategy. Students discover the thermal activity of the earth, its properties and the distribution and use that can be made of the surface heat. In the first investigation students will draw tomographic sections of the earth

crust to find favourable locations. In the second investigation they have to derive from documents the heat performances of various regions to determine the different types of geothermal activities and their properties.

Justification why this is an exemplary ILS

Three properties of this ILS lead us to promote it: It is built around two investigation processes on the same topic , detailed information are provides to help the teachers integrate it in their courses and there is a tool to get feedback from the students.

Two types of investigation are proposed on geothermal activity to stimulate different student's skills. The first deals with the geological principles behind the production of surface heat by the earth, it is based on the use of a lab to understand how internal activity of the earth induces an uneven repartition of the heat flux. The second tackles the uses of various forms of geothermal energy with their economic implications, the investigation is based upon document analysis.

The topic is listed in the French instructions to teachers and the ILS provides information to teachers on how to insert the ILS in their courses with information on the official texts and comments on how the activity fits into the recommended framework, which skills and knowledge are taught. There are also some comments on the pedagogy that can be used with a proposal of flipped classroom.

The ILS is built with a self-evaluation tool for the student to enable him check if he has spent the time foreseen by the teacher in each phase or if he is ahead or behind schedule.

The following criteria are met in this ILS: 1-4, 7, 9, 11-12, 14-19, 22, 23-24, 26, 28-30.

4.19 Globulozobot; Globulozobot

Topic: Biology and robotics, programing an Ozobot micro-robot to simulate the path of a red blood cell in the blood system

Age group: 9-10 11-14

Link to the ILS: https://www.golabz.eu/ils/globulozobot

Short description of the content

With his interdisciplinary ILS students will have an introduction to robotics and learn a simplified description of the blood system by programming an Ozobot robot that simulates the path of a red blood cell. In the first step the student explores a schematic view of the blood system, then he draws a sketch of the system using lines and signals that the Ozobot can understand and finally writes the program to drive the robot.

Justification why this is an exemplary ILS

This ILS is an interdisciplinary bridge between biology and robotics, the student has to activate prior knowledge on human blood system and derive a model that will enable a small robot to display what happens to a blood cell in the circuit, then use the model to build the code and finally check if the result describes the reality.

The major interest is to link the coding work to other knowledge and make it more attractive than drawing a curve or moving a sprite.

This ILS also provides a rich “about” section that describes how to use and program the Ozobot in this case which is of great help for newbies teachers.

The following criteria are met in this ILS : 1, 3-4, 6-9, 11, 14-15, 18-24, 26, 29.

4.20 Dihybridisme en terminale S; Dihybridism in final year

Topic: Biology Genetics using drosophila to investigate the transmission of two characters across generations

Age group: 15-16+

Link to the ILS: https://www.golabz.eu/ils/dihybridisme-en-terminale-s

Short description of the content

The *Drosophila melanogaster* fly is used as biological material to highlight the shuffling of alleles during meiosis. This ILS is built to use live flies which implies that such material is maintained in the institution.

In the first stage students perform a transplanting of a pure strain and take a photo of the “sorted” flies and "alive" flies in their culture tube, then count the offspring of two different testcross crosses and deduce the location of the gene loci whose mutated alleles studied. Counts made on two resin fly plates are reported in the ILS table from the "experimentation" stage. A shared table between groups is constructed in the “conclusion” stage.

The rest of the work is done using the virtual lab to simulate a large number of generations. Results are saved in the virtual laboratory, then dropped in the space "experimentation and results". The conclusion is drawn by the whole group in the etherpad or the wiki according to the version of the ILS made available.

Prior Knowledge Requirements

meiosis, intra-chromosomal mixing, interchromosomal mixing, chromosomes, locus, gene, allele.

Justification why this is an exemplary ILS

This ILS provides an exemplary follow-up of the student’s activity using :

- The student dashboard
- An additional phase to realize homework
- multiple learning analytics tools in the teacher’s dashboard

The ILS starts with a detailed description of the investigation sequence and the various tasks the student will have to do. To fulfil these tasks the student can find in his(her) dashboard various tools and documents to help him (her) including collaborative spaces. One part of the work must be made on real biological material in the class another part can be made in any connected place including home.

The teacher’s dashboard contains learning analytics applications to assess results and behaviour of the student.

This ILS demonstrates the efficiency of the Golab ecosystem for ubiquitous learning with strong support of learner’s activity and the power of learning analytics.

The following criteria are met in this ILS: 1 (real life lab), 3-7, 9, 11-12, 14-17, 20-23, 24, 26-31.

4.21 Visibilité des planètes_Master; Planets visibility_Master

Topic: Astronomy and Pedagogy visibility of the solar system planets from a given place on earth and differentiation strategy to teach to heterogenous public

Age group: 8-16+

Link to the ILS (French English) : http://graasp.eu/spaces/5ad0b8d2cda0f4cd57177282 http://graasp.eu/spaces/5adb63a14514a2fe9ae44e12

Short description of the content

This ILS is built to demonstrate differentiation capabilities of GoLab ecosystem. It enables to derive some ILSs for students with different age/skills/knowledge by choosing among the resources those that are exposed or hidden according to the target group to produce ILSs adapted to their age/skills/knowledge while learning the same scientific concept.

This ILS helps to understand why planets are visible at night at certain times and not at others. Moreover, with the help of the Planets laboratory, it allows to determine the periods of visibility of the 7 planets (Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune), and the characteristic positions such as conjunctions or oppositions. This ILS makes it also possible to differentiate learning by studying only one or few planets. It is also possible to only use the Lab (easy) or investigate the confrontation of the Lab and the ephemerides (hard).

Justification why this is an exemplary ILS

This ILs illustrates a way to set up differentiation in a class with students having various skill levels. It is considered as a “master ILS” that is used to produce 3 “differentiated ILS” displaying 3 different levels of difficulty by hiding or showing resources, exercises, hints or questions. In each phase 3 (or more) documents or videos or images are available for each resource; the teacher clones the master then chooses which resources are displayed for each level. The class is divided into groups and each group can enjoy an ILS adapted to its skills and knowledge.

A second advantage of this ILS is to enable the teacher add exercises or questions if a group finishes their assignments earlier than foreseen just by clicking to display any hidden resource.

The following criteria are met in this ILS: 1, 3-7, 11-14, 16-24, 26, 28-30.

4.22 Raconte-moi le ciel étoilé; Tell me the starry sky

Topic: Astronomy discovering celestial bodies

Age group: 12-16+

Link to the ILS: http://graasp.eu/ils/5b87b99102e852fe991ffb44/?lang=fr

Short description of the content

This ILS starts with students' representations of what they can observe in the starry sky. They must then explore documentary resources to refine their knowledge. Using the Lab / Stellarium software they must then prepare an observation on a chosen date and describe at least one type of object they can observe (position, type, distance, visual and absolute magnitude ...).

This ILS can both serve as a first introduction to understand the diversity of objects in the sky and a first use of the software / Lab Stellarium.

Justification why this is an exemplary ILS

This ILS based on astronomical observation is constructed to accompany the construction and implementation of a scientific method to conduct a valid observation of the sky. It relies on the Stellarium lab. A sequence of quiz helps the student to identify the parameters necessary to make a valid observation, position of the observer, list planets and other visible celestial objects, identify valuable targets.

The following criteria are met in this ILS: 1-3, 5, 7-9, 11-15, 17-19, 22, 24, 26-29.

4.23 Les conditions de germination des graines (DIPHTERIC); Seed germination conditions

Topic: Plant biology germination pedagogy DIPHTERIC strategy

Age group: 7-8 9-13

Link to the ILS: https://www.golabz.eu/ils/les-conditions-de-germination-des-graines-diphteric

Short description of the content

The scenario of the ILS is to build a class project to make a vegetable garden in a college space. Each student in the class offers ideas for planting. To help them choose the seeds to sow and to have time to harvest, documents are proposed on the periods of sowing and harvesting for some vegetables.

Students discover the needs of a plant at the time of germination.

Skills worked: introduction to the experimental approach to the French oheric-diphteric for students in difficulty…….

Justification why this is an exemplary ILS

This ILS is built using one of the pedagogical strategies recommended for inquiry based learning in France called DIPHTERIC which relies on the succession of phases:

- Initial Data
- Problem
- Hypothesis
- Test
- Results
- Interpretation
- Conclusion

Inquiry phase is performed in the test phase and in the conclusion a collaborative sequence is added using a wiki. This ILS demonstrates how to introduce DIPHTERIC method in the Go-Lab ecosystem.

The following criteria are met in this ILS : 2-9, 11-14, 16-18, 22-27, 29-30.

4.24 Datation d'une roche au rubidium strontium; Rock dating with rubidium strontium method

Topic: earth sciences geochemistry physics rock dating

Age group: 15-16+

Link to the ILS: https://www.golabz.eu/ils/datation-d-une-roche-au-rubidium-strontium

Short description of the content

This ILS is built to be used in a flipped classroom sequence, it enables to investigate the method used to date the continental crust available data and theory is exposed in a first phase. In a second phase measured data on a rock are used to calculate its age. This ILS tackles skills in geophysics and the use of spreadsheets for computations.

Justification why this is an exemplary ILS

Flipped classroom strategy is more and more popular to have students more involved, the purpose of this ILS is to check the feasibility of flipped classroom strategy with an ILS. This successful ILS is meant to be played outside the class before a course on rock dating. One of the interests is to collect traces of activity through student contributions and learning analytics to assess student and evaluate the status of the class to deliver a better course adapted to the student's needs.

The following criteria are met in this ILS : 3-4, 6-7, 9, 11-15, 16-17, 20-22, 26-30.

4.25 Enrichissement de l'atmosphère en O2; Enrichment of the atmosphere in O2

Topic: earth sciences, history of the earth geochemistry

Age group: 15-16+

Link to the ILS: https://www.golabz.eu/ils/enrichissement-de-l-atmosphère-en-o2

Short description of the content

Secondary school final year, specialty climate. The goal of this ILS is to discover how the Earth has acquired a rich atmosphere in O2. The experimentation is made in the chemistry lab without digital lab to produce real iron oxides identical to those visible in banded iron rocks.

Skills worked, experimental approach type benchtop

Justification why this is an exemplary ILS

This ILS combines laboratory work with the use of digital tools to enhance learning. The ILS path facilitates the setting up of the inquiry by providing selected documents and guiding the student with appropriate quizzes. The applications provide efficient tools to collect results and write conclusions. It is an example of the use of GoLab ecosystem with real life experiments during investigation phase.

The following criteria are met in this ILS: 2-7, 9, 11-12, 14, 17, 21-22, 24-30.

4.26 Les conditions nécessaires à la nutrition des végétaux verts; The conditions necessary for the nutrition of green plants

Topic: discover the needs of a plant as it grows in relation to meteorological parameters

Age group: 9-11

Link to the ILS: http://graasp.eu/ils/5b8fb5f361326fb1d3eb81fd/?lang=fr

Short description of the content

The flowering plants produce seeds during their reproduction. A seed consists of a seedling, nutrient stores and protective wraps. When germinated, it will give birth to a young plant and then an adult plant that will form flowers again. Lena and her dad decide to make a vegetable garden this year in their garden. At the beginning of April, they sow seeds of beans as well as carrots. Sometime later, Lena returns to the kitchen garden with her dad and she is surprised to notice that the carrot seeds evolve into young plants which is not the case of the beans which did not germinate. Lena's dad sows new bean seeds in May, this time the seeds germinate and give seedlings of beans.

Lena wonders why the bean seeds did not germinate the first time but only the second…

The ILS explores the growth of plants with Lena making observations, hypothesis and experiments to understand what happened in her garden.

Competencies tackled: introduction to investigation with the experimental approach of the French oheric-diphteric scenario.

Justification why this is an exemplary ILS

This ILS is built using one of the pedagogical strategies recommended for inquiry based learning in France called OHERIC which relies on the succession of phases:

- Observation
- Hypothesis
- Experimentation
- Results
- Interpretation
- Conclusion

Inquiry phase is performed in the Experimentation phase and in the conclusion a collaborative sequence is added using a wiki. This ILS demonstrates how to introduce OHERIC method in the Go-Lab ecosystem.

The following criteria are met in this ILS: 2-8, 9-14, 17-18, 20-26, 28-30.

4.27 Dérive génétique; Genetic drift

Topic: Biology, genetics, genetic drift

Age group: 15-16+

Link to the ILS: http://graasp.eu/ils/5b2e0d2a02e852fe99c5381b/?lang=fr

Short description of the content

The evolution of populations is partly dependent on a phenomenon known as genetic drift. The objective of this ILS is to present an illustration of this drift in a mastered context with a limited number of variables. It uses an online laboratory proposed by M. Cosentino, the experiment is limited to 100 beads that can take 5 different colours representing alleles of the same gene.

Justification why this is an exemplary ILS

This ILS demonstrates the integration of external labs in an ILS on the example of genetic drift study. It provides also a rich report tool prepared to collect experimental results in various forms: tables, figures, observations and comments.

The following criteria are met in this ILS: 1, 3-9, 11-12, 14, 16-17, 19-22, 24, 26-30.

As mentioned before the work on developing exemplary ILSs will be continued after the delivery of this deliverable. All ILSs will be published on golabz.eu.

References

American Psychological Association, Coalition for Psychology in Schools and Education. (2015). *Top 20 principles from psychology for preK-12 teaching and learning.* Retrieved from: http://www.apa.org/ed/schools/cpse/top-twenty-principles.pdf

Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. NJ: John Wiley & Sons.

Gagné, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of Instructional design* (4th ed.). Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.

Hattie, J. A. C., & Donoghue, G. M. (2016). Learning strategies: A synthesis and conceptual model. *Npj Science of Learning, 1*, 16013.

Keller, J. M. (1987). The systematic process of motivational design. *Performance + Instruction*, *26*(9-10), 1-8.

Keller, J. M. (2008). First principles of motivation to learn and e3-learning. *Distance Education, 29*(2), 175-185.

Kerkhoven, A. H., Russo, P., Land-Zandstra, A. M., Saxena, A., & Rodenburg, F. J. (2016). Gender stereotypes in science education resources: A visual content analysis. *PloS one*, *11*(11), e0165037.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning: The case for guided methods of instruction. *American Psychologist, 59*, 14-19.

Miettinen, R. (2010) The concept of experiential learning and John Dewey's theory of reflective thought and action. *International Journal of Lifelong Education*, *19*, 54-72.

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., ... & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47-61.

Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychological Bulletin, 143*, 565-600.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction*, *4*, 295-312.