Next-Lab

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

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Executive Summary

Labs, apps, and a manual for primary education are described in this Next-Lab deliverable, which is a follow-up of deliverable 3.2: First releases of labs and apps (Van der Graaf & De Jong, 2017). The labs and apps have been selected and/or adapted to match the curriculum of primary education and students' needs and talents in inquiry learning. A manual has been written to provide tips and tricks for primary school teachers.

Go-Lab offers a wide range of labs, apps, and learning spaces that use inquiry-based learning. Inquiry-based learning is becoming more popular in education (European Commission, 2007), as it stimulates acquisition of both scientific knowledge and skills. Primary education is no exception to this trend and therefore, one of the aims of Next-Lab is to offer inquiry-based learning materials (labs, apps, and Inquiry learning Spaces: ILSs) for primary education. This deliverable describes the lab collection in the Go-Lab sharing platform1 with a specific focus on labs for primary education and the adaptation of apps for primary education.

First, an overview is given of which labs have been added (and removed) from the Go-Lab sharing platform1 and the resulting current collection of labs and then more specifically labs that are suited for primary education and their relation to the curriculum of primary education in Europe are presented. In this context, we also set up collaboration with lab developers, which has resulted in several new labs for primary education.

Second, apps will be discussed that have been adapted to primary education. This resulted in new versions of the Hypothesis Scratchpad and Experiment Design Tool that offer additional support compared to the old version. One new app has been created to support identifying and using of variables in the lab, the so-called Name the Frame app. Two other apps have also been adapted, the Calculator and the Viewer. We also collected feedback on additional apps: the Data Viewer, Conclusion Tool, and Observation Tool, which can be used in the future for adaptations of the apps and they were also used to write general guidelines for primary education.

In addition, tips were created for teachers of primary education, who create inquiry learning spaces. During the project, we have discussed Go-Lab with teachers and we noticed that teachers wanted additional support. We received requests to add features in Go-Lab that were already in place. In addition, we identified common problems teachers experienced. In order to address these requests and problems, tips were written. The aim of the tips was to provide suggestions on how to use Go-Lab in primary education. Three levels were identified: tips for beginners, tips for advanced users, and technical tips.

Finally, the standard on which the apps and labs are based was updated. The new application programming interface (API) enables any interactive Web content to be used in Graasp.

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[1] https://www.golabz.eu/

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Introduction

Go-Lab offers a large set of online laboratories (575 labs) and a range of applications that support inquiry learning (40 apps). Most of these materials focus on secondary education, but a fair share has been designed with primary education2 in mind. In the Next-Lab project, we started to extend the set of available labs for primary education and adapt apps so that they would better suit primary education. This started with deliverable 3.2 (Van der Graaf & De Jong, 2017) in December 2017, and continued during the project. The present deliverable provides an overview of the materials for primary education that have been added to the Go-Lab sharing platform.

At the time of deliverable 3.2 (1st December 2017) 524 labs were available of which 183 were suited for primary education. This number has grown since to 575 labs (1st of December 2018). Nine of the newly added labs were selected because of their suitability for primary education, and two labs have been redesigned by lab developers (PhET) in collaboration with the Next-Lab team to make them fit for the European curriculum.

Concerning the apps, six have been unpublished and replaced by new apps. An example is the Concept Mapper, which is a new app, and it replaces Concept Cloud and Semantic Group Formation App. A short overview of apps will be provided, but this deliverable focuses on apps for primary education. New versions (for primary education) of the Hypothesis Scratchpad (HS) and Experiment Design Tool (EDT) have been created. We also created a basic version of the Calculator. The functionality of the Viewer has been extended to allow more apps to be viewed in the Viewer. One new app has been created, which is called the Name the Frame app (NTF). To identify suggestions for additional apps, the Conclusion Tool (CT), Data Viewer (DV), and Observation Tool (OT) have been evaluated. It appeared that there were some common issues primary school teachers experienced when creating Inquiry Learning Spaces (ILSs). Three tips pages were written to address common issues, one page for beginners, one for advanced users, and one page with technical tips.

In this deliverable, first, an overview of labs will be given. Some labs will be highlighted because of their relevance for primary education. Next, apps will be discussed: a new app, adapted apps, two apps with slight adaptations, and suggestions for adaptations on three other apps. Finally, the tips for primary school teachers will be described.

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[2] The age of students in primary education ranges from 6 to 12 years old in most European countries, see Deliverable 1.2 (Tasiopoulou, Jimenez, & Chiotellis, 2017).

2 New labs

First, we have searched for and found labs that were of added value to the Go-Lab sharing platform. Second, we have created new labs that match the needs of primary education in Europe. Third, we have adapted existing labs in such a way that they better fit with what primary school students are capable of and that they better fit the European curriculum. In this process, we have worked together with lab developers. Two collaborations have been set up; with PhET and Amrita. The collaborations will be explained in more detail in the next sections. When it comes to adding, creating, and/or adapting labs, topics have been identified in deliverable 3.2. The topics are part of the European primary school curriculum, but not yet available on Go-Lab. These topics guide the process and all labs discussed below add a new topic to Go-Lab or deal with an existing topic but in a new way that is more suitable for primary education.

2.1 The Go-Lab lab collection

As the project carries on, the work on adding new labs is going on as well. As of 1st of December 2018 the number of labs on the Go-Lab ecosystem was 575. Eighty-four labs have been added since the 1st of December 2017. The number of currently available labs is 127 more than at the start of the Next-Lab project (448). Thirty-three labs were unpublished, because the lab developer removed them or the labs did not work anymore.

The work on adding labs is still built round three directions: finding new sources of labs, adding new labs from existing sources, and assisting lab owners to add labs themselves.

Achieved during this year in all three directions:

1) Some new contributors have been contacted. For example, seven newly added labs were created by a group of Indian developers (Learning Sciences Research Group) from Tata Institute of Fundamental Research[3], who gave permission to add their labs to Go-Lab.

2) New and/or updated labs from existing contributors have been added. Biology labs from Virtual labs (Thomas C. Jones) are examples where owners update their labs to make them more attractive technically and visually. We are keeping both versions so teachers can choose themselves. An example is the Fishbowl Population Genetics lab (former version[4]; updated version[5]), see Figure 1. More than fifteen labs have been added from the PhET collection[6].

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[3] https://www.golabz.eu/user/799
[4] https://www.golabz.eu/lab/fishbowl-population-genetics
[5] https://www.golabz.eu/lab/fishbowl-population-genetics-new
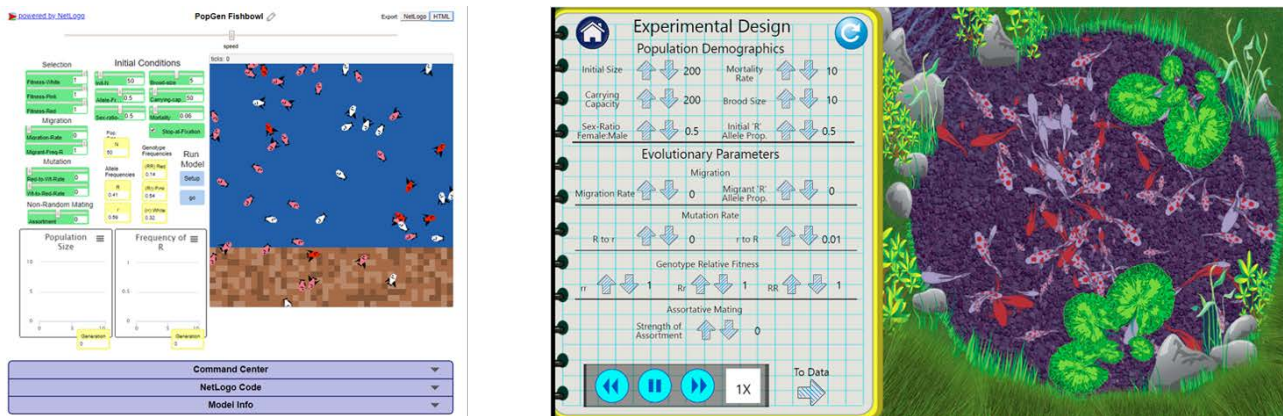[6] https://phet.colorado.edu/

Figure 1. The former (left) and updated (right) version of the Fishbowl Population Genetics lab.

3) Several lab owners added their labs to Go-Lab. The biggest example is Ming-Hua Chang from Taiwan with more than 30 labs both in Chinese and English[7]. This is especially remarkable as Taiwan is outside the original scope of the project and has no Ambassador working in the country. Having many labs in Chinese makes the project more accessible for this language group. The labs cover a broad spectrum of topics with a straightforward and simple design for investigation, which makes them suitable for younger students.

Current work:

Two new big sources of labs have been found and the owners have granted their permission to add the labs. This work is in progress.

1) ChemCollective[8] presents workbench settings which allows its users to conduct chemistry experiments in various topics. Several labs have been added.

2) Vladimir Vascak's labs[9] cover a big number of different topics in physics. Due to their simplicity in manipulating and focusing on only one research question, they can be used by younger students as well. Several labs have been added.

Further plans:

The work on adding labs will be continued throughout the whole project period, following the same approach.

There is also a new approach to make existing labs available to a bigger and more varied audience through translation of the labs. We are working on getting big lab contributors to make their labs compatible with the app translator. This means that the labs can be translated via the app translator. Next-Lab team members translate the lab to the languages that are supported by the project. One of the first trials involves labs from Frank McCulley[10]. The agreement for cooperation has been received. Technical preparations are in progress.

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[7] https://www.golabz.eu/user/1806
[8] https://www.golabz.eu/user/1175
[9] https://www.golabz.eu/user/178
[10] https://www.golabz.eu/user/156

2.1.1 Labs for primary education

Of the newly added labs approximately 25 match the age range of primary education. Twelve of these labs for primary education were specifically selected by the Next-Lab team, see Table 1. The labs were selected, because they deal with a primary education topic, that was new on Go-Lab, such as learning about three-dimensional objects, because they are more suitable for primary education students, such as the Circuit Construction Kit: DC lab, or because they deal with a topic in a new way, such as the strategy to solve multiplication problems in the Area Model labs.

Table 1.

An overview of the labs, lab developer, and topics of newly added labs that deal with primary education topics.

Lab	Lab developer	Topic
1. Building With Blocks	Freudenthal Institute	Mathematics - three-dimensional objects
2. Triangle - Numbers Game	Freudenthal Institute	Mathematics - addition
3. Zlizer	Freudenthal Institute	Mathematics - subtraction
4. Area Model Multiplication	PhET Interactive Simulations	Mathematics - multiplication of numbers
5. Area Model Decimals	PhET Interactive Simulations	Mathematics - multiplication of numbers with decimals
6. Area Model Algebra	PhET Interactive Simulations	Mathematics - multiplication of algebraic expressions
7. Circuit Construction Kit: DC	PhET Interactive Simulations	Physics - construct a simple series electrical circuit
8. Bell Jar Experiment	Amrita Olabs	Physics - identify how sounds are made and recognise that vibrations from sounds travel
9. Field Lines Around A Bar Magnet	Amrita Olabs	Physics - Learn the basics about magnetic forces

10. Eye Defects	Vladimir Vascak	Physics - recognise that light appears to travel in straight lines
11. Boiling Point - Atmospheric Pressure	Vladimir Vascak	Physics - about molecules and how they affect different objects' characteristics and study and experiment with daily materials
12. Boiling Point - Altitude	Vladimir Vascak	As 11

Regarding mathematics labs, some topics that are part of primary education curriculum were not yet represented in the Go-Lab sharing platform. Three labs from the Freudenthal Institute (Utrecht University) were added to fill part of the gap. They deal with new topics, namely three dimensional shapes (Building With Blocks lab, see Figure 2), addition of numbers (Triangle - Numbers Game lab), and subtraction (Zlizer lab). For addition and subtraction these new labs have the advantage of solely focusing on addition or subtraction, compared to labs that were already available and offer different mathematical operations simultaneously, such as the Unit Rates lab.
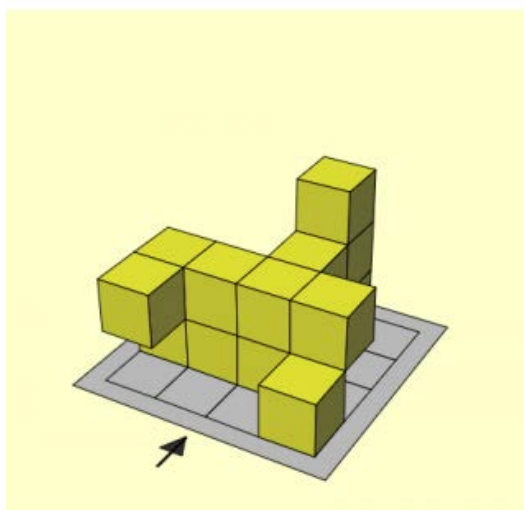

Figure 2. Screenshot of the Building With Blocks lab.

Other mathematics labs that have been added were created by PhET and they use area models to learn new strategies for multiplication (Area Model Multiplication lab, Area Model Decimals lab, and Area Model Algebra lab). These labs offer squares that can be manipulated to discover how multiplication of two numbers results in the product, see Figure 3. This way, extra guidance (in the form of the square) is offered to help children discover how to multiply numbers. Guidance makes the lab more suitable for primary education.
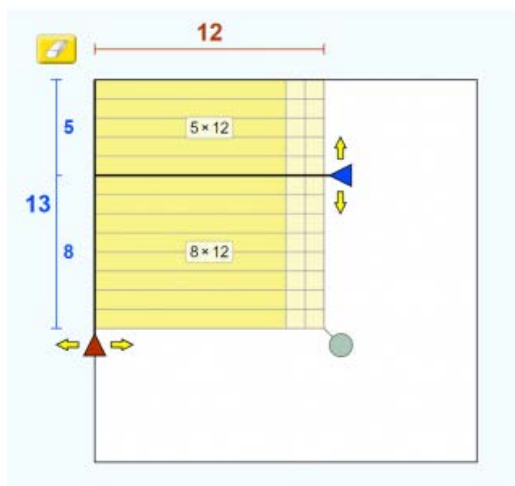
Figure 3. A screenshot of the Area Model Multiplication lab.

One important source of new labs was and still is Amrita OLabs11. The collaboration with Amrita helps us to add labs. In addition, learning materials by Amrita were used to co-create an ILS. Amrita has developed multiple labs and lessons around these labs. Some of these are suitable for primary education. Those labs have been added to Go-Lab over the course of 2017 and 2018. New labs that have been added in 2018 that deal with primary education topics are The Bell Jar Experiment lab, see Figure 4, and the Field Lines Around A Bar Magnet lab. The bell jar experiment shows that without any air sounds cannot be heard and therefore helps students to learn how sounds are made and recognise that vibrations from sound travel. The lab with field lines around a bar magnet allows students to learn the basics about magnetic forces, which is a new topic on Go-Lab.

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[11] http://www.olabs.edu.in

Figure 4. A screenshot of the Bell Jar Experiment lab.

Another new series of labs on the Go-Lab sharing platform, created by Vascak, deal with various topics in primary education. Two of them will be highlighted, because they deal with an existing topic in a new way. One of them is the Boiling Point-Atmospheric Pressure lab, which adds to Go-Lab that students can manipulate atmospheric pressure and altitude to study their effect on the boiling point of water. In other labs it is not possible to manipulate factors that affect the boiling point. Therefore, this lab helps to fill part of the gap of topics that are part of the primary school curriculum, but were not yet part of Go-Lab, see Figure 5.

The other lab is called Eye Defects. Students can change the distance of a lens to the eye and see when the eye defect, such as myopia, can be fixed by the lens. It is not a new topic, but it is an intuitive visualization, which makes the lab attractive and the topic easier to comprehend.
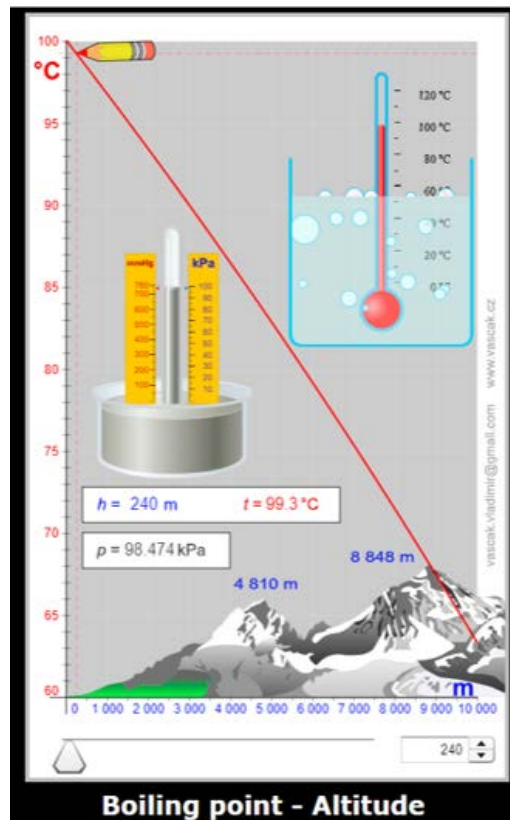
Figure 5. Screenshot of the Boiling Point-Atmospheric Pressure lab in which the relation between altitude and the boiling point of water can be examined.

2.2 Newly created labs

After creating two new labs in the previous deliverable (the Seesaw lab and the Gravity Drop lab in deliverable 3.2 (Van der Graaf & De Jong, 2017), two Next-Lab partners have created two new labs, the Water Cycle Lab and the Plastic Degradation lab, see Table 2.

Table 2.

An overview of the labs, lab developer, and topics of newly created labs that deal with primary education topics.

Lab	Lab developer	Topic
1. Water Cycle Lab	Leo Siiman	Physics - about evaporation and condensation in the water cycle, and association of the rate of evaporation with temperature
2. Plastic Degradation	Anjo Anjewierden	Physics - identify and compare the suitability of everyday materials, including wood, metal, plastic, glass, brick, rock, paper

		and cardboard for particular uses

The water cycle is part of primary education curriculum and was not yet dealt with on Go-Lab. Therefore, a suitable lab was created. In the lab cloudiness can be manipulated and it simulates the effect of sunlight on the water cycle, see Figure 6. Each step in the water cycle is animated: evaporation, condensation, precipitation, and infiltration.

The Plastic Degradation lab lets a student determine and compare the amount of degradation of two types of plastic: degradable PLA (polylactic acid) and non-degradable plastics like PET (polyethylene terephthalate) and PE (polyethylene).   Students can vary the environmental conditions (type of plastic, temperature, humidity) and determine the time needed to degrade bottles of various plastics underground, and see the amount of degradation over time.
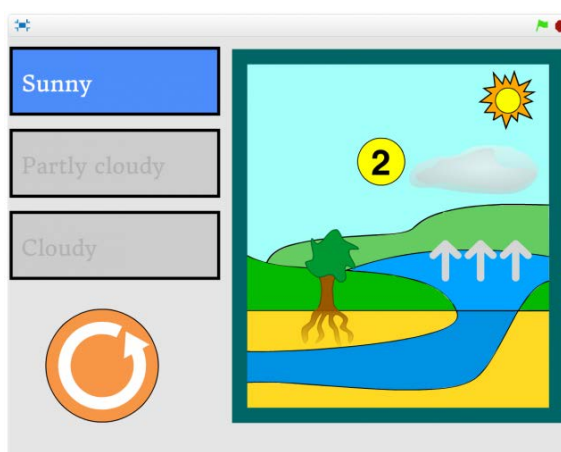
Figure 6. A screenshot of the Water Cycle Lab.

2.3 Adapted labs

Three existing labs were adapted to improve their usability for primary school students, see Table 3. We have set up a collaboration with PhET labs and one of the Next-Lab partners adapted an existing lab and also created a collaborative version of it. PhET was redesigning a number of labs and we have arranged that we could provide input to make the labs better suit primary education. To do this, we have identified labs that revolve around topics in primary education.

Table 3.

An overview of the labs, lab developer, and topics of adapted labs that deal with primary education topics.

Lab	Lab developer	Topic
1. Energy Forms And Changes	PhET Interactive Simulations	Physics - about basic types of energy, and how energy is never lost and how it changes forms and it is stored
2. Masses And Springs	PhET Interactive Simulations	Physics - basic mechanics and results of simple experiments with levers, pulleys, springs, and elastic materials, and to recognise motion
3a. Rate Of Photosynthesis Lab (HTML5)	Leo Siiman	Physics - to observe and describe how seeds and bulbs grow into mature plants and describe how plants need water, light and a suitable temperature to grow and stay healthy, and to explore the requirements of plants for life and growth (air, light, water, nutrients from soil, and room to grow) and how they vary from plant to plant
3b. Collaborative Rate Of Photosynthesis Lab	Leo Siiman	A collaborative version of the Rate Of Photosynthesis Lab

Energy Forms And Changes is a lab that was adapted. Its old version was in Java and therefore not suitable for Go-Lab. The new version is in HTML5 and it has been adapted. In the lab it is possible to investigate how energy in the form of heat (thermal energy) affects the temperature of water and a brick, and how different types of energy can be changed into other types, such as kinetic to electrical energy. When heating water, the moment it starts to evaporate can be seen. In cooperation with the Next-Lab team, the PhET developers have included an additional type of liquids type, namely olive oil see Figure 7. This way students can learn that different types of liquids start to evaporate at different temperatures, which is a topic in primary education curriculum that was not yet covered on Go-Lab. In addition, a new type of output has been added to the Energy Forms And Changes lab, namely kinetic output, see Figure 8.
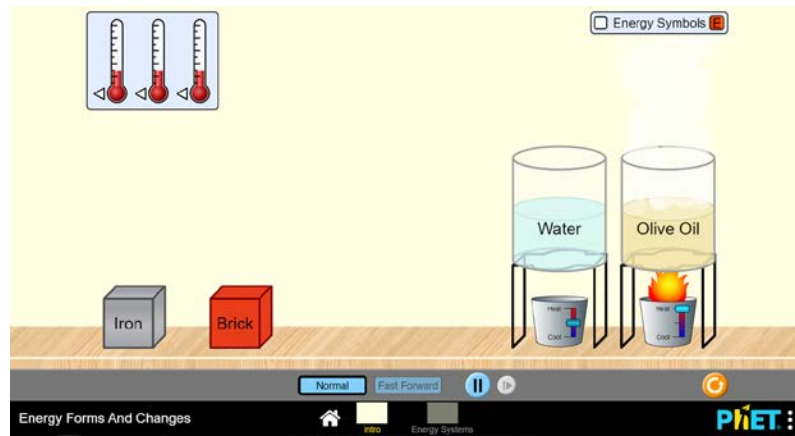
Figure 7. A screenshot of the Energy Forms And Changes lab in which olive oil is being heated.

Figure 8. A screenshot of the Energy Forms And Changes lab in which thermal energy (heat under the teapot) is transformed into mechanical energy (rotating fan).
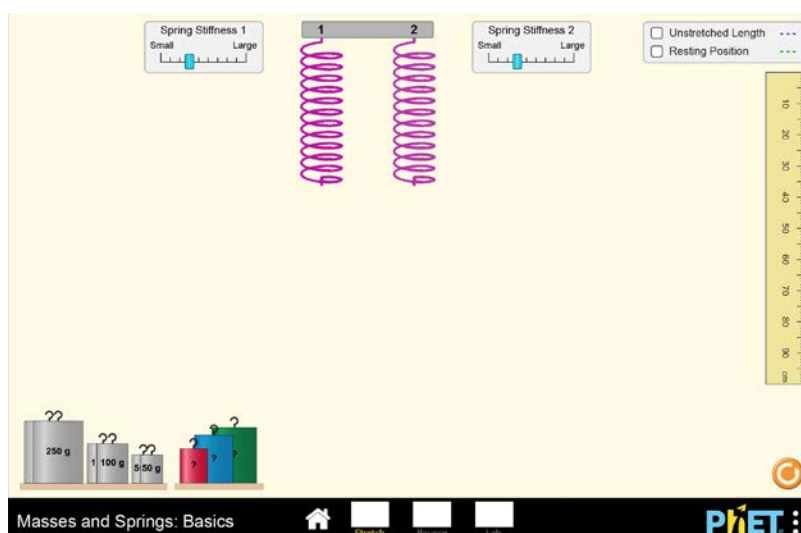
Figure 9. A screenshot of the Masses And Springs: Basics lab in which two springs can be manipulated and their stretch can be studied.

We are currently collaborating on a basic version of the Springs And Masses lab. Although this topic has been addressed in labs on Go-Lab, it seems that the interface could be made more intuitive and that a basic variable could be added, namely the manipulation of spring length. A new version of the lab is being developed in which students can investigate the effect of spring length, spring stiffness, and mass attached to the spring on both the stretch of the spring, see Figure 9, and the bounce of the spring, see Figure 10. Students can also apply what they have learned to determine the mass of a mystery object. Another aspect of this lab that might help primary school children is that accessible vocabulary was used. An example is the the 'equilibrium position' was named 'resting position'.
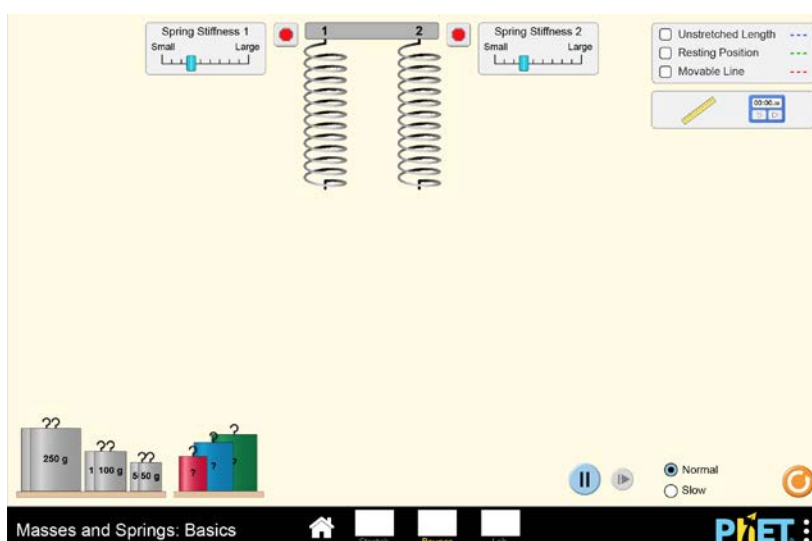
Figure 10. A screenshot of the Masses And Springs: Basics lab in which two springs can be manipulated and their bounce can be studied.

PhET labs have also included the Next-Lab project in their credits, see Figure 11. They credit Next-Lab in all labs in which we collaborate. We will continue exchanging ideas and views with PhET about inquiry-based learning materials, including labs for primary education, and more labs will be added to Go-Lab.
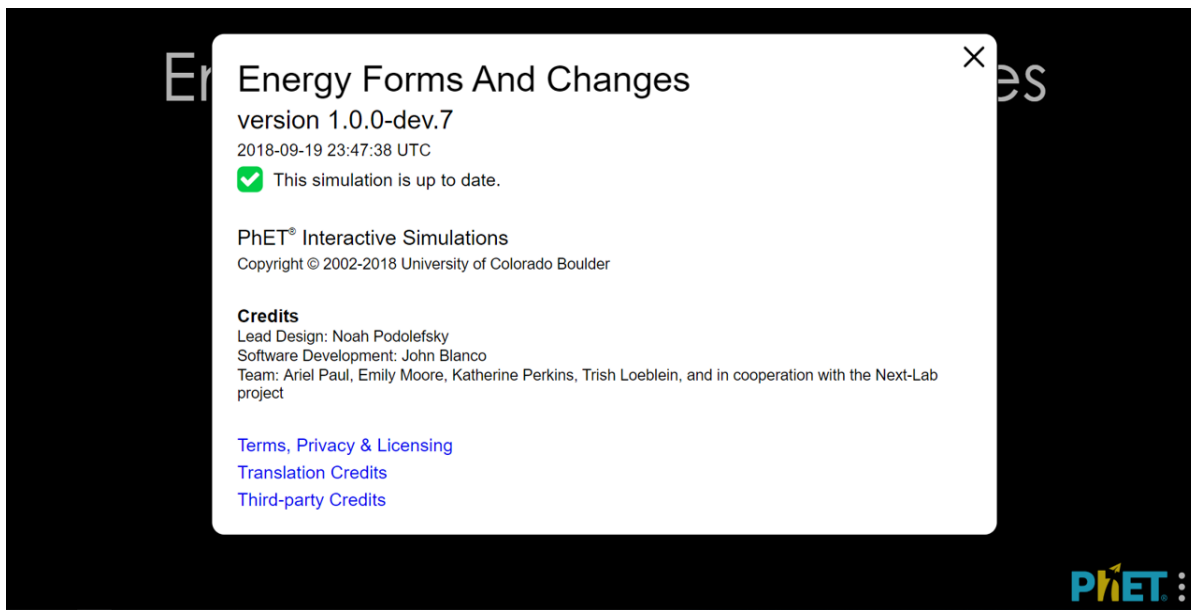
Figure 11. A screenshot of credits in the Energy Forms And Changes lab.

A topic that is frequently taught in primary education is plants and growth. Go-Lab offered a user-friendly lab for this, the so-called Photolab, see Deliverable 3.2 (Van der Graaf & De Jong, 2017). A new version of this lab has been created by us. The new lab is called Rate Of Photosynthesis Lab. The focus is on two variables and their effect on the rate of photosynthesis, namely the amount of light and the temperature. Two more complex variables have been excluded from the lab, namely the amount of CO_2 and the color of light. This makes the interface less cluttered and all variables in the lab understandable for primary school students, see Figure 12. There is also a collaboration version, which offers two versions of the lab. In one version students can only manipulate light and in the other seasons of the year. Collaboration is required, because lamp intensity does not matter in the summer, while season does not matter if lamp intensity is high.
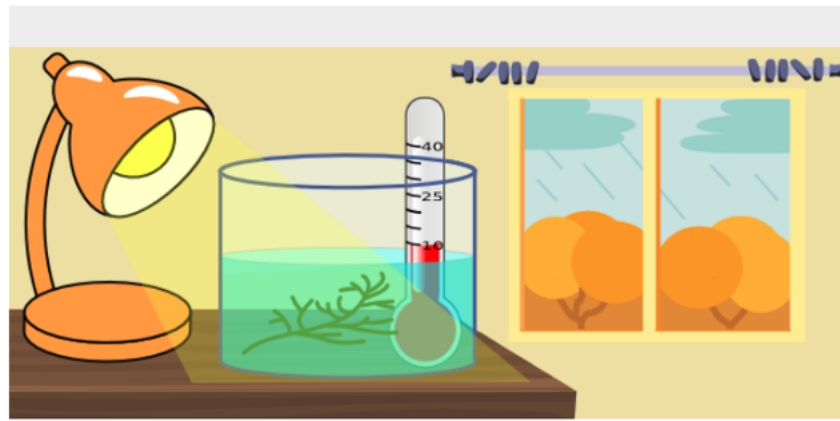
Lamp intensity (Lumens): 1000

Temperature: 10°C

Number of bubbles: 0

0 seconds

Figure 12. A screenshot of the Rate Of Photosynthesis Lab in which lamp intensity and temperature can be manipulated and the rate of photosynthesis of a plant can be studied.

3 Created and adapted apps

Go-Lab offers 40 apps as of the 1st of December 2018. There are learning analytics apps (11), collaboration apps (4), general apps (6), domain specific apps (1), math related apps (4), and the largest number of apps are inquiry apps (14). Since the start of the Next-Lab project new apps have been developed. They replace six old apps that were unpublished, because they were barely used. New apps are explained in the deliverables in work package 3: Empowering learners. This deliverable deals with apps from a primary education perspective and is the final one in this regard.

Apps provide guidance in the inquiry process and help students to learn from their inquiry. It is known that primary school students do struggle with inquiry learning (Zimmerman, 2007) and that guidance does help them in acquiring scientific skills and knowledge (Lazonder & Harmsen, 2016). Therefore, we wanted to make sure that our apps are suitable for primary education.

One new app was created, the Name the Frame app (NTF), two apps were adapted, the Hypothesis Scratchpad (HS) and Experiment Design Tool (EDT), two apps were slightly adapted, the Calculator and the Viewer, and for three apps feedback was gathered, the Data Viewer (DV), Conclusion Tool (CT), and Observation Tool (OT), see Table 4. These apps support the core processes (Klahr, 2000) of inquiry, namely hypothesis generation (NTF and HS), designing and conducting experiments (EDT, DV, and OT), and evidence evaluation (CT). These apps were all high on the list of apps that teachers wanted most, see Appendix A. For more details on the ratings see Deliverable 4.1 (Heintz & Law, 2017).

Table 4.

An overview of the apps, whether it is new, adapted or feedback was obtained, and the process of inquiry learning it supports.

App	New, adapted, or feedback	Inquiry learning process
1. Name the Frame app	New	Observing and describing
2. Hypothesis Scratchpad	Adapted	Predicting
3. Experiment Design Tool	Adapted	Experimenting
4. Calculator	Slight adaptations	Describing, predicting, and comparing
5. Viewer	Slight adaptations	All
6. Data Viewer	Feedback	Comparing
7. Conclusion Tool	Feedback	Reflecting
8. Observation Tool	Feedback	Observing

3.1 Newly created apps

In order for new apps to be useful, they should support part(s) of the inquiry process, that primary school students have difficulties with. The process skills involved in inquiry learning are observing, describing, predicting, comparing, questioning, experimenting, reflecting, and cooperating (Greenfield, Jirout, Dominguez, Greenberg, Maier, & Fuccillo, 2009). Go-Lab already deals with most of them: Hypothesis Scratchpad for predicting, Data Viewer for comparing, Questions Scratchpad for questioning, Experiment Design Tool for experimenting, Conclusion Tool for reflecting, and SpeakUp, as well as, the collaborative labs, Seesaw Lab and Rate Of Photosynthesis Lab for cooperating. However, for observing and describing the present tools offer little guidance, see for example the Observation Tool. Therefore, an Name the Frame app was created.

3.1.1 Name the Frame app

The very first step is observing and describing. While often the relevant information is presented as text in the ILS or the students are requested to explore the lab, there is no specific app that guides students through this process. It is important that students observe specific phenomena, which are part of a lab, because then they know what their investigation will be about. In addition, students do not always incorporate all variables in their predictions and experiments (Siegler & Chen, 1998). Explicit introduction of variables is something that can help young students in using those when designing multivariable experiments (Van der Graaf, Segers, & Verhoeven, 2015). A tool is created to focus on this aspect.

The new app, Name the Frame, interactively guides the students to the identification of variables. It consists of two steps. The first step is a visual presentation of variables as used in the lab. The variable names are presented on the top side of the app and the lab on the bottom side. On the bottom, frames are drawn around the locations where variables are visualized. The names should be dragged to these frames, such as 'Weights', see Figure 13. The final part of the first step is that students check their answers by clicking on the validate icon to see if their answers were correct.
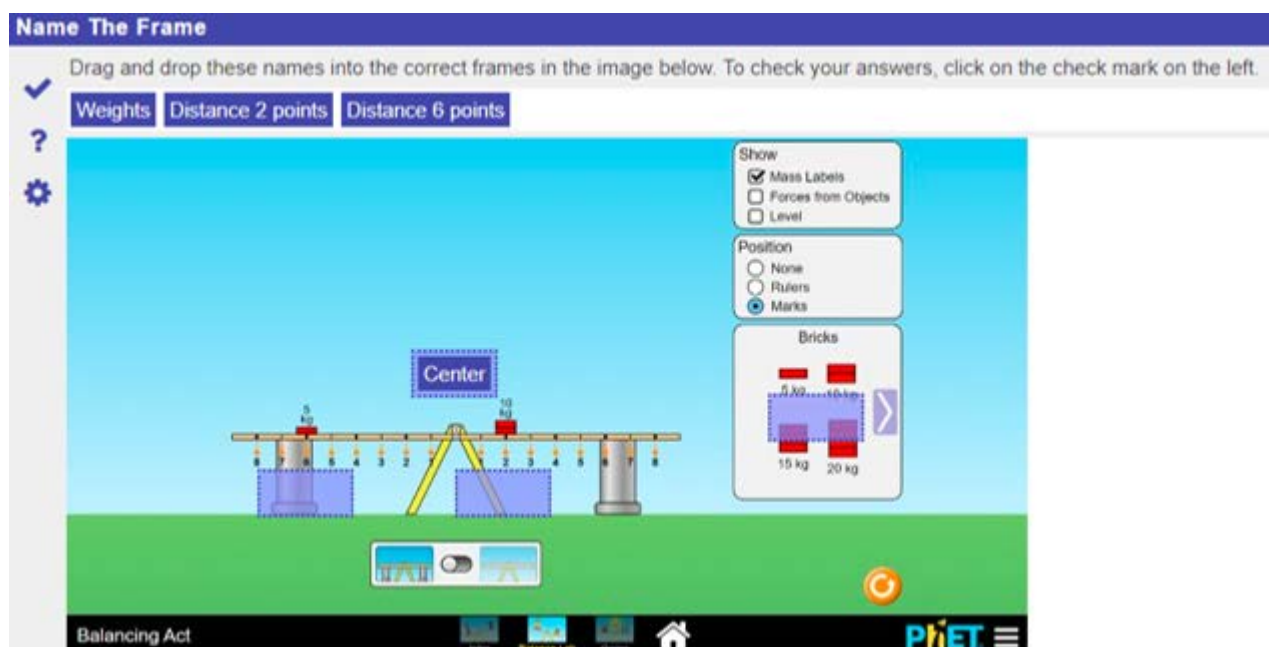
Figure 13. An example of how the Name the Frame app can be used with the Balancing Act lab. The blue frames in the lab show the locations to which the names can be dragged. The names are on the top of the screen. Center has already been placed.

The second step is to study the variables in more detail. This step is optional. After the correct answers have been given, students can click on the variables. A pop-up appears with a description of the variable or a question about it, such as asking which possible settings there are for a given variable, see Figure 14. In this example, students can type in their answers, but it can also be multiple-choice questions.

Name the Frame was designed in such a way that teachers can upload their screenshot, identify areas in which there are variables, and type in the variable names. The app is not limited to labs and their variables, because other screenshots can also be uploaded and frames can be drawn around areas of interest. For the students to be able to name the frames correctly and identify possible settings, an exploration of the lab is needed first. Therefore, it is suggested in the app description to use it after or during exploration of the lab.
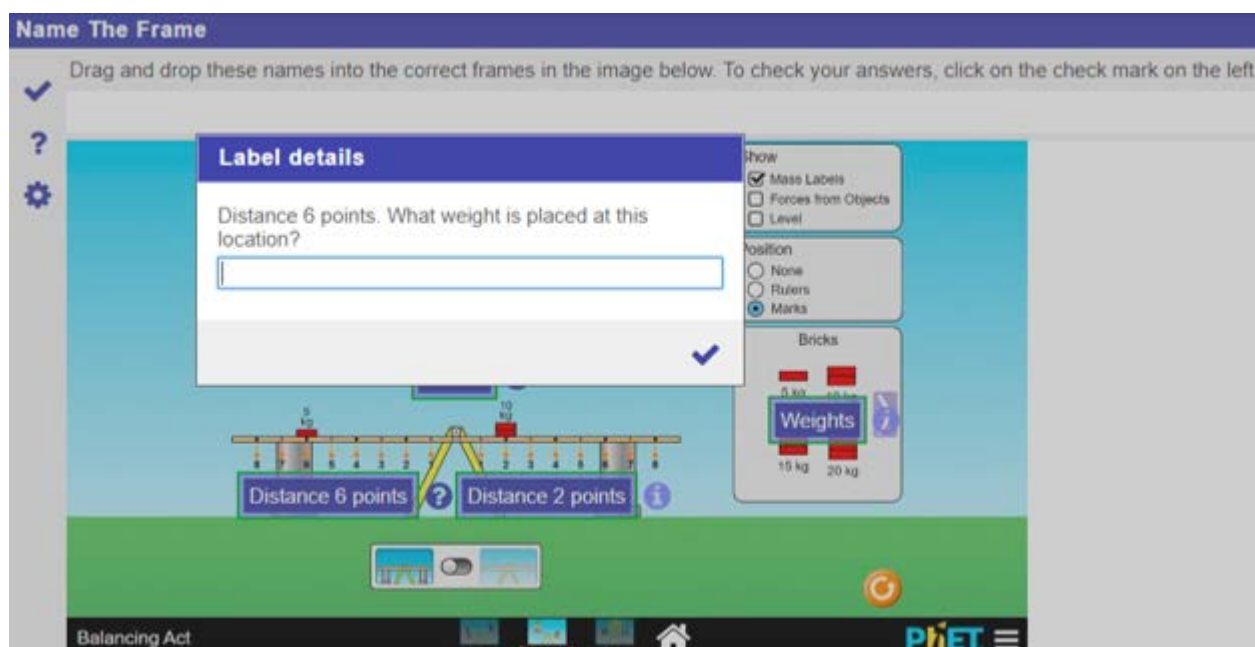
Figure 14. An example of how the Name the Frame app can be used to ask for the settings of a specific variable. In this case, the student is asked to state what the weight is that is placed at 6 points from the center of the seesaw.

3.2 Adapted apps

The Hypothesis Scratchpad (HS) and Experiment Design Tool (EDT) have been adapted. We used feedback from an evaluation study to adapt the apps, see Deliverable 3.2 (Van der Graaf & De Jong, 2017) for a description of the evaluation study. The suggestions will be discussed one by one, first what they were and to what concrete proposals they led, and finally how they were implemented. After acquiring the feedback and suggestions, we discussed them with the technical team to make sure that all suggestions were concrete enough and adapting the apps would be feasible.

3.2.1 Hypothesis Scratchpad

The HS can be used to generate a hypothesis. Multiple hypotheses can be created and for each one students can drag terms to the hypothesis area. Terms are combined to create a hypothesis and they are preset by the teacher. In addition, there is one type-your-own term (that can be used multiple times). Hypothesis generation is challenging for primary school students (Zimmerman, 2007). Therefore, it is good to offer them guidance via the HS and to make the HS suitable for primary education. A total of 17 suggestions were made to adapt the HS that revolved around the following issues: 1) what is the HS for, 2) terms usage and languages, 3) type your own term, 4) meaningful hypotheses, 5) pictures in the HS, and 6) pictures, spoken text, and feedback. These issues will be discussed in the upcoming sections.

3.2.1.1 What is the Hypothesis Scratchpad for?

There appeared to be a general difficulty with understanding what to use the HS for. An example is one student's question about whether all terms should be used. This might be related to difficulties in understanding what hypotheses are and what they are for with respect to inquiry. Therefore, the word 'hypothesis' might be changed to something that is easier to understand for primary school students. An option is to call it 'expectation' or 'idea', because that is what the HS often is used for. This does not mean that the name of the app has to be changed, as this is only visible to the teachers. However, a different name for the new version of the HS would be useful. This led to the following proposals:

1. Change the name of the app from 'Hypothesis Scratchpad' to:
    a. Hypothesis Scratchpad Basic
2. Change the word 'hypothesis' in the app interface to:
    a. Something the teacher chooses
    b. Idea Generator
    c. Expectation Simulator
    d. Prediction Creator

3.   Add a help-function with the description of what a hypothesis is, see Figure 15 below. The context of gravity can be used, because it is part of the primary school curriculum and because it is a popular lab on the Go-Lab portal. The help function will look like this: 'An expectation is a description of what you think will happen, for example: What do you think would happen if we drop a small and a large weight from the same height; which one will be on the ground first? Your answer to this question is called an expectation. Your expectation could be: 'The large weight will be on the ground first.' Expectations are used to create experiment. You can use the Hypothesis Scratchpad to create your own expectations.'
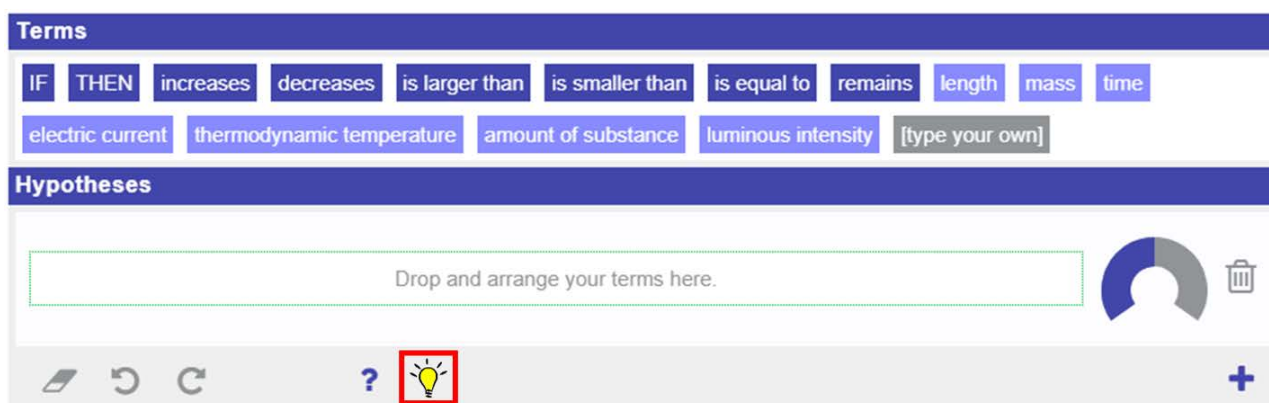
Figure 15. The Hypothesis Scratchpad and the addition of a function to show an example of an ILS.

3.2.1.2 Terms usage and languages

Another difficulty was the usage of terms. A simple interface-related problem was the dragging-and-dropping and removing of terms. Especially the removal of terms appeared to be difficult, because they had to be dragged to a specific area for removal. A suggestion would be to allow dragging terms outside of the hypothesis area in order to remove them. This led to the following proposals:

4. Change the name of the section with terms in the interface from 'Terms' to:

   a. Words

   b. Parts

   c. Pieces

   d. Blocks, see Figure 16

   e. Choices

5. Also use clicking to move terms in addition to dragging-and-dropping. In other words, when you click on a term you enable dragging. The second click would be on the location where you want the term to drop.

6. Remove terms by dragging them outside the hypothesis area.

7. Allow terms to be edited after placement. This is sometimes needed for grammatically correct sentences (e.g., Estonian).

   a. This can be a setting teachers can turn on/off

8. Let the HS retrieve the default standard translations from the Go-Lab App Composer to see which language is used for the ILS and present the default terms in the corresponding language. The HS displays terms by default, such as 'IF', 'increases', and 'electric current', see the terms in Figure 15 or 16. These default terms are in English, even after the language of the ILS has been changed to a different language.
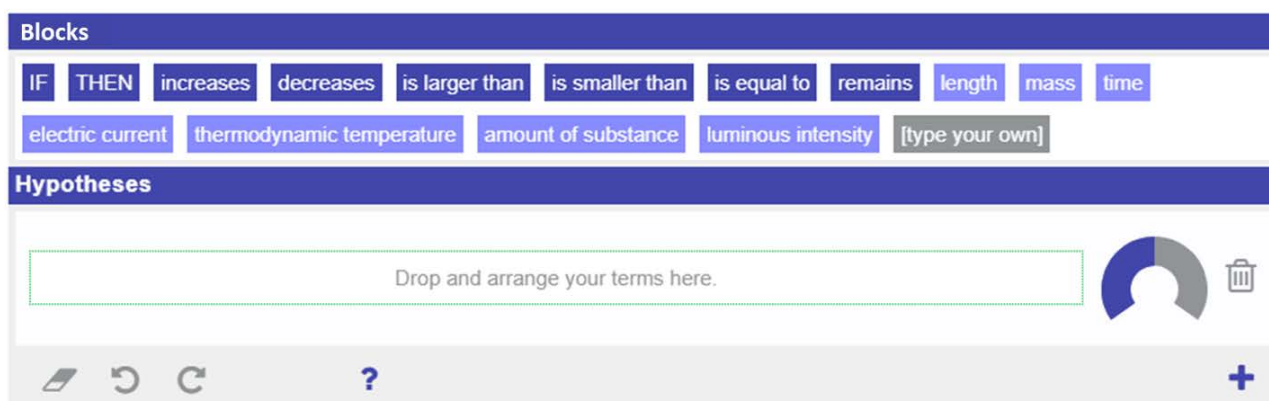
Figure 16. Example of the Hypothesis Scratchpad, where the word 'Terms' has been replaced with 'Blocks'.

3.2.1.3 Type your own term

There is an option [type your own] that allows users to type something themselves. This can be done in the location of the HS where the terms are presented, but it appeared to be more intuitive to allow typing at the location where the hypothesis is created. This would improve the HS. Therefore, the following was proposed:

9. Allow typing of the term when it has been placed in the hypotheses area.

3.2.1.4 Meaningful hypotheses

Not all students could use the terms to create a meaningful sentence or intelligible hypothesis. This indicates that students should possess school-related vocabulary with words such as 'comparison', 'if', and 'then', and domain-related vocabulary, such as 'plant growth', before they can properly generate hypotheses. A suggestion would be to explain such concepts beforehand and another suggestion is to use them in a worked example. The HS can incorporate worked examples in the first place by providing specific terms to choose from and in the second place teachers can also put some terms in place for the students. The following suggestions were proposed.

10. Add a help-function with a worked example of a hypothesis, see point 3.
11. Instruct the teacher to create an almost complete hypothesis as a start.
12. When nothing has been placed in the hypothesis area show, see Figure 17:

    a. Some instruction on what to place there, such as: 'Start with dragging the word 'If' to this area and then add more words'.

    b. An example of a hypothesis.

13. Let the teacher change the text "Drop and arrange your terms here." and "Drag/type here to create your research question.", see Figure 17 below.

Figure 17. Proposed version of the Hypothesis Scratchpad, where the default text in the hypothesis area changes.

3.2.1.5 Pictures, spoken text, and feedback

The HS could be made better fit for primary education by adding graphics next to words, see Figure 18. The pictures might help to think about what the variables are and how their settings look like or what the outcome would look 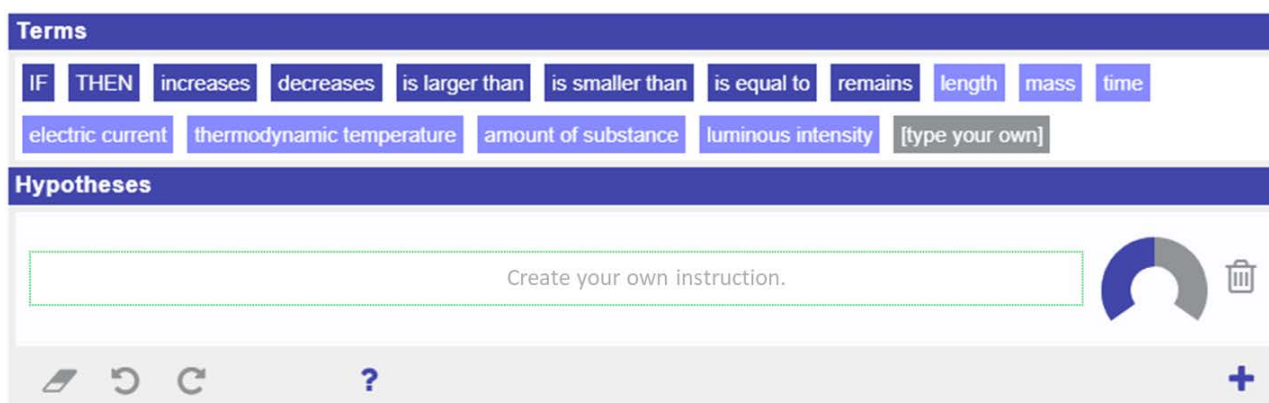like. Another suggestion is to use spoken text instead of written elements. If there are troubles with reading, the spoken text can help understand what the hypothesis is. Primary education students would also possibly profit from getting online feedback on the hypotheses that they entered. An example is to provide feedback on whether the hypothesis is complete, in that the hypothesis includes an independent and dependent variable and a relation between them is specified. Feedback can help in the creation of hypotheses and in correcting the hypotheses. However, hypotheses also depend on the domain that is being investigated. Feedback on the hypotheses for all domains is unrealistic, but it might be added for some. Those could be selected based on the curriculum analysis and availability of labs, see Deliverable 3.2 (Van der Graaf & De Jong, 2017) for on overview of topics in the curriculum and which labs Go-Lab offered on that topic. The following concrete proposals were identified:

14. Allow the insertion of pictures, see Figure 18.

15. Provide an option so text is spoken.

16. Create a feedback mechanism to automatically evaluate the created hypothesis.
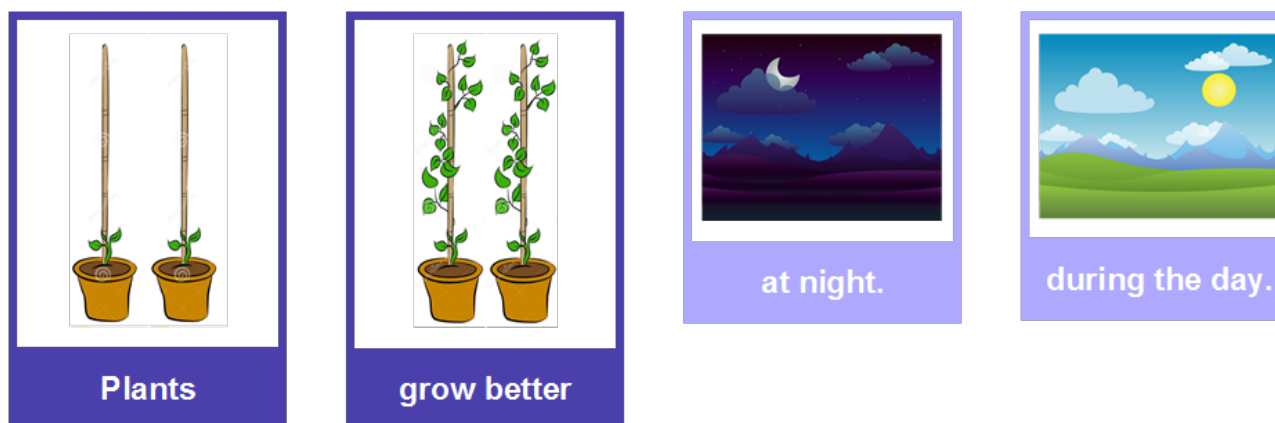
Figure 18. Example of how parts of the hypothesis can be presented in both picture and text.

During the discussion with the technical team, a new suggestion was proposed. The suggestion was to predefine relations, for example 'if' and 'then' determine which variables relate and how: 'if light intensity increases, then photosynthesis increases'. To predefine it would mean that when an 'if' is placed a 'then' is automatically added. Space is left open in between for the student to drag blocks to and complete the hypothesis. Another example of relations that can be predefined is 'when' that determines a condition and 'compared to' that defines the condition that is compared to: 'there is more photosynthesis when temperature is 25 degrees Celsius, compared to 40 degrees Celsius'. Such predefined relations help to create the hypothesis, but also provide the opportunity to provide feedback. If there is a 'when' statement, it should include a variable and a setting. In addition, there should be a condition to which it should be compared, defined by the 'compared to' part of the hypothesis.

3.2.1.6 Summary

A total of 17 suggestions were made to adapt the HS of which 11 were implemented and six were not, see Table 5. Out of all the implementations, the addition of pictures was regarded the most important one, as it helps students to visualize what the hypothesis is about. It is also the one that resulted in the biggest change in the HS. Therefore, it was decided to create a separate app with all adaptations mentioned in this deliverable. The regular HS will still be available on Go-Lab.
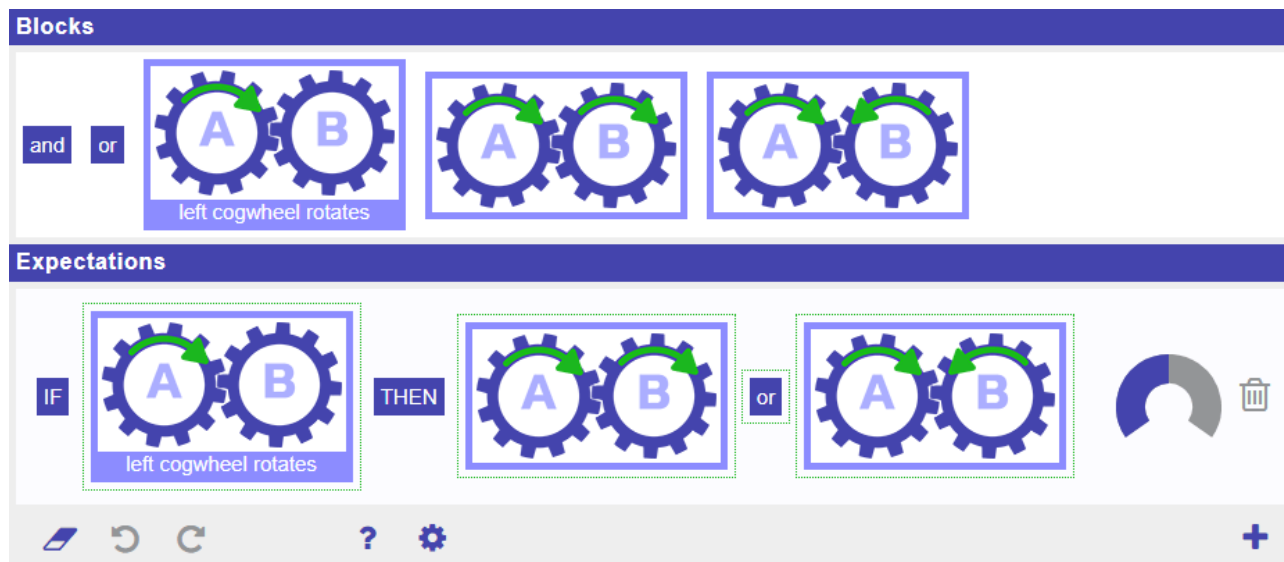
Figure 19. A screenshot of the new app, Hypothesis Scratchpad Basic, where pictures accompany words.

The name of the new app is the 'Hypothesis Scratchpad Basic'. If the teacher chooses to use the new app, pictures can be uploaded in the app, see Figure 19. To help with the pictures, a short explanation was added. The explanation is: "You can upload pictures to match blocks (of words) in the hypothesis. It is suggested to use screenshots of the lab you want to use. This way, you can use the variables in their specific settings as pictures for the Hypothesis Scratchpad." The use of pictures makes the distinction between variables and relations less applicable, because within the context in which the hypothesis is made, the pictures with relations should depict the variable as well. An example is specifying that 'plants grow better during the day'. In order to depict 'grow better', something that grows (a plant) should be added to the picture, as in Figure 18. The Hypothesis Scratchpad Basic supports hypotheses with pictures. It is possible to create a hypothesis with only pictures. The new app also offers predefined relations, which means that if an 'if' is dropped in the hypothesis area, then a 'then' is automatically added, with some space in between to complete the hypothesis, see Figure 20. The terminology has also been changed and the option has been added that teachers can change the terms if they want, such as 'expectation'.
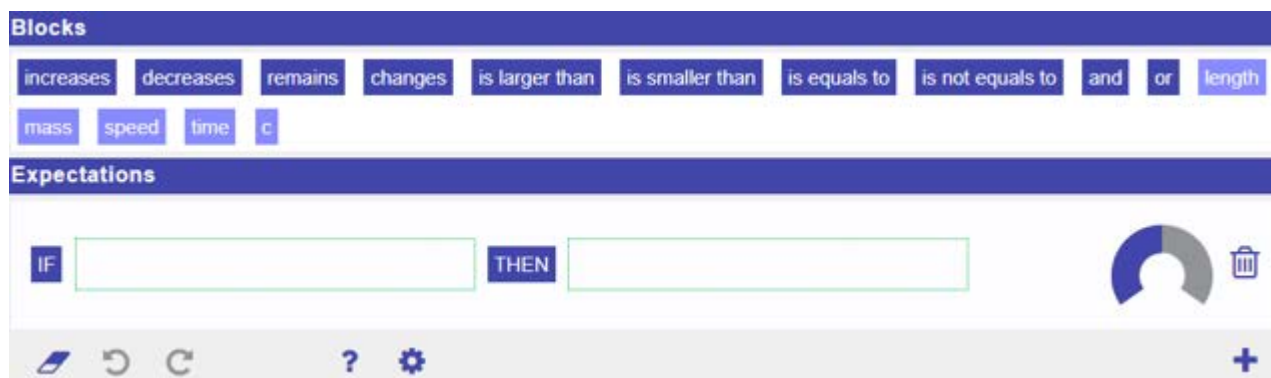
Figure 20. A screenshot of the new app, Hypothesis Scratchpad Basic, which automatically adds blocks based on which block was dragged to the hypothesis area. In this case the 'if' block was dragged to the hypothesis area and the 'then' block was automatically added.

Table 5.

Features of the Hypothesis Scratchpad and whether they will be changed, and how (if yes) or why it will not be changed (if no).

Number	Implemented in app	Feature	Adaptation
1	Yes	Name of the app	Former: 'Hypothesis Scratchpad'. New: 'Hypothesis Scratchpad Basic'
2	Yes	Name of the hypotheses	Former: 'Hypothesis'. New: 'Expectation' and the possibility to change the name.
3	No	Description of hypothesis	No description of what a hypothesis will be added as help, because it can be added as text near the app in the ILS.
4	Yes	Name of terms	Former: 'Terms'. New: 'Blocks'
5	No	Dragging and dropping	Dragging and dropping remains as is, because it is a common way of using apps.
6	Yes	Removal of terms	Former: Terms can be removed by dragging them to the trash bin.

			New: Terms can be removed by dragging them anywhere outside the hypothesis area.
7	Yes	Term editing	Former: Pre-specified terms cannot be edited. New: An option was added so pre-specified terms can be edited after placement.
8	Yes	Default terms	Former: The app shows some variables and relations by default in English. New: The variables and relations are translated into the language of the ILS.
9	Yes	Term to type your own text	Former: Text could be typed before placing the term in the hypothesis area New: Text can be typed after placing the term
10	No	Example in help	No explanation of a hypothesis has been added to the help function, because it can be added as text near the app in the ILS.
11	No	Prepare the hypothesis	No instruction to the teachers has been added to prepare the hypothesis by already putting some terms in place, because this is too detailed information.
12	Yes	Default text in hypothesis area	Former: The default text could not be changed New: An option has been added to change the default text.
13	Yes	As 12	As 12.
14	Yes	Term presentation	Former: Terms are text-only. New: Pictures can be added to the terms.
15	No	Read the text out loud	The text cannot be read out loud, because a natural spoken text in various languages is not available yet.
16	No	Feedback on the hypothesis	Automatically generated feedback on the hypothesis is currently not feasible, because it depends on the

			specific context in which a hypothesis is created.
New	Yes	Predefined relations	Former: Relations between variables could be typed as text. New: A predefined set of relations is available to choose from. When placed, the hypothesis area adapts to the relation, such as adding a 'then' when an 'if' has been placed.

3.2.2 The Experiment Design Tool

The EDT assists the process of designing and conducting experiment. Variables can be dragged to their position based on whether they will be manipulated (vary) or not (keep constant). Subsequently, specific settings for each variable can be chosen. Multiple lines can be created and each line represents an experimental trial. When the trial has been run, the results can also be noted in the EDT, namely in the column 'measure'. Setting up experiments often goes wrong in primary school, but students of all ages can learn it (Schichow, Croker, Zimmerman, Höffler, & Härtig, 2015). Thus, there is a need for support by the EDT to (learn to) set up experiments. Therefore, the EDT was adapted to primary education. Nine suggestions were proposed to adapt the EDT, which revolve around 1) what is the EDT for, 2) the language of the EDT, 3) more guidance in setting up experiments, and 5) miscellaneous.
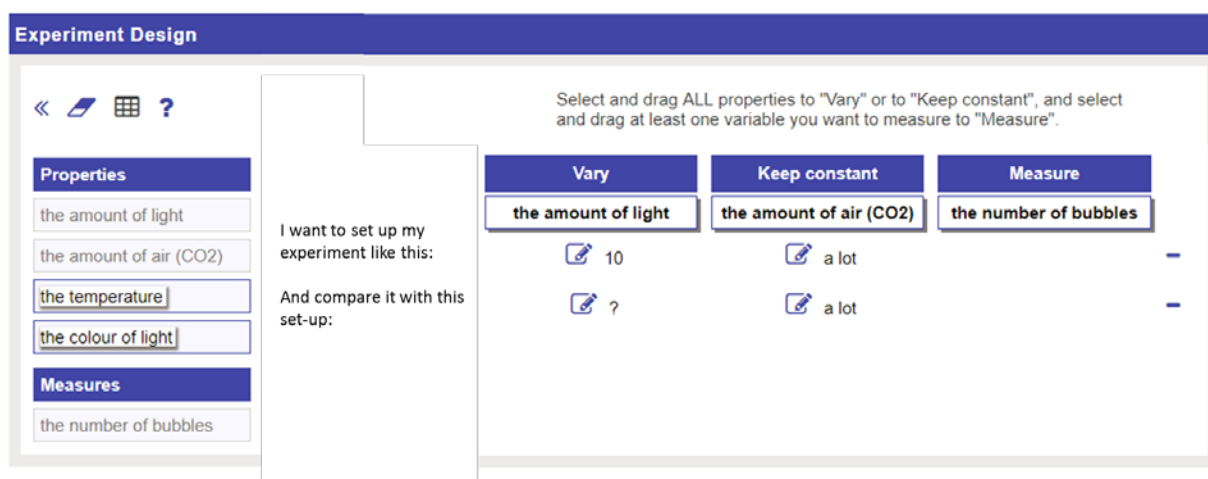
Figure 21. An example of the Experiment Design Tool, where the number of the trials has been replaced with text.

3.2.2.1 What is the Experiment Design Tool for?

With regard to the EDT, a general difficulty, similar to the HS, was found concerning understanding what the app is used for. However, this might be less related to the language used, but more to the use of experimental strategies, such as the VOTAT (Vary One Thing At a Time) strategy. The VOTAT strategy states that to learn about the effect of one variable, one should manipulate that variable and keep the other variables constant (do not manipulate them). Such strategies often require multiple trials in order to generate informative results. That students did not seem to understand experimental strategies was supported by the notion that students often did not create more than one trial. A suggestion is to explicate the need for comparison on the EDT, for example by providing two lines in advance. There could be text, such as 'I want to set up the experiment like this: trial one' and then for the second line 'and compare it with this set-up: trial two'. This led to the following proposals to adapt the EDT:

1. Add text to indicate what the lines for the trials are for. Add this before the first line 'I want to set up my experiment like this:' and before the second line: 'and then compare it with this set-up', see the Figure 21.

2. Just as for the HS, add a help-function with a worked example, see Figure 15. Use gravity as a topic. The text could be: 'To set up an experiment, you should compare at least two set-ups, for example if you want to investigate whether a light or heavy weight reaches the ground faster, you can do two set-ups: 1) drop a light weight from a table, and 2) drop a heavy weight from a table. You first drop a light weight and then a heavy weight. You drop it from the same table, so you can learn about the weight only.'

3. The design of the EDT app could better emphasize the instructions a student has to follow to use it. The eraser, table and help icons could be moved to a less conspicuous location to allow room for the instructions to appear. In Figure 22 the former (top) and the proposed version (bottom) are displayed.
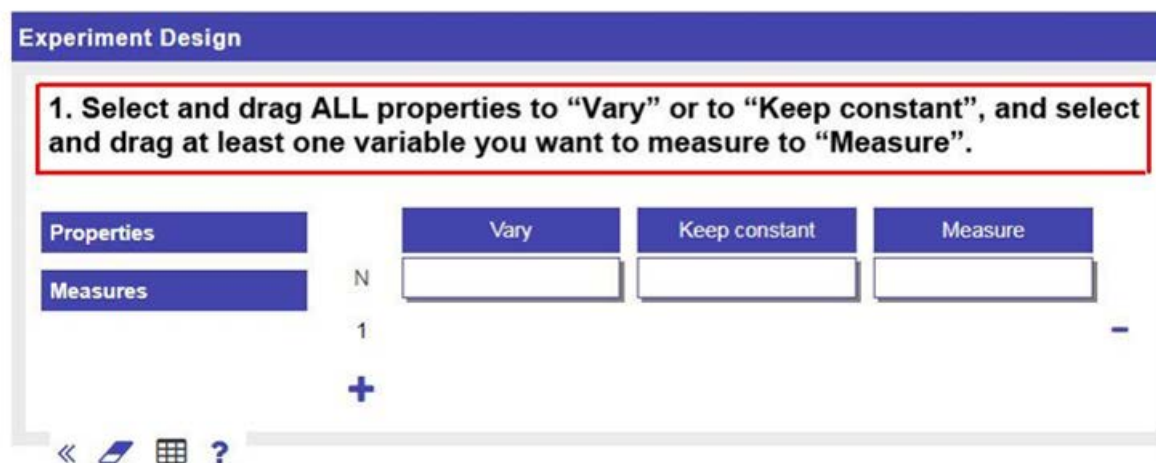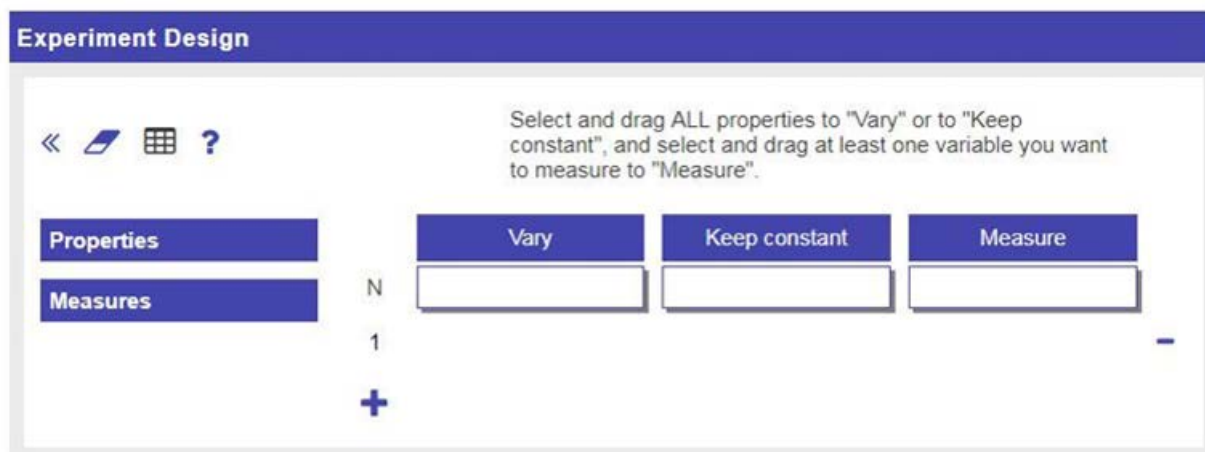
Figure 22. The former version of the Experiment Design Tool (top) and an example of how the instruction could be emphasized (bottom).

3.2.2.2 Language in the Experiment Design Tool

Usage of the EDT was also troubled by the language that was used and that was needed to comprehend what should be done. Examples of difficult words are 'vary', 'compare', and 'valid'. 'Vary' and 'constant' are part of the EDT, see Figure 21 or 22. In the EDT there are multiple columns. One of them is about variables that students want to vary, one of them is about variables that students want to keep constant, and the final one is about variables that students want to measure. The first two columns appeared to be difficult to comprehend; students did not know what to do without instruction. Therefore, the language in the EDT can be changed. In line with the addition of text to explicate comparison, the word 'vary' could be replaced with 'change', whereas 'constant' can be replaced by 'do not change'. Even a whole sentence could be presented, where the variables, their settings, and the relations are specified, for example "When the amount of water is __ liters/day, then the plants grow to a height of __ cm". This led to the following proposals:

4. Change 'vary' to:
   a. Change
5. Change 'keep constant' to:
   a. Keep the same
   b. Keep it similar
   c. Do not change, see Figure 23
6. Also note that lines can be added for experimental trials/rows. Change 'trial' to:
   a. Test
   b. Run
   c. Try
7. Present the experimental trial in a sentence.

Figure 23. Example of the Experiment Design Tool, where 'vary' and 'keep constant' have been replaced by 'change' and 'do not change'.

3.2.2.3 More guidance in setting up experiments

Even when it is clear what the students should do in the EDT and how it works, designing experiments appeared to be a complex process. A solution that was proposed is to use a step-by-step instruction. There could be a first step asking for which variable should be investigated, after which the variable is automatically placed in the table of the EDT. In the same step it can be asked what the students want to measure and finally what they want to do with the other variables. A second option is to provide feedback in between, for example when the first trial is empty and a second one is being added. The following list of suggestions were proposed:

8. Fill in the EDT step by step:
   a. A first step to ask which variable should be changed, which variable(s) should not
      be changed, and what should be measured.
      i. These steps should show a selection of available variables.
   b. The next step is to ask how the variables should be set.

          i.   This step should make use of the predefined settings of the variables, such as a categorical variable with three settings.

    c.   Automatically add a second line when the first one is complete.

    d.   Again, in this step it is asked how the variables should be set.

          i.   Or ask it the first time 'how do you want variable X to be set in the first test of the experiment and how in the second test?' In this case, two lines should be pre-created and filled in using the steps.

9. Show a reminder if the first trial is empty and a second one is being added.

3.2.2.4 Miscellaneous

Finally, regarding EDT's functionality in an ILS, some additional improvements could be made. One is allowing the data to be imported in the Conclusion Tool or shown in the Viewer without any steps in between, but these are improvements that will be made in the other apps. A final suggestion was proposed during the meeting with the technical team. It was proposed to add pictures to the EDT, in line with the picture proposal of the HS. Pictures can depict the variables that are changed or not changed and how they are set.

3.2.2.5 Summary

Nine suggestions were proposed to adapt the EDT. Seven of them were implemented and two of them were not, see Table 6. The new app is called the Experiment Design Tool Basic. The step-by-step helper was regarded by us as the most useful for primary school and it is the largest adaptation. The step-by-step helper was added to aid in setting up experiment via three steps. The first step is choosing which variables to use and whether to change them or not, the second step is selecting the settings, and the third step is filling in the outcomes of the experiment, see Figure 24. The instruction what to do in each step was added. Like in the HS, the terminology has been changed and the option has been added that teachers can change the terms if they want, such as 'do not change'.

Figure 24. A screenshot of the three new steps in the app, Experiment Design Tool Basic. Step 1 (top) is about selecting variables, step 2 (middle) is about setting them, and step 3 (bottom) is about measuring.

Table 6.

Features of the Experiment Design Tool and whether they will be changed, and how (if yes) or why it will not be changed (if no).

Number	Implemented in app	Feature	Adaptation
1	Yes	Trial numbers	Former: Each trial was preceded with a number. The column was named N. New: Each trial is preceded with explanatory text 'I

			want to set up my experiment like this:' for the first line and 'and compare it with this set up:' for subsequent lines.
2	No	Example in help	No explanation of an experimental set-up has been added to the help function, because it can be added as text near the app in the ILS.
3	Yes	Emphasise instruction	Former: Instruction appeared above the columns in the app. New: Instruction appears step-by-step, see below.
4	Yes	Name of the columns	Former: 'Vary'. New: 'Change'.
5	Yes	Name of the columns	Former: 'Keep constant'. New: 'Do not change'.
6	Yes	Name of the columns	Former: 'N' New: nothing
7	No	Experimental design	When the design is done, it will not appear as a sentence, because text already was added to explain what each line stands for.
8	Yes	Step-by-step helper	Old: No helper was available. New: A helper guides students through the process of creating an experimental design. It is a step-by-step procedure by using guiding questions.
9	Yes	Number of lines	Former: Lines can be added by clicking on the plus. New: Line 2 is automatically added when line 1 has been completed. This does not happen for line 3 and onwards.
New	No	Variables and their settings	Pictures were not added, because the app is complex as it is. In such cases, pictures can actually distract students from performing the learning activity, i.e.,

			setting up an experiment so it is informative.

3.3 Slight adaptations

Slight adaptations were applied to the Calculator and the Viewer. The Calculator and Viewer could be improved, see Deliverable 3.2 (Van der Graaf & De Jong, 2017). These suggestions emerged in the course of using Go-Lab with teachers in the classroom. Below it is explained how the apps were adapted.

3.3.1 The Calculator

The Calculator is an app in which mathematical operations can be performed, from addition and subtraction to square root and exponentiation. Since students in primary school are still learning and practicing with addition, subtraction, multiplication, and division, the Calculator is a very useful tool. It helps to focus on inquiry learning, because results can be calculated. In its current form, there are several functions that primary school students do not need. Therefore, a basic version of the Calculator is proposed. The Calculator still needs the clear function, the '=' function, and the decimal point. This resulted in a simple version of the Calculator, with only the functions as shown in Figure 25. Another addition is that the operation that was performed is visible after clicking on the '=' function. This serves as a reminder of what operation was performed and what the input was. A final adaptation is that the app has been made shorter. This is useful when the app is being used as a general tool in an ILS. General tools appear at the bottom of the screen and can be collapsed and extended. When the app is short, more space is available for the content of the ILS.
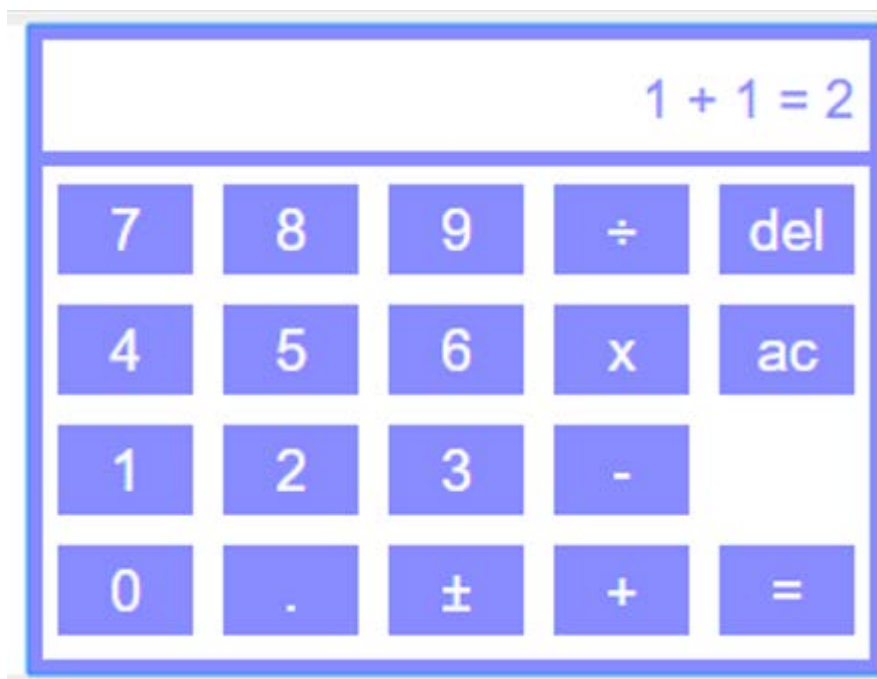
Figure 25. The Calculator: simple version.

3.3.2 The Viewer

The Viewer is an easy-to-use tool that shows the content of another tool. The Viewer can serve as a reminder about what has been done, created, and/or written down. This helps in performing the task at hand by freeing up space in working memory. What can be improved in the Viewer is that it can cover more tools. The Viewer can display the content of the Concept Mapper, HS, Question Scratchpad, Data Viewer, and Table Tool. The following apps have been added: the Input Box and the Observation Tool. Other apps, such as the EDT, will follow.

4. Feedback on Additional Apps

Feedback was gathered that covered additional apps: the Data Viewer, the Conclusion Tool, and the Observation Tool. Feedback was acquired from primary school teachers during the Go-Lab Spring School 2018 in Bilbao and feedback was acquired from university students. In the School, participating teachers co-created ILSs and they used the Go-Lab apps as well. In collaboration with the organisers of the spring school and the Leicester team, who organised feedback sessions, feedback was gathered using two different approaches.

The first approach was to provide a link to an ILS that consisted of a Padlet. The accompanying question was to fill in any feedback that come to mind. In the Padlet app, the teacher wrote down their feedback. They also had some questions which were asked using this channel. Twenty different teachers created 45 posts. Most suggestions were to improve the attractiveness and usability of the interface of the website and the apps. An example was the suggestion to add colours. There was a suggestion for a new app, namely an avatar app, in which teachers can choose their avatar and put text in a speech bubble. This, then, can be used in an ILS in which students can see the avatar and read the text, which might be more attractive than simple text. There were four suggestions about the HS. One of them was to add a "clear all" button, so it would be easier to start entering new content when setting up the app as a teacher. Another request was to help teachers when they let the students use passwords. Let the teacher specify the number of his or her students, e.g. 22, and then the system automatically creates 22 passwords.

The second approach was to ask for feedback during face-to-face sessions with the teachers. There was one session during the spring school where specific feedback was gathered and a discussion was held to elicit more feedback, opinions, and ideas, see Deliverable 4.3 (Heintz & Law, 2018) for more information about the workshop in Bilbao.

Specific feedback was gathered by letting teacher work in an ILS in which the focus was on two apps, namely the Conclusion Tool and the Data Viewer. They could write down their feedback on a piece of paper. Afterwards there was a general discussion.

The second source of feedback was the analyses of second year university students at the University of Twente participating in the module 'Psychology in Learning and Instruction' in 2018. The students wrote an essay about the Data Viewer, Conclusion Tool, or Observation Tool. They could choose whether they evaluated the usefulness of the app for primary or secondary education. The abstracts of essays about primary education can be found in Appendix B. The next few sections summarize the findings from the teacher and student feedback for the Data Viewer, the Conclusion Tool, and the Observation Tool.

4.1 The Data Viewer

The Data Viewer (DV) allows students to visualize the data. To do this, first data has to be gathered and/or loaded. This can be done in, for example, the EDT. Then variables can be dragged to the x- and y-axis and a chart type or a table can be chosen. The DV helps in the process of comparing and reflecting. Data from different trials can be compared and a reflection on this data helps to draw a conclusion. There are labs in which the outcomes of experiments are directly visible and a conclusion can be made without quantifying the data, such as the Gravity Drop Lab. However, sometimes one needs to keep track of the data during experimentation, such as in the Rate Of Photosynthesis Lab. In this case, the DV is useful, because the data can be viewed once more and it can be compared. Graphs help primary school students to revise their

prior belief and adopt a correct explanation (Koerber, Osterhaus, & Sodian, 2017). Therefore, it is important that primary school students can use the DV. The Data Viewer might be adapted to properly support the comparison of data and drawing of conclusions. The focus in the Data Viewer would be on how to visualize data best for primary school students to interpret them. Note that learning to interpret graphs is a learning goal in primary school education (see Deliverable 1.2; Tasiopoulou, et al., 2017). Therefore, it is a good app to let students practice this skill.

Outcomes of the workshop in Bilbao showed that teachers did not find the DV appropriate yet for primary education, because it is too complicated. The DV offers too much freedom and required too much knowledge from the students regarding selecting and interpreting data and charts. A suggestion was to use the DV to display the data and/or the chart that was predefined by the teacher. Another suggestion was to create a simpler version of the DV with fewer options for both the teacher to set up the app, as well as for the students to use the app. Also, a different name was discussed. It was proposed to change the name from Data Viewer to Graph Tool.

Next to feedback from teachers, university students analysed the DV. Five students wrote their essay about the DV in primary education. A common disadvantage they found was that students should know about charts when working with the DV and the DV does not provide this. It was recognized that visualization can help. Suggestions were instruction prior to first usage and providing feedback. One student proposed that for these reasons a teacher should be present when students use the DV for the first time.

To summarize, the DV should be simplified and more guidance should be incorporated for both teachers and students. This can be done by limiting the number of chart types and the options to generate or select data. Finally, some explanation around the DV should be present for primary school students to understand how to use it during inquiry learning.

4.2 The Conclusion Tool

The Conclusion Tool (CT) supports comparing and reflecting. Children can reflect upon the hypotheses and results and compare them to draw a conclusion. In the app, the hypotheses are visible, data can be imported, and an input box is available to write down the conclusion. Simultaneously presenting the hypotheses and results diminishes effects of split attention and directs the students to the link between theory and evidence (because the hypothesis is presented), which might help in the construction of knowledge (Kuhn, 2004). This step is also called evidence evaluation, which is something primary school students can perform and this process helps them to learn (Van der Graaf, Segers, & Verhoeven, 2018). Therefore, the CT should be optimized to support inquiry learning of primary school students.

We asked primary school teachers what they thought about the CT during the Bilbao Spring School. It appeared that the teachers were divided, about half said the CT was appropriate for their students, and the other half thought it was not. Suggestions were proposed to add colours and offering less features to make the CT less abstract and complex. An example was to show all data without specifying whether it was a chart or observation, so students could select which data to use when drawing their conclusions. Finally, teachers pointed out the need for feedback to make sure the correct conclusions were made. Some proposed to add this as a feature to the app, while others would use a different app, the Teacher Feedback app.

Twenty students evaluated the CT in their essay. Their findings were in line with the teachers' feedback. While the structure helps to draw conclusions, primary school students would benefit from reinforcement, such as motivating statements about their efforts or products, and feedback.

For example, one student proposed to add a pet avatar, as a playful feature and others suggested to add prompts to guide the process even more.

To summarize, the CT helps primary school students, mostly due to the structure it offers. When feedback is offered as well, the app seems suitable for primary education. Finally, the complexity might be reduced by prompting the students to perform specific actions.

4.3 The Observation Tool

The Observation Tool (OT) allows students to write down what they have observed. This can be done throughout the inquiry, but is mostly done during the experiment. Children can create multiple observations in the OT. Each one offers an input box to type the observation.

Twenty-one students wrote their essay about the OT in primary education. The main advantage and disadvantage was the simple structure. On the one hand it makes the OT simple to use. On the other hand, guidance is missing on how to take notes, what to observe, etc.. This led to the suggestion to add guidance in the form of heuristics that direct the students towards taking notes and suggest what to observe, such as configuring some initial observations, leaving blank key words for a student to fill-in, e.g. "When the amount of water is 10 liters/day, then the height of the plants grow to _____ cm.", "When the amount of water is 40 liters/day, then the height of the plants grow to _____ cm.", "When the amount of water is _____ liters/day, then the height of the plants grow to 35 cm." Finally, drawing might be added to allow observations to be drawn, which can help young children who do not yet know how to verbalise the relevant information.. This way, attention is directed to the relation between two variables. Another suggestion was to make the OT more like the Concept Mapper, so different observations can be related to each other. A final suggestion was to remove unnecessary text, see Figure 26. This way, the OT would keep its simple structure.
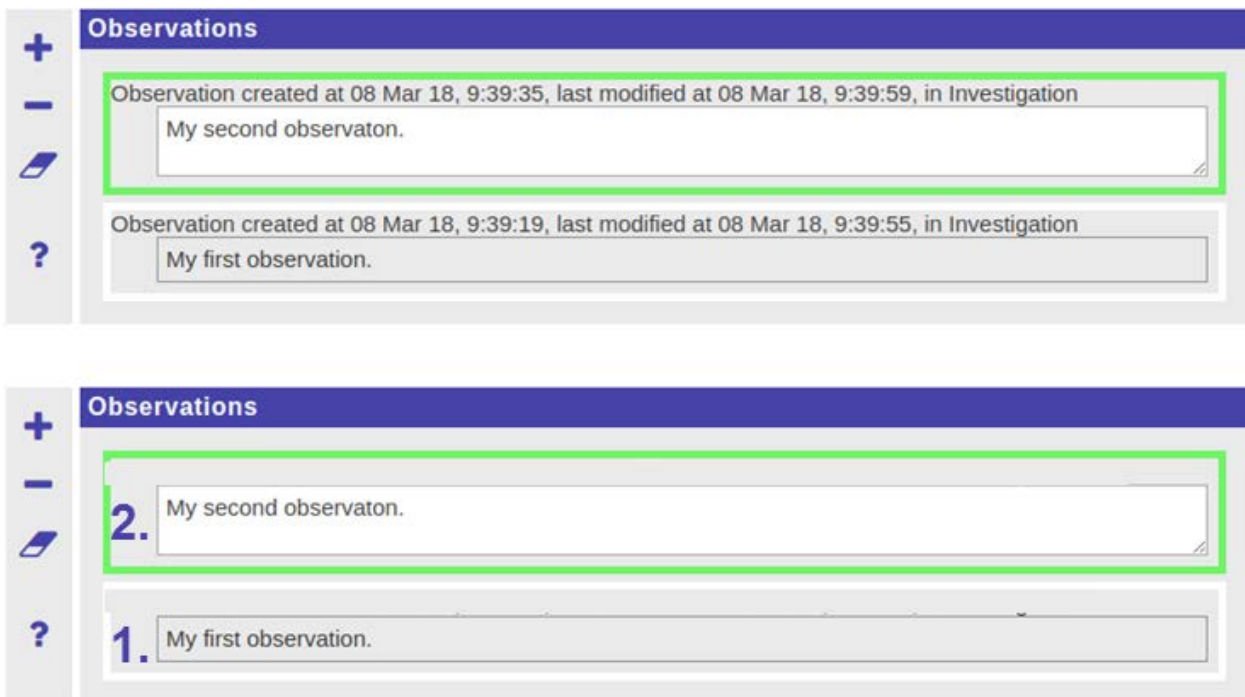
Figure 26. The Observation Tool original version (top) and how it might be changed to use numbers instead of text (below).

5 Tips for Primary School Teachers

During our feedback sessions and discussion with teachers, we noted that there were some common requests, which all could be solved using the functionalities that are currently available in Graasp. Since these were common, we decided to write tips for primary education. These tips were not designed to be exhaustive, but to address common needs. They were categorized in 1) tips for beginners, 2) tips for advanced users, and 3) technical tips, see Appendix C. These were written to be published on the new support page of Go-Lab.

5.1 Tips for Beginners

The tips for beginners addressed issues that mostly occurred at the very start of using Go-Lab or creating a space (ILS):

1) Starting with Go-Lab by looking at pre-made lessons.

2) Where to start when building a space (ILS).

3) How to find labs and ILSs in a specific language.

4) Finding apps, labs, and ILSs for a specific age group.

5) How to use apps.

5.2 Tips for Advanced Users

The tips for advanced users addressed issues that emerged when trying to set up apps, labs, and spaces. This is related to implementation issues as well. The topics of the tips were:

1) Examples of apps for primary education.

2) Setting up apps.

3) Examples of labs for primary education.

4) Providing feedback.

5) Combining classroom discussions and Go-Lab

5.3 Technical Tips

Finally, there were issues related to the technical part of Go-Lab in creating spaces in Graasp and sharing with students. These revolved around the following topics:

1) Auto-saving of student data.

2) Using images in a space.

3) Using other content in a space.

4) Sharing with students.

5) Using spaces in a space (ILS).

6 Next-Lab Infrastructure

In Go-Lab and up to now in Next-Lab, the apps and the labs are based on the opensocial standard which is enabling to run code hosted outside the ecosystem. This scheme has enabled teachers to easily integrate in Inquiry Learning Spaces content from a large community of providers. However, this technology which is relying on a Shindig server is now obsolete.

This old opensocial and shindig solution is now complemented by a new application programming interface (API) enabling any interactive Web content to be integrated and executed in Graasp. The old and the new scheme are supported concurrently, enabling old and new apps to work seamlessly in Inquiry Learning Spaces. All apps and labs are progressively adapted to rely on the new API, which should enable to depreciate the opensocial and shindig solution by the end of the project. The new API is described in Deliverable 4.4: Release of the consolidated underlying infrastructure (Gillet, 2018).

7 Conclusion

In conclusion, labs have been added to Go-Lab that cover the European primary school curricula. Labs have also been added that are easier to use for primary school students. Seventeen labs were discussed that either offer a new topic or are easier to use. Twelve of these 17 were selected and added from external sources, two labs were created, and three labs were adapted. In addition, we identified problems that primary school students could experience during inquiry learning and proposed suggestion to solve these. This led to new and adapted apps that better suit the needs and competence of primary school students. Eight apps were discussed of which one app was created, four apps were adapted, and three additional apps were evaluated. The feedback on the evaluated apps can be used in the future to further improve those apps or create versions for primary education. Finally, in the process of evaluating labs and apps for primary school, multiple common issues were identified. These were used to create tips for primary education. All these developments extend inquiry learning to a younger audience. In addition to work done in this deliverable, other developments in the Next-Lab project help to extend inquiry learning to primary education. An example is the co-creation of ILSs to empower teachers, where teachers and Next-Lab members collaborated to create ILSs, see ILSs with the label 'example ILS' on Go-Lab.

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Van der Graaf, J., Segers, E., & Verhoeven, L. (2015). Scientific reasoning abilities in kindergarten: dynamic assessment of the control of variables strategy. *Instructional Science, 43*, 381-400. doi: 10.1007/s11251-015-9344-y

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9 Appendix A: Teacher ratings of app usability in primary education

Based on the evaluation of suitability of apps performed by ULeic in collaboration with UCY and with the Next-Lab Core Group and PD teacher group, together with data on the actual usage of apps in ILSs, we would suggest to cover the following apps in our PD activities with primary school students and teachers or representatives (experts), see Deliverable 4.1 (Heintz & Law, 2017).

9.1 Must have (most to least):

Concept Mapper

• 4 out of 5 experts rated it as suitable for primary school students (8y+)

• Highly interactive

Conclusion Tool

• 3 out of 5 experts rated it as suitable for upper level primary school students (10y+)

• Highly interactive, but maybe complicated interactions

Data Viewer

• 5 out of 5 experts rated it as suitable for upper level primary school students (10y+)

• Highly interactive, but maybe difficult interactions

Experiment Design Tool

• 5 out of 5 experts rated it as suitable for upper level primary school students (four 10y+, one 11y+)

• Highly interactive

Question Scratchpad

• 5 out of 6 experts rated it as suitable for primary school students (four 8y+ and one 10y+)

• Medium level of interactivity

Hypothesis Scratchpad

• Maybe test Question Scratchpad, which is aimed at younger students, instead?

Padlet

• Not developed by project partners(?)

9.2 Nice to have (most to least):

Report tool

• Highly interactive

Reflection Tool

• Was not working in our test ('your time' was not displayed)!

• GUI is not very interactive for students, but comprehensibility of visualisation and the data presented could be tested.

ActionStatistics

• GUI is not very interactive for students, but comprehensibility of visualisation and the data presented could be tested.

ConceptCloud

• GUI is not interactive for the students => not much adaptation possible, but comprehensibility and reasoning for visualisation could be tested.

• Was not working in our test: Went into "loading forever mode" as soon as a second student created a hypothesis/concept map (in the student view).

Concept Map Aggregation

• GUI is not very interactive for students, but comprehensibility of visualisation and the data presented could be tested.

• Was not working as expected in our test: It only aggregated the Concept Maps of a single student, not all students in the ILS.

SpeakUp

• Typing as main interaction, but some additional functionality that could be evaluated

Observation Tool

• Typing as main interaction

Quiz tool

• Main tool features are for teachers

• Generated questionnaires could be tested with students, but not much interaction there (selecting an answer and typing as only interactions). Above Quest tool, because it provides feedback.

Quest

• Main tool features are for teachers

• Generated questionnaires could be tested with students, but not much interaction there (selecting an answer and typing as only interactions).

Calculator

• Standard calculator UI (which should be simplified for primary school students, e.g. remove square root and other advanced mathematical features)

Wiki App

• Typing as main interaction, but collaborative editing could be tested

• Some additional navigation functionality

• Was not working as expected in our test: It only showed the pages of a single student, not all students in the ILS.

Shared Wiki

• Typing as only interaction, but collaborative editing could be tested

Table tool

• Typing as only interaction

Input Box

• Typing as only interaction

File Drop

• Dragging and dropping of file as only interaction

Progress Bar

• Dragging being the only interaction

Online users visualisation

• No interaction

• Mainly for teachers

9.3 Not to have (least to most):

Chempy

• Too advanced for primary school students

Function Plotter

• Too advanced for primary school students (based on CGT rating)

GoModel

• Too advanced for primary school students (based on CGT rating)

Periodic Table

• Too advanced for primary school students (based on CGT rating)

• Not a lot of interaction

• The description on the portal contains a description of a FLICKR app (which no longer exists).

Reflection Tool (transitions)

• Too advanced for primary school students (based on CGT rating)

• Not a lot of interaction

• Was not working in our test!

Timeline

• Was not working in our test!

Geogebra

- Too advanced for primary school students (1 out of 5 thinks it is suitable for primary school students)
- A lot of functionality to be tested

Sysquake

- Too advanced for primary school students

SSH Webconsole FORGEBox widget

- Too advanced for primary school students

Mindmeister Widget

- Too advanced for primary school students (based on CGT rating)
- A lot of functionality to be tested
- To be replaced in the portal with a free tool?

Experimental Error Calculator

- Too advanced for primary school students
- A lot of functionality to be tested
- To be removed from the portal?

Concept Map Dashboard

- For teachers only
- Was not working in our test!

Student time spent

- For teachers only

Submitted files in ILS

- For teachers only

Teacher Feedback

- No interaction for the students

Viewer

- No interaction for the students

Semantic Group Formation App

- For teachers only

Automatic Generator of User Interfaces for Smart Labs

- For teachers only, but the automatically created UI could be tested with primary school students, if we have an appropriate lab.

10 Appendix B: Abstracts of Go-Lab app Evaluations

We want to thank all students that evaluated the Go-Lab apps as part of the module Psychology in Learning and Instruction at the University of Twente in 2018-2019. We want to thank the following students in specific, because their abstracts were used:

B. Alink, A. Assink, L. Bareišytė, J. Bašić, K. Bakker, T. Beadle, A. Böcker, L. Bernebée-Say, N. Binnenmars, N. Brummelhuis, I. Brüninghoff, C. Brychlec, S. Christin Linkhof, F. Dawo, A. Dehmel, T. Fastenrath, P. Friedrichs, C. Grömping, J. Hachmeister, M. Hackmann, H. Hanckmann, F. Hanefeld, L. Hogenkamp, I. Iliadis, N. Jenske, J. Kalefeld, I. Kovacs, A. Kühn, M. Lechtermann, L. te Mebel, S. Nagel, C. Nieto Subrá, L. Offereins, F. Platjes, R. Preissler, D. Rietvelt, M. Sares, M. Schaab, A. van Schaik, S. Schmeer, A. Sonawane, J. Stoelhorst, E. Tabune, S. Wehrmeyer, J. Zabrowarny.

10.1 Data Viewer

In this essay, it will be critically examined to what extent digital media aids children's inquiry learning through online lessons. This essay focuses on primary education students, which are given the possibility to learn via an online ecosystem called Go-Lab. The aim is to analyze whether online lessons can improve inquiry learning and to furthermore critically evaluate the usage of apps in the process of learning. At first, a theoretical framework about inquiry learning (Bell, Urhahne, Schanze, & Ploetzner, 2010), primary education (Copple & Bredekamp, 2009) and technology (Edmondson, Winslow, Bohmer, & Pisano, 2003) will be reviewed to deepen the information available to that topic and its connections to other relevant topics as cognitive development (Resnick & Ford, 2012). Based on that, features of the app 'Data Viewer' will be described, its relevance discussed, and evaluated in the light of scientific reasoning as less sufficient in a setting of primary education because the app required too many demands for that target group. Furthermore, with the possibility to expand the knowledge on a wider spectrum via generalization to another app from the Go-Lab platform the app 'Data viewer' will be compared to another app called 'Observation tool'. This essay manifests why the app 'Data viewer' is less appropriate in a primary education setting and gives reasons why some features of the app 'Observation tool' could be improved regarding the target group. This essay concludes that children's inquiry in online lessons can only be enhanced when the students' demands meet their developmental phase in which they are currently situated.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. International journal of science education, 32(3), 349-377. doi:10.1080/09500690802582241

Copple, C., & Bredekamp, S. (2009). Developmentally appropriate practice in early childhood programs serving children from birth through age 8: ERIC. Retrieved from: https://eric.ed.gov/?id=ED510265

Edmondson, A. C., Winslow, A. B., Bohmer, R. M., & Pisano, G. P. (2003). Learning how and learning what: Effects of tacit and codified knowledge on performance improvement following technology adoption. Decision Sciences, 34(2), 197-224. doi: 10.1111/1540-5915.02316

Resnick, L. B., & Ford, W. W. (2012). Psychology of mathematics for instruction: Routledge.

Nowadays, due to the global process, the fields of education, engineering, mathematics and science become more and more important. Science education gets therefore more attention and shifts the focus from traditional learning methods to digital media and inquiry learning (Gillet, De Jong, Sotirou, & Salzmann, 2013). One system, which deals with inquiry learning and digital media

at the same time is the online ecosystem Go-Lab (www.golabz.eu). Here teachers can design various spaces, in which students can explore the world of science on their own by doing different experiments. Students have the possibility to design their own experiments, generate hypotheses, observe the trials and form conclusions in different online labs (Gillet, De Jong, Sotirou, & Salzmann, 2013; Go-Lab, 2018). When dealing with complex tasks like inquiry-based learning in the Go-Lab, children often have problems. Especially children in primary school need help by the execution of these processes as their scientific reasoning is not fully developed yet (Mayer, 2008; Zimmerman, 2007). Thus, they get help by the "data viewer", which is an app in order to visualize the data which were collected during an experiment in form of different types of charts. This can help the children to engage in the process of inquiry learning more easily. All in all, children can benefit from using the data viewer as they learn how to deal with inquiry learning by using digital media simultaneously, which supports the students in executing different inquiry learning activities. Furthermore, the visualization in a chart can help them to better understand the results. However, the data viewer should only be used with the support of a teacher as students in primary school probably have no prior knowledge about charts as it is not part of the syllabus in primary school. Furthermore, the app does not give explanations itself about the different charts, which the students need in order to understand them.

This Essay examines the beneficial features and features that can be improved of the Go-Labs app Data Viewer, which is an inquiry-learning tool to support this process. Media literacy is gaining importance across international school curricula since the usage of technical devices and programmes are becoming increasingly expected and meaningful for the later working life as well as in an academic career. During the inquiry-learning cycle, students participate in four stages, in which they are assisted by their teacher to successfully develop knowledge about the topic they are curious about. However, the currently available version of the Go-Lab is the first version and not perfect by now, therefore main criticism points are the usability and design for a target group that is ranging from 10 to 18. The results provide the implication that the usability can be increased by an instruction to the app prior the first usage, to ease the students understanding of functions, benefits and feature of the app for a more successful use of the app. Furthermore, the look of the app can be improved through the visualisation of the icons. The most important implication is to split up the app to make it more age-specific and usable to students until the age of 12.

Inquiry learning is a way of learning where students get to explore scientific discoveries themselves by making investigations (Lazonder, & Harmsen, 2016). Studies have shown that online learning spaces have positive effects on student's engagement, interest, and motivation (Jagušt, Boticki, & So, 2018). Go-lab is an online inquiry learning space where students have the chance to work as scientists in virtual laboratories. Since science can be difficult for primary school students, Go-Lab offers multiple apps to make the process of generating theories and investigating data, easier. One of these apps is the Data Viewer app. The Data Viewer app aims to help students investigate their data and see it as more concrete. The aim of this paper is to answer the research question: "Is the Data Viewer app a suitable tool for primary school students to use as an aid for inquiry learning?". An analysis of the app was conducted to answer this. Improvements such as adding guidance on what to do, providing feedback on whether the task is completed as it should be and adding colours to make the app more user-friendly and appealing for young children, were suggested. By focusing on improving the app, primary school students can use the app as an aid for their learning process and focus primarily on science learning instead of trying to interpret the app and therefore overloading their cognitive capacities.

Lazonder, A, W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. Review of Educational Research, 86(3), 681-718. Doi: 10.3102/0034654315627366

Jagušt, T., Boticki, I., & So, H.-J. (2018). A review of research on bridging the gap between formal and informal learning with technology in primary school context. Journal of Computer Assisted Learning, 34(4). 417-428. Doi: 10.1111/jcal.12252

The online learning environment 'GoLabz' is an interactive space that aims at fostering knowledge in children by offering the chance to conduct scientific experiments. Since this method of inquiry learning is still a novelty with regard to teaching approaches, this essay discusses the appropriateness of the data viewer app to foster inquiry learning in children in primary education. The data viewer is a GoLabz tool aiding graphical visualization of data obtained in GoLab experiments. Taking scientific framework into consideration, it can be said that the current version of the data viewer is not yet suitable for fostering inquiry learning in children in primary education, because the knowledge requirements with regard to statistical knowledge are not in accordance with the actual knowledge skills of primary school students. Nevertheless, the data viewer app provides a valuable basis for a general educational shift towards inquiry learning.

10.2 Conclusion Tool

Technology turned out to be a useful instrument in nowadays education. Teachers are looking for effective ways to implement new media in their lessons. The online ecosystem GoLab provides the opportunity for teachers to create lessons according to their needs. The essay focuses on the app conclusion-tool that is offered on the platform. The conclusion tool supports students in making conclusions. In order to do so, they can revise their hypothesis and the respective confidences. The advantages and disadvantages of the GoLab-app for the usage in primary educations' inquiry learning were evaluated. In general the app seems to be useful for the target group, especially because of the structured guidance, concrete methods and the overview over hypotheses and observations. Limitations are the lack of an attractive design, as well as missing reinforcement methods and feedback. Suggestions for improvement are that the app should include more playful features such as a pet avatar that the children can achieve points for.

This essay offers an insight into how Go-Lab apps, by looking at the app "conclusion tool", can contribute to aid children in educational settings. Thus, the essay focuses specifically on the pros and cons of establishing this app in a classroom environment for primary school students in the age of 5-9 and is an attempt to further optimize it when it comes to design and content features. The question that is central to this paper is to what extent does the virtual Go-Lab "conclusion tool" with its structure, composition and content features succeed, in supporting an effective and nurturing inquiry learning environment for primary school children in the age of 5-9. Introduced inquiry and digital learning literature argue and highlight the importance of primary school students overcoming their misconceptions and along the way are supported by valuable instructions that foster scientific and critical thinking. The Go-Lab conclusion tool is considered to be one of these instructional scaffolds that combines inquiry learning within a digital media environment. Consequently, as literature supports, a digital environment is created that can promote cognitive processes by integrating them in tools, such as the conclusion tool, to help learners overcome persisting pre-existing beliefs on scientific contents and change them (De Jong, 2006). Along with the analysis of the Go-Lab evaluation tool, theories and perspectives on inquiry learning in digital settings, conclude that the tool succeeds in providing a base for the discussed main aspects of

inquiry learning in digital classrooms. However, in order to create a conclusion tool that successfully contributes to a development of structured, scientific working in primary school children aged 5-9, the developers need to consider improving structural features and integrate feedback options in combination with collaborative working methods. De Jong, T. (2006). Technological advances in inquiry learning. Science 312, 532-533.Doi:10.1126/science.1127750

With increasing changes in the field of education, one can see a rise in the use of technology and computer simulations in learning environments. Learning is also becoming more learner-centric, and there is a strong focus on the learner as an active agent in the process of knowledge acquisition. (de Jong & Joolingen, 1998) This essay is centered around the role of inquiry based learning and digital media. It further talks about the factors that are necessary for it to be an effective contributor to the learning process. The essay analyzes the use of the Conclusion Tool of the Go Lab ecosystem for students of ages 7-9; the main areas of focus being - the role of digital media, support in inquiry learning, the importance of feedback, cognitive load and assessments and how all these factors affect the utility of the conclusion tool for the target age group. It aims to analyze whether students of the target age group are able to identify how a tool such as the conclusion tool works, whether they are able to understand its purpose and most importantly, does this tool work effectively and facilitate good learning outcomes. It is noted that an app such as the conclusion tool could be an effective contributor to facilitate better learning outcomes; however, since feedback facilitates learning performance (Ovando, 1994), it would require more guidance, prompts and a greater degree of feedback to be of optimal use for this age group. Jong, T. D., & Joolingen, W. R. (1998). Scientific Discovery Learning with Computer Simulations of Conceptual Domains. Review of Educational Research, 68(2), 179. doi:10.2307/1170753
Ovando, M. N. (1994). Constructive Feedback. International Journal of Educational Management, 8(6), 19-22. doi:10.1108/0951354941006918

Nowadays the use of digital media in the learning environment is very common and different learning materials based on technology are being created. The Go-Lab website is an online laboratory which helps students learn science through inquiry learning thanks to different applications. The purpose of this paper is to conclude whether one of this apps, the conclusion application, is suitable for primary school students, more concretely, the ones who are finishing this educational cycle. Aspects which have been taken into account to determine the suitability of the app are the steps of the inquiry cycle (Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T. Constantinos C. Manolic Zacharias C.Zachariac & Tsourlidaki, E. 2015), the importance of metacognitive skills in order to carry out an effective inquiry learning (Hacker, Dunlosky, Graesser, 2009) and the advantages that digital media offers to education (Edelson, Gordin, Pea, 1999). Based on different studies and literature by psychologists and experts in the education field, it is concluded that, even though some features could be added to the application to make it more efficient, it is suitable for students between 10 and 12 years old when it´s use is accompanied by appropriate guidance.

The European Project Go-Lab is set up to make it easier to use inquiry-based learning and let education fit in with the current beliefs and trends in learning. Inquiry-based learning is in this case supported by apps. One of these apps is a conclusion tool, which supports the user in drawing a conclusion. The project focuses on children between six and eighteen years old, but they have differences in development, which makes it hard to make an app suitable for all ages. So focussing on only one target group, the main question is: Is the conclusion tool suitable for children in the age

group of 6-8 years old? Suitable in this context means that the average child in that age group is capable of using the app without further instructions. The app contains a lot of problems concerning the suitability of the app. The metacognitive skills , for instance, are not corresponding to the degree of skills the children developed. Furthermore, the app does not take the shift from the iconic to the symbolic mode (Bruner, 1964) into account, as well as considering systematically and logically thinking (Piaget, 1951). Overall, the app is thus not suitable for children in the age group of six to eight years old.

Bruner, J. S. (1964). The course of cognitive growth. American Psychologist, 19, 1-15. DOI: 10.1037/h0044160.

Piaget, J. (1951). Play, dreams and imitation in childhood. New York: International Universities Press (Original published in 1936).

Inquiry learning, digital media, and technology is the debate for the 21st-century learning environment. The government of the Netherlands calls for more necessity for skilled workers and researchers in the future that have the knowledge about science and can work successfully with digital media in a 21st-century environment. Inquiry-based learning follows basic cycle of Orientation, Conceptualisation, Investigation, Conclusion, and Discussion. Digital media helps to acquire skills to learn about new technologies. Following Conceptual Change theory described in the book of Mayer (2008) by views of Piaget, students follow new conception of learning sciences not by description, but by explanation. The aim of this paper was to investigate application called Conclusion tool and the extent to its aid for primary school children age 9 and up. The app is available online as a part of the Go-Lab Ecosystem and is available on https://www.golabz.eu/app/conclusion-tool. Conclusion tool is an app that gives an opportunity for students to write down their conclusion after experiment. Where, within the app, student can access information such as hypothesis, review data and change the hypothesis. Findings show that app helps students to navigate with ease and easy access to toolbar and hypothesis, where hypothesis can be activated. Conclusion tool also gives opportunity to write down the reflection of the results and use scientific language. App has some inconsistencies with demo and actual use, which could be improved. Overall, app is good tool in education with digital media as young as nine and older, with reasonable guidance.

The goal of the at hand essay is, to answer the question of whether the 'conclusion tool' is suitable for primary education students. The 'conclusion tool' belongs to the webpage 'Go-Labz', which is a panel where children can try different experiments and evaluate their collected data. Students in primary education are four to 12 years old, however, the focus of this essay lays on children from five to eight years. Main findings reveal that the 'conclusion tool' is not yet suitable for children in primary education. The app displays a variety of aspects that might not be easy for children from this age group to understand because children did not yet develop the capability of thinking abstract as the app partly demands. In order to make the app as enjoyable and convenient as possible, improvements such as changing wordings or introducing symbols need to be made.

Technology transformed learning and instruction in decisive ways (Prensky, 2005). The platform golabz.eu provides apps that aid students' inquiry learning in a 21st-century style (Gillet, Rodríguez-Triana, De Jong, Bollen, & Dikke, 2017). Inquiry learning includes familiarizing with a scientific problem, developing and testing hypotheses as well as drawing conclusions (GO LAB, n.d.-b). To test the usefulness of inquiry learning in secondary school, the app "Conclusion Tool" was analysed. Results show that the aforementioned tool guides students' self-regulation and promotes students' motivation and engagement during inquiry. Yet, the app does not support students' inquiry learning holistically. The students do not learn how to familiarize with and

investigate scientific problems. Instead, students only learn how to draw conclusions (GO LAB, n.d.-a). Thus, the conclusion tool is exclusively useful for students in secondary school who are advanced   inquiry   learners.

Gillet, D., Rodríguez-Triana, M. J., De Jong, T., Bollen, L., & Dikke, D. (Eds.). (2017). Cloud ecosystem for supporting inquiry learning with online labs: Creation, personalization, and exploitation (4th). Faro, Portugal: IEEE.
GO-LAB. (n.d.-a). Conclusion Tool. Retrieved October 20, 2018, from https://www.golabz.eu/app/conclusion-tool
GO-LAB. (n.d.-b). Inquiry Learning Cycle. Retrieved October 20, 2018, from http://support.golabz.eu/support/inquiry-learning-cycle
Prensky, M. (2005). Listen to the Natives. Educational Leadership, 63(4), 8–13.

This paper discusses the question to what extent the Go-Lab conclusion app can aid inquiry of children in primary education within an online lesson. During the last years, there was a shift in education from simple expository methods to more interactive and exploratory methods used in classrooms. The example used in this essay is the online inquiry-learning space "Go-Lab" which offers different lessons and apps which help learners to develop scientific knowledge and reasoning abilities. The "conclusion app" of Go-Lab should help children to arrive at a final conclusion for an experiment they have conducted. However, there are several implications for learning that need to be taken into account when confronting young children with an online learning space of this kind and the corresponding apps. In this essay, the conclusion app of Go-Lab is analyzed based on theoretical frameworks concerning learning in primary education and inquiry learning. For instance, Lazonder and Harmsen (2016) argue that inquiry learning is more effective than traditional methods, but children need adequate support and guidance in order to be successful in those tasks. Furthermore, it was found that children's attention must be guided towards the most important steps of problem-solving to achieve learning (Reiser, 2004). The analysis indicates that the conclusion app incorporates some main elements of inquiry learning such as the opportunity for children to explore the subject matter since they have to arrive at a conclusion on their own. However, in order to achieve the best aid for inquiry for children in primary education, feedback, and some instructions should also be added to the app. This paper informs about advantages that already are incorporated in the online learning space Go-Lab and its conclusion tool, and about disadvantages and how those can be changed to improve the usefulness of the conclusion tool.

Lazonder, A. W., & Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning. Review of Educational Research, 86(3), 681–718. doi:10.3102/0034654315627366
Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. Journal of the Learning Sciences, 13, 273–304. doi: 10.1207/s15327809jls1303_2

This essay aims to establish the extent to which digitalization of the educational field aid's children's inquiry learning. Firstly, the terms digital media, inquiry learning, and web-based inquiry learning will be explained followed by an analysis of the effectiveness of the inquiry learning approach. The analysis part refers to the specific app chosen for this paper, called the 'conclusion tool'. It is part of a web-based learning program for students, Go-Lab, which uses the educational strategy of inquiry learning online. The concrete app will be analyzed in regards to its effectiveness for children 12 years of age in terms of an argumentation in favour and against it. The conclusion will consist of an answer to the research question, a way of improving the existing app and, also a reference to a different app of the Go-Lab program. At last, based on the reviewed literature, it can

be said that the app is well suited for the targeted group and has positive influences on children's inquiry.

Go-Lab is an online inquiry based learning platform which uses several apps as scaffolds to aid learners in the inquiry process. One of these apps is the conclusion Tool which scaffolds the evaluation process by prompting hypotheses recall, input of experiment data and evaluation of confidence in the hypothesis. Since inquiry based learning is used more and more as a means to prepare learners for solving the complex problems the twenty first century holds (Vincent-Lancrin, 2014), we ask whether the Conclusion Tool in particular can aid learners in acquiring the necessary skills to be prepared for their futures. The app is analyzed to determine its suitability for classroom instruction in primary education. The app provides adequate structure for the evaluating process, by remembering the hypothesis, providing evidence and indicating confidence, thereby using scaffolding and prompts (de Jong & Lazonder, 2014). Yet it offers no support for assessing the experiment data, which is something that young learners still experience difficulties with (Klahr & Dunbar, 2018), (Koslowski, Marasia, Chelenza, & Dublin, 2008). It is determined that for the app to be suitable for use in primary education extra support should be provided for determining the usefulness of the data collected during experiments. This support could be in form the form of prompts during the experiment phase which tell the student that the current design is incapable of providing evidence for the hypothesis, such as demonstrated by Veermans in a different digital environment (Veermans, 2003), or the input of data in the tool could be restricted to the variables used in the current hypothesis. We conclude that with extra support for evaluating the experiment data, the Conclusion Tool can be suitable for use in inquiry based learning in primary education.

de Jong, T. & Lazonder, A. W. (2014). The Guided Discovery Learning Principle in Multimedia Learning. In The cambridge handbook of multimedia learning (p. 371). Cambridge University Press.
Klahr, D. & Dunbar, K. (2018, 10). Dual Space Search During Scientific Reasoning. Cognitive Science, 12 (1), 1–48. doi: 10.1207/s15516709cog1201_1
Koslowski, B., Marasia, J., Chelenza, M., & Dublin, R. (2008). Information becomes evidence when an explanation can incorporate it into a causal framework. Cognitive Development, 23 (4), 472–487. doi: https://doi.org/10.1016/j.cogdev.2008.09.007
Veermans, K. (2003). Intelligent support for discovery learning (Unpublished doctoral dissertation). Netherlands.
Vincent-Lancrin, S. (2014). Overview: Why and how to measure innovation in education. In Measuring innovation in education: A new perspective. OECD Publishing, Paris. doi: 10.1787/9789264215696-en

The goal of this research was to investigate whether the conclusion tool app was suited for twelve year old primary school children. This has been examined by considering the pros and cons. The first advantage of the app is that metacognitive strategies will be taken into consideration in the conclusion tool; the students have to reflect on their own learning process. Secondly, students work according to the predict-observe-explain (POE) method, which leads to better learning outcomes (Mayer, 2008). Unfortunately, some cons have been discovered as well. To start with, no sufficient support has been given in the app. On top of that, children are not provided with feedback in the app. The main finding of this essay is that it would be advisable to make some adjustments in the app, which can be done by including features of the "Speak up" app, in which children and the teacher can explain things to each other, give feedback, and test each other's knowledge. In conclusion, it can be said that although the conclusion tool has a lot of good features, it is not complete in being a sufficient tool for twelve-year-olds.

Mayer, R.E. (2008). Learning and instruction. Upper Saddle River, NJ: Pearson Education.

Inquiry based learning and digital media might influence the way in which primary school children learn about science. They both – inquiry learning and digital media – represent a change in how education in the 21st century takes place. While inquiry learning is succeeding direct instruction which for a long time has been the primary source of teaching in school settings (Cobern et al., 2010), digital media finds its ways in the schools with the usage of computers, smartphones, and tablets throughout all levels of education (Domingo & Garganté, 2016). A recently developed app – the conclusion tool – combines the two aspects of using media and inquiry based learning, which also is known as ''scientific discovery learning'', since it is most often used in scientific fields of working (van der Graaf, 2018). The conclusion tool is part of a web page in which several apps are available to guide children through different scientific experiments. There are a number of advantages the conclusion tool bears based on theoretical frameworks in the field of learning and instruction. However, some disadvantages of the usage of the app for primary school children emerge due to the fact that those theoretical frameworks could be incorporated more adequately. All in all, the app can be used in classroom settings, but it could be tailored to the learning capacities of primary school children more effectively.

Cobern, W. W., Schuster, D., Adams, B., Applegate, B., Skjold, B., Undreiu, A., ... & Gobert, J. D. (2010). Experimental comparison of inquiry and direct instruction in science. Research in Science & Technological Education, 28(1), 81-96. doi:10.1080/02635140903513599
Domingo, M. G., & Garganté, A. B. (2016). Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom. Computers in Human Behavior, 56, 21-28. doi:10.1016/j.chb.2015.11.023
van der Graaf, J. (2018). Inquiry based instruction [PowerPoint slides]. Retrieved from: https://canvas.utwente.nl/courses/1749/pages/theory-part-b-lectures-and-tutorials

Today using digital media and technology is unconceivable. Thus, also in today's classrooms technology becomes used more frequently (Dillorn & Gabbard, 1998). Websites like "Go-Lab" support learning through digital media. The website offers different experiments which can be conducted. Additionally, students can use different apps that help them to keep track of their learning process. With the Conclusion Tool students can come up with conclusions about conducted experiments. However, Go-Lab is introduced as suitable for children from young age until adolescence. Keeping different theoretical frameworks into mind, it is questionable whether the same learning spaces are suitable for children of all age. Therefore, the research question whether the Conclusion Tool is suitable for its use in primary school (6-10 years) has been formulated and answered. Research has shown that using technology in general is beneficial already for primary school students (Rachmadtullah, Ms, & Sumantri,2018). However, it needs to be analysed what it takes to be effective. On basis of theoretical framework of digital media (Interactive Learning Environments) (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003) and on inquiry-based learning (de Jong, 2010) the app has been analysed. Since not all criteria of effective digital media use and additionally, not all aspects of inquiry-based learning are covered by the app, it has been analysed as not suitable for its usage in primary school (6 -10 years). Therefore, fulfilling criteria of effective digital media use, for instance including feedback and adding new information, could help to improve the app.

Aleven, V., Stahl, E., Schworm, S., Fischer, F., Wallace, R. (2003). Help Seeking and Help Design in Interactive Learning Environments. Review of Educational Research, 73(3), 277-320.
de Jong, T. (2010). Technology supports for acquiring inquiry skills. In International Ecyclopaedia of Education. Elsevier.

Dillon, & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. Review of Educational Research, 68(3), 322-3.
Rachmadtullah, R., Ms, Z., Sumantri, M.S. (2018). Development of computer-based interactive multimedia: Study on learning in elementary education. International Journal of Engineering and Technology (UAE), 7(4), 2051-2054.

In modern society there is a growing need for people well educated in the fields of STEM (Science, Education, Engineering, and Mathematics) (OECD, 2014). Due to this, science education is getting more attention worldwide, and traditional teaching techniques are increasingly being replaced by digital media and inquiry learning (OECD, 2014). Research (Eshach, 2005) agrees science should be taught in early childhood. Guidance in inquiry learning is shown to enhance performance success and learning outcomes (Lazonder & Harmsen, 2016). A modern version of this guidance can be supplied using digital media, like the online eco-system Go-Lab and apps such as the conclusion or observation tool. The focus in on first-grade students learning inquiry in an online setting. The conclusion tool is designed to help in the fourth step of the inquiry cycle: Conclusion (Pedaste et al., 2015). It provides many forms of guidance (Lazonder & Harmsen, 2016), as well as resource-based learning environment tools and scaffolding mechanisms (Hill, 2001). Prompts (Lazonder & Harmsen, 2016) enable them to do tasks they could perform but are not aware they have to do. Explanation (Lazonder & Harmsen, 2016) helps fill the children's lacking knowledge about the inquiry cycle. Several scaffolds (Lazonder & Harmsen, 2016) offer the learner support in the more demanding parts of their task. Conceptual and metacognitive scaffolding mechanisms (Hill, 2001) aid the learner in understanding what is known, how to think, and stating things to consider. There are no process constraints (Lazonder & Harmsen, 2016), keeping the task simple for the students. The digital media setting is taken advantage of to supply the children with tools (Hill, 2001) provide cognitive support, by aiding processing or locating of data. Furthermore, coinciding with the aim of the conclusion step of the inquiry cycle, manipulating tools (Hill, 2001) are embedded in the tool to aid the children in testing their beliefs, theories, or in this case their hypothesis. In conclusion, the Go-Labs conclusion app can be a useful tool to aid children's inquiry in a first-grade online lesson.

Eshach, H. H. H. (2005). Should science be taught in early childhood? Journal of Science Education and Technology, 14(3), 315-336. https://doi.org/10.1007/s10956-005-7198-9
Hill, J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. Educational Technology Research and Development, 49(3), 37-52. https://doi.org/10.1007/BF02504914
Lazonder, A. W., & Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning: Effects of Guidance. Review of Educational Research, 86(3), 681-718. https://doi.org/10.3102/0034654315627366
OECD. (2014). Measuring innovation in education: a new perspective, educational research and innovation. OECD Publishing. https://doi.org/10.1787/9789264215696-en
Pedaste, Margus & Mäeots, Mario & Siiman, Leo & de Jong, Ton & Riesen, Siswa & T. Kamp, Ellen & Manoli, Constantinos & Zacharia, Zacharias & Tsourlidaki, Eleftheria. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. Educational Research Review. 14. https://doi.org/10.1016/j.edurev.2015.02.003.
Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. Developmental Review, 27(2), 172-223. https://doi.org/10.1016/j.dr.2006.12.001

The aim of this essay was to look whether the Go-Labz conclusion tool aids primary school children, around ten years of age, in their online learning process of scientific reasoning abilities. Children start developing this ability when entering primary education and develop this through the years. This ability enables students to construct their own knowledge and improve their mental models, which can be done their inquiry learning. Inquiry learning is a strategy in which students obtain new knowledge by conducting an experiment similar to the way professional scientist do. Go-Labz is an online learning environment based on inquiry learning in which several apps are provided, the conclusion tool is one of these apps. This app assists the students in stating a conclusion. The findings suggest that the conclusion tool lacks the opportunity to use newly obtained mental models and the lacks attention for the difference between students. However, there was also found that the Predict Observe Explain theory had a positive influence on the scientific reasoning abilities. The conclusion tool does therefore aid the scientific reasoning abilities to some extent but there has to be improved a lot.

Daniel, M. F., de la Garza, T., Lafortune, L., Pallascio, R., Slade, C., & Splitter, L. (2005). Modeling the development process of dialogical critical thinking in pupils aged 10 to 12 years. Communication Education, 54(4), 334-354. doi:org/10.1080/03634520500442194

Cavallo, A. M., Gerber, B. L., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. International Journal of Science Education, 23(5), 535-549. doi:org/10.1080/09500690116971

Karamustafaoğlu, S., & Mamlok-Naaman, R. (2015). Understanding Electrochemistry Concepts using the Predict-Observe-Explain Strategy. Eurasia Journal of Mathematics, Science and Technology   Education,   11(5),   923-936.   doi:org/10.12973/eurasia.2015.1364a

Digital media and new technologies showed to be influential and successful in the educational setting. There is a shift from classical pedagogy to more authentic and inquiry-based learning, which can be effectively implemented within an online environment (Bruce, & Casey, 2012). It incorporates a process of active engagement with the learning content by orienting on the topic, asking questions, investigating solutions, discussing-/ and reflecting on experiences (Bruce & Casey, 2012.). The online application "Go-Lab" provides a digital learning environment for primary and secondary students. The website consists of several apps such as the "Conclusion Tool", that provides support in drawing conclusion. But less is known about whether this app offers an appropriate design and application for the younger users of this website. Primary students put different demands on the website and the online learning environment must account for the differences in cognitive and executive skills of their user (Lazonder, & Harmsen, 2016). This essay evaluates the suitability of the app "Conclusion tool" for its application in an online learning environment for six-year-old students. The app is useful for elementary students as it fosters inquiry learning and supports students in their metacognition and scientific reasoning (Mayer, 2008b). Limitations are missing reinforcers and guidance. The arrangement, design, and function of the features lack essential components such as essential principles for implementing learning instructions in an online learning environment (Mayer, 2008a). To increase motivation and learning performance, a more attractive design, a pictorial representation such as smileys, and change in the handling of the app are suggested to improve.

Bruce, B. C., & Casey, L. (2012). The practice of inquiry: A pedagogical 'sweet spot 'for digital literacy? Computers in the Schools, 29(1-2), 191-206. doi: 10.1080/07380569.2012.657994

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. Review of Educational Research, 86(3), 681-718. doi:.10.3102/0034654315627366

Mayer, R. E. (2008a). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. American psychologist, 63(8), 760. Doi: 10.1037/0003-066X.63.8.760

Mayer, R. E. (2008b). Learning and instructions (second edition). Upper Saddle River, NJ: Pearson. ISBN: 978-0-13-170771-9

The following essay has investigated the Conclusion Tool App. The app is part of Go-Lab, a European project which is trying to integrate inquiry-based learning and its complexity in one website. To find pros and cons for the use of the app, the following paper has drawn a connection between it and the learning approaches of cooperative learning and guided discovery. The conducted analysis found that working in groups and being guided by a teacher can improve the appropriates of the app (Slavin, Hurley & Chamberlain, 2003; Mayer, 2008). Moreover, it was shown that metacognition development exerts an influence on scientific reasoning (Veenman, 2013). Overall, it was clarified that the app can help students with writing a conclusion. However, the app does not distinguish between children with a high metacognition level and the one with a low level. In addition, there is not enough help provided in case students do not understand the app's features or cannot recognize anomalous data. Together, these findings suggest that the app is more helpful for students who are highly developed in metacognition and do not need much guidance to use the app.

Mayer, R. E. (2008). Learning and instruction. Upper Saddle River, N J: Pearson Merrill Prentice Hall.

Slavin, R. E., Hurley, E. A., & Chamberlain, A. (2003). Cooperative learning and achievement: Theory and practice. In W. M. Reynolds & G. E. Miller (Eds.), Handbook of psychology: Vol. 7. Educational   psychology   (pp.   177-198).   New   York: Wiley. https://doi.org/10.4000/educationdidactique.334

Veenman, M. V. J. (2013). Metacognition: 'Know thyself'. Use that knowledge especially to regulate your own behavior. De Psycholoog, 50 (special ed.) 8-17.

In this study, the online inquiry learning environment app "Conclusion tool" is investigated based on its suitability for educational purposes in primary schools. The observations displayed a lack of competence in working effectively for elementary school children, due to a lack of guided discovery. Young learners undergo extensive development in terms of conceptual knowledge and do not possess subject domain concepts (such as writing-processor writing skills) required to carefully execute the App.

Schools are continuously faced with the challenge of better-equipping their students with 21st century skills such as critical thinking, technological literacy, and scientific reasoning (National Research Council, 2000). Educational policy bodies around the globe consider Inquiry Learning to be vital to the development of these 21st century skills (European Commission, 2007). Go-Lab, an online inquiry learning ecosystem, has been developed to support students during online scientific investigations. The Conclusion Tool, an application used in Go-Lab, allows students to actively formulate a conclusion to their investigation. The present paper analyzes the extent to which the Conclusion Tool is effective for developing primary school students' inquiry skills (i.e., scientific reasoning) in an online lesson. Firstly, it is shown that the Conclusion Tool makes age-appropriate use of inductive and authentic methods of learning, both of which have been found to promote primary school students' scientific reasoning skills (Roughead and Scandura, 1968; Lee & Butler, 2003; Mayer, 2007). Secondly, it is shown that the CT may not effectively support primary school students, in the form of both scaffolding and feedback. There is substantial evidence attesting to the importance of support and guidance during inquiry learning (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; Brown & Campione, 1994). Despite its usage of inductive and authentic learning methods, the present paper concludes that the CT may not provide sufficient guidance to

effectively foster primary school students' inquiry learning skills. Recommendations to improve the suitability of this application for primary school students are highlighted.

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? Journal of educational psychology , 103 (1), 1.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. The MIT Press.

European Commission. High Level Group on Science Education, European Commission. Science, Economy, & Society. (2007). Science education now: A renewed pedagogy for the future of Europe (Vol. 22845). Office for Official Publications of the European Communities.

Lee, H. S., & Butler, N. (2003). Making authentic science accessible to students. International Journal of Science Education , 25 (8), 923-948.

Mayer, R. E. (2007). Learning and instruction. Upper Saddle River, N.J: Pearson.

National Research Council. (2000). Inquiry and the national science education standards: A guide for teaching and learning . National Academies Press.

Roughead, W. G., & Scandura, J. M. (1968). " What is learned" in mathematical discovery. Journal of Educational Psychology , 59 (4), 283.

10.3 Observation Tool

The increasing use of social media causes an ongoing information stream requires people to constantly analyse the incoming information (Luka, 2014). To avoid overstimulation of the brain, people should be taught to learn what to do with this information starting as young as possible in the primary education. To teach children the required skills to look critical to incoming information, inquiry based learning is used. Inquiry based learning teaches to explore the world, to be critical, to ask questions and make new discoveries to understand new concepts and information (De Jong, 2016). This increasingly gets taught by the use of online learning environments. Go-Lab is such an learning environment and in this essay it is examined whether the observation tool of Go-Lab is suitable for 10 and 11 year old children to help them learn in an inquiry based environment. The observation tool can be used to write down observations of online or offline experiments, and exists of one page with 7 icons to execute different actions. Three pros and four cons can be found when analysing the page. The main advantage was the clearness and structure of the tool and its icons. The main disadvantage was the lack of information and explanation to make it understandable for 10 – 11 year olds. The disadvantages make the inquiry based learning process difficult for the targeted age group. Therefore it is concluded that the tool is not suitable for the target group. It is advised to add more information on what observation is and how it should be conducted. Also observation schemes can be useful and guide the students. It was found that the findings for the observation tool can also be generalized to the conclusion tool of the Go-Lab app.

De Jong, T. (2006). Technological advances in inquiry learning. Science Magazine, 312, 532- 533. Retrieved from: http://users.edte.utwente.nl/jong/JongScience2006.pdf

Luka, I. (2014). Design thinking in pedagogy. Journal of Education Culture and Society, 2, 63-74. DOI: 10.15503/jecs20142.63.74

The goal of this essay was to analyze the effectiveness of the observation tool of the Go-labz website. Very broad, Go-labz was designed to offer students of all ages a chance to work and experiment within a virtual context. One of the many tools to use is the observation tool, which gives an elaborative space to put in observations the student came up with up to this point. The purpose of this study is to identify the possibility of the tool to help second to fourth graders to come up with correct observations. There is a focus on the mechanisms of inquiry learning and the

amount of guidance, the app offers during the process (Abd-El-Khalick et al., 2004). It turned out that the app does a good job in offering a platform for students to come up with their own solutions and enable inquiry learning. However according to Chen and Klahr (1999) without any kind of guidance, the students might fail to deliver the correct solution, since the young target group is still at the very beginning of their academic careers. Therefore, additional extra help within the app should facilitate the process of a successful guided inquiry learning process.

Abd-El-Khalick, F., BouJaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., … Tuan, H. (2004). Inquiry in science education: International perspectives. Science Education, 88(3), 397–419. Doi:10.1002/sce.10118

Chen, Z., & Klahr, D. (1999). All Other Things Being Equal: Acquisition and Transfer of the Control of Variables Strategy. Child Development, 70(5), 1098–1120. Doi:10.1111/1467-8624.00081

The Go-Lab was created in 2012 to serve as an online platform to support inquiry-based learning in schools. In the Ecosystem, both high school students as primary school students can conduct their own digital experiments in virtual laboratories. While conducting experiments in these laboratories, students can use Apps that support them in their process (Go-Lab, 2018). The Go-Lab aligns with inquiry-based learning, which has grown to have an important role in science education nowadays (Edelson, Gordin, & Pea, 1999). Digital media is another trend in education and is often combined with inquiry-learning, like in the case of Go-Lab. In education, digital media is helpful because "the digital visualization of information aids the understanding of abstract concepts" (Kraidy, 2002). This Essay will focus on a Go-Lab App, called the Observation Tool. This App allows students to write down their observations when doing an experiment. This app connects to the investigation phase of the inquiry-cycle (Pedaste, 2015). This essay will elaborate on the features of the App, as well as on the advantages and disadvantages and the research question of this essay will be as follows: to what extend can the Go-Lab Observation Tool App aid the inquiry-based learning process of primary school students? In this essay it is seen that the Observation Tool is indeed a useful tool to aid the inquiry-based learning process. Nevertheless, it is also seen that the App is less useful when a student has errors in their current mental model, but not enough metacognition skills to fix these errors (Mayer, 2003). On top of that, the Observation Tool only supports a very small part of the inquiry-cycle. Also, some suggestions are made to improve the App. One example of a suggestion is adding a save option to the app. To conclude with, the App can be very useful in inquiry, when used properly and in cooperation with other materials.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. Journal of the learning sciences, 8(3-4), 391-450.

Go-Lab Ecosystem. (n.d.). Home | Golabz. Retrieved October 15, 2018, from https://www.golabz.eu/

Keselman, A. (2003). Supporting inquiry learning by promoting normative understanding of multivariable causality. Journal of Research in Science Teaching, 40(9), 898-921.

Kraidy, U. (2002). Digital media and education: cognitive impact of information visualization. Journal of Educational Media, 27(3), 95-106.

Mayer, R. E. (2003). Learning and instruction. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

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.

Pedaste, M., Mäeots, M., Leijen, Ä., & Sarapuu, T. (2012). Improving students' inquiry skills through reflection and self-regulation scaffolds. Technology, Instruction, Cognition and Learning, 9(1-), 81-95.

Petranová, D., & Burianová, Ľ. (2014). Potential of digital technologies use in the formal pre-primary education. European Journal of Science and Theology, 10(Supplement 1), 263-276.

Sinatra, G. M., & Pintrich, P. R. (Eds.). (2003). Intentional conceptual change. Routledge.

Go-Lab is an online ecosystem and is offering inquiry-based lessons which allows students and teachers to use, create or adapt lessons. All these lessons are combined in so-called Labs and allows students to conduct scientific experiments in a virtual environment (Go-Lab, n.d.b). In those Labs there are also a couple of apps that can possibly support the online inquiry learning of students. The aim in this essay lies on the app that is called the Observation Tool (Go-Lab, n.d.a). This app is designed for students to be able to record all the important observations they make during the whole cycle of an experiment like preparing, conducting and analysing. On the basis of two relevant theoretical frameworks; inquiry learning and digital media, the following research question is created; 'To what extent can the Observation Tool be improved to a better version for aiding children in a lesson in primary education'. Consequently, all the functions within the app are reflected upon to identify pros and cons. Most important findings that were found are concerning the lay-out, content and usability of the app. Recommendations are given on the domains of visuals, name, and functionality of the app. Besides, there is a suggestion to implement more scaffolds in the app, which are examples to explain how the app works for learners, so that they can use the app in his full potential and in the right way (Lazonder & Harmsen, 2016). Finally, the findings from the analysis of the Observation Tool are generalized to the app Data Viewer.

Go-Lab. (n.d.a). Observation tool. Retrieved from: https://www.golabz.eu/app/observation-tool

Go-Lab. (n.d.b). About. Retrieved from: http://support.golabz.eu/about

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: effects   of guidance. Review of educational research, 86(3), 681-718. doi: 10.3102/0034654315627366

One active learning method that is used in science subjects is called 'Inquiry learning'. During inquiry learning, students can do their own investigations (Lazonder & Harmsen, 2016). Nowadays, this is also possible in an online environment. An example of such an online environment is called 'GoLab'. It provides laboratories as well as supportive apps that teachers can use to create a science lesson. As GoLab is designed for elementary and secondary education, the question arises whether the supportive apps are suitable for the whole target group. This essay focuses on the suitability of an app called 'observation tool'. This app aims at helping to organize observations that were made during investigations. In this essay, it is analyzed whether the app is suitable for the specific target group of fourth graders. To do that, the level of cognitive as well as psychosocial development of children at that age was taken into account. It turned out that the main characteristic that interferes with an appropriate use of the app is that children at that age are not able to think abstractly (Berk, 2013). In general, it is recommended to make some adoptions concerning the design, guidance, and kind of feedback of the app. When this is done, the app could indeed support the children of grade four to go through the inquiry process.

Berk, L. E. (2013). Child development international edition. Boston: Pearson

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance.   Review   of   Educational   Research,   86(3),   681–718. https://doi.org/10.3102/0034654315627366

The current paper examines the Go-lab app 'observation tool'. This tool is trying to help students making inferences, anticipations, and deriving conclusions. The platform of Go-labs is aimed at students from 10 to 18 ("Go-Lab Initiative", n.d.). However, this paper is concerned with elementary school pupil from 8 to 10 years and investigates the appropriateness of the 'observation tool'. Besides its advantages, which to name one is having freedom to write all observations down, it seems that children may encounter difficulties to put the given material into context (Mayer, 2008). The tool is found to have spare guidance, visible in only six simple icons. Thus, it becomes clear that the little guidance can confuse the children in its usage and can impede its helpfulness. So, pupils could face difficulties in translating the observations of labs into the observation box. Moreover, it seems that inquiry learning, and metacognitive skills are needed in order to use the 'observation tool' appropriately. Inquiry learning stresses exploratory learning with appropriate guidance (Suduc, Bizoi, & Gorghiu, 2015). In the phases of conceptualisation and investigation, the tool's text box supports appropriate inquiry learning. Nevertheless, prompts and heuristics can help pupils (Lazonder & Harmsen, 2016) in the age range of 8 to 10 to use the 'observation tool' to its potentials.

This aim of this essay was to review one of the many apps within Go-Lab, an electronic learning environment that focuses on inquiry-based learning. In addition, implications for future use and improvement for the app were made. The app reviewed in this essay was the observation tool, a tool students can use within Go-Lab labs to note down any observations within the lab. Inquiry-based learning has been gaining popularity in recent years and its effectiveness is well studied. Children in fourth grade (age 10-11) tend to not take note of observations effectively, if at all (Zimmerman, 2007; Garcia-Mila & Anderson, 2007). Therefore, this age group was targeted in this essay. The Observation Tool is simple to use and students will not get easily distracted or overstimulated while using this app (Sottilare and Goldberg, 2012). However, the lack of features gives reason to implement improvements. In this essay, all suggested improvements seem to match an already existing app: the Concept Mapper. The Concept Mapper can be used to take note of observations, but in this app, observations can be linked to each other, can be colored, can be rearranged, and teachers can add predetermined words or sentences to guide the learner. All of the aforementioned benefits were implications made based on the analysis of the Observation Tool in this essay.

Sottilare, R., & Goldberg, B. (2012). Designing adaptive computer-based tutoring systems   to accelerate learning and facilitate retention. J. Cogn. Technol, 17(1), 19-   33.
Garcia-Mila, M., & Andersen, C. (2007). Developmental change in notetaking during   scientific inquiry. International Journal of Science Education, 29(8), 1035-1058.
Zimmerman, C. (2007). The development of scientific thinking skills in elementary and   middle school. Developmental Review, 27(2), 172-223.

The Web 2.0, providing internet users with the autonomy to decide what information they wish to obtain as well as share online (Al-Khalifa & Al-Salman, 2006), has redefined the way education works. Never before has autonomy and efficiency in learning been more emphasized. The demand for increasing proficiency has influenced how primary school students learn. It has paved the way for inquiry learning, a student-led approach where they make their own experiences, of which inferences are drawn and critical thinking is developed (De Jong, 2006). Furthermore, it created an environment enabling online learning platforms to take the spotlight. A detailed analysis of the Observation Tool, a Go-Lab application, based on inquiry learning principles is conducted to adduce reasons, both for and against the suitability of the learning environment and the application in aiding learning performance. The results revealed that the help option, the addition and deletion

of observations, as well as the return button and the interaction between Observation and Conclusion Tool are insufficient in their usability. This reduced usability may lead to cognitive overload and disorientation, ultimately impairing the learning performance (Chen, 2008). Therefore, alterations resulting in a smoother interaction are recommended to reduce disorientation in the students. In doing so, the study experience can be optimized in efficiency as the goal is to make it as rich as possible.

Al-Khalifa, H. S., & Al-Salman, A. S. (2006). From web 1.0 to web 2.0 and beyond: Is the web becoming more accessible for people with visual impairments? iiWas. Retrieved from https://www.semanticscholar.org/paper/From-Web-1.0-to-Web-2.0-and-Beyond%3A-Is-the-Web-More-Al-Khalifa-Al-Salman/2ee82a332f6d2700263002a116db4e1b7143104f

Chen, C. M. (2008). Intelligent web-based learning system with personalized learning path guidance. Computers & Education, 51(2), 787-814. doi: 10.1016/j.compedu.2007.08.004

De Jong, T. (2006). Technological advances in inquiry learning. Science, 312(5773), 532-533. doi: 10.1126/science.1127750

Introduction. This paper investigate whether the application 'observation tool' of Go-lab is suitable for 10-12 year old primary school students to increase the knowledge gain within the scientific sector. There are two theoretical frameworks, inquiry learning describes self-regulated, explorative learning behavior to understand and apply new knowledge in different contexts (Mayer, 2008; Bell, Urhahne, Schanze & Ploetzner, 2010). Digital media is a new way of learning and supports the students by reach their needs and interest what results in increased motivation (Jansen et al., 2002; Nokelainen, 2006). However, the target group has to deal with some difficulties. They are not able yet to perform scientific research, so primary school students are unlikely to take notes during observations which is the most important skill within the 'observation tool' (van Dijk, 2017; Mayer, 2008). Analysis. The 'observation tool' consists of seven different features. There are multiple advantages and disadvantages, the application is an open environment which stimulates explorative, self-guided learning behavior and is usable for a variety of different experiments. It supports high 'perceived ease of use' (Venkatesh, 2000). Contrarily, the 'observation tool' do not consider the student's difficulties of taking notes, because there is no stimulation given for it. This can lead to a leak of information and thus to unreliable, uncontrollable results. Conclusion. After a few adjustments the 'observation tool' should be suitable to be implemented successfully in primary schools. The application can sustain the open environment which stimulates inquiry learning, but it is important to add features which stimulates the student taking notes, like comic-figures who ask specific questions. The findings of these application can partly be generalized to others.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. International journal of science education, 32(3),   349-377.   doi: 10.1080/09500690802582241

van Dijk, A. M. (2017). Learning and Instruction: Lecture A5-Learning science (lecture slides). Enschede: University of Twente, Department of Instructional Technology.

Jansen, W., van den Hooven, H. M., Jägers, H. P. M., & Steenbakkers, G. C. A. (2002). The added value of e-learning. Informing Science. InSITE-" Where Parallels Intersect.

Mayer, R. (2008). Learning Science. In Learning and Instruction. Upper Saddle River, New Jersey:Pearson Education.

Nokelainen, P. (2006). An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students. Journal of Educational Technology & Society, 9(2).

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. Information systems research, 11(4), 342-365.

Writing and note making are important abilities which are used in various situations during a person's lifetime (Piolat, Olive, & Kellogg, 2005). Being able to write enables humans to take notes. In general, note making can be seen as the ability to write information down. Research has shown that children have trouble with deciding which information is most important, with writing and with continuing taken notes (Berk, 2013; Godfrey, 2014; Mayer, 2008). The observation tool, of go-lab is an app which should help children to construct their observation during an experiment. The goal of this essay is to check whether the app is suitable for six-to-seven-year-old primary education students. Findings show that the app has both advantages and disadvantages. The two main advantages are the general aim and the fitting perceptions between the mental representation. The lack of consideration of children´s overall ability level during the first grade and of guidance and promotions are disadvantages. The overall conclusion is that the app is not suitable for first graders. In addition, suggestions will be provided to make the app user-friendlier for first graders. Suggestions to improve the suitability include prompts, heuristics and a pencil icon. Prompts can help with ease of workflow through the app, while heuristics give children some guided cues what to write (Lazonder & Harmsen, 2016). The pencil feature enables children to draw what they observe and to create concept maps. Finally, findings will be generalized by showing a way how the improvements can be transformed to the conclusion tool. Berk, L. (2013). Child Development (9nd ed.). Upper Saddle River, NJ: Pearson. Godfrey, J. (2014). Reading and making notes. Macmillan International Higher Education. Retrieved from https://books.google.nl/books?hl=en&lr=&id=F1YdBQAAQBAJ&oi=fnd&pg=PP1&dq=Godfrey,+J.+(2014).+Reading+and+making+notes.+Macmillan+International+Higher+Education.&ots=pbmbfX7 UBt&sig=yDBF5M1- J8lf1mwxtUDhOrOR2WM&redir_esc=y#v=onepage&q=Godfrey%2C%20J.%20(2014).%20Readin g%20and%20making%20notes.%20Macmillan%20International%20Higher%20Education.&f=false Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. Review of Educational Research, 86(3), 681-718. doi: 10.3102/0034654315627366 Mayer, R. E. (2008). Learning and instructions (2nd ed.). Upper Saddle River, NJ: Pearson. Piolat, A., Olive, T., & Kellogg, R. T. (2005). Cognitive effort during note taking. Applied cognitive psychology, 19(3), 291-312. doi:10.1002/acp.1086

Primary education students aged 10 to 12 are not yet familiar with doing scientific research (Zimmerman, 2007). However, in the digital learning environment GoLab, learning is done through scientific research. This could be confusing for the students and take the focus away from the lesson material, since it might be their first introduction to this kind of research. Moreover, GoLab has apps that support the lessons provided on the website. One of these apps is the observation tool. This is a simple tool that allows students to write down their observations that they made during a specific lesson. The observation tool has advantages, as for instance, helping children to stay active in learning, it helps the processes of thinking, problem-solving, memory and knowing in the students' mind, the observations from the tool can later be retrieved in the conclusion tool and at last the observation tool has a nice feature, the question mark button. This button helps students understand the available features provided in the tool ("GoLab | Home", n.d.). However, there are

also disadvantages. These respectively are some confusing and probably unnecessary features- It does not have clear guidelines in doing scientific research for students in the age group 10 to 12 years and it has no extra features, as for example tables or charts, to make the observations possibly clearer for students to process and understand. The recommendations are that the features that are confusing and unnecessary could be taken out of the observation tool. To guide the students in what they are expected to observe from the lesson, questions could be added. The questions could be for example: "What have you seen happen?" and "What kind of influence does this have?" For the last disadvantage, features to make tables and charts could be included in the app.

Next-Lab. (n.d.) Home | Golab. Retrieved September 25, 2018, from: https://www.golabz.eu/app/observation-tool

Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. doi: 10.1016/j.dr.2006.12.001

The purpose of the essay is to try to answer the question whether the observation tool of Go-Lab is useful addition to inquiry-based learning. There is a changing from traditional teaching methods to more problem-oriented methods and also is a switch from traditional classical teacher-centered learning environments to the inquiry-based learning environments with the use of online learning tools (Mayor, 2008). In current fields of education there is an increasing use of computers and online learning materials (Damodharan & Rengarajan, 2013). A good example of a online learning environment is Go-Lab, a website with a large collection of online labs, inquiry applications, inquiry learning spaces that can be shared with teachers and students all around the world. In this essay the observation tool of Go-Lab will be analyzed to know more about the pros and cons of this tool in comparison the traditional ways of making analysis. There will also be looked to what extend the observation tool can increase inquiry-based learning at students in primary school. There are several assets of using the observation tool as a method of making observations in a inquiry-based method. However online learning environments require technological facilities and those often come with high costs, not only for educational institutions but possibly also for students. The conclusion that was made in this essay, is that Go-Lab and the observation tool are a useful and valuable addition to the traditional lesson methods, however there is still plenty of room for improvement of the observation tool. A possible drawback of the observation tool is the costs of media and technology However, do various reasons these investments seem justifiable and the observation tool of Go-Lab is useful for improving inquiry-based learning at primary school students.

Mayer, R. E. (2008). Learning and instruction (second edition). Upper Saddle River, NJ: Pearson. ISBN 0-13-170771-X

Damodharan, V.S. & Rengarajan, V. (2013). Innovative methods of teaching. Retrieved from http://math.arizona.edu/~atpmena/conference/proceedings/Damodharan_Innovative_Methods.pdf

Nowadays, almost all children have access to technology. This access does not only apply to their private lives, but also to their school lives. Technology is used more and more in education and it has had a positive effect on the learning experience of primary school students (Fokides, 2018). A website that uses digital media to enhance learning is the Go-Lab website (https://www.golabz.eu). This site offers a platform, where students can use apps and labs to gain knowledge based on an inquiry-based learning approach. The aim of this essay is to investigate, whether the online application 'observation tool', which is one of the many apps on Go-Lab, is suitable for primary education and thus encourages the learning of 6 to 12 year-olds. The analysis is performed with the help of the two theoretical frameworks digital media and inquiry learning. During the analysis it

is shown that the app has several pros and cons. On the basis of digital media, aspects such as engaging and interactive, usability and support material, support the suitability for primary education (Eady & Lockyer, 2013). On the basis of inquiry learning, the fact that students are encouraged to actively participate supports the suitability of the app, but the missing instruction and guidance contradicts (Anderson, 2002; de Jong, 2010; Dignath & Büttner, 2008). All in all, it was concluded that the app is suitable for primary education. Despite this conclusion, suggestions are offered, through whom it is believed that the suitability can be improved. These suggestions refer to including feedback, instruction and guidance. It was suggested that the latter could be implemented through the use of questions and categories.

Anderson, R. D. (2002). Reforming Science Teaching: What Research Says About Inquiry. Journal of Science Teacher Education, 13(1), 1-12. doi:https://doi.org/10.1023/A:1015171124982

de Jong, T. (2010). Technology supports for acquiring inquiry skills. In International Ecyclopaedia of Education. Elsevier.

Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. Metacognition Learning, 3, 231–264. doi:10.1007/s11409-008-9029-x

Eady, M. J., & Lockyer, L. (2013). Tools for learning: technology and teaching strategies. Learning to teach in the primary school, 71-92. Retrieved from https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1413&context=asdpapers

Fokides, E. (2018). Digital educational games and mathematics. Results of a case study in primary school settings. Education and Information Technologies, 23(2), 851-867. doi:10.1007/s10639-017-9639-5

Research on inquiry learning and digital media show that both have a positive influence on a primary students' learning attitude and learning outcome. This early improvement of learning can reduce the enforced pressure to perform by society when the students go to the second grade. Go-Lab is an online tool where students learn science by implementing online experiments. This website stimulates inquiry learning, working actively with the information received. Most apps of Go-Lab have an observation tool, in which students can note down his or her expectations about the experiment. Scientific research demonstrated that the observation tool is optimizing the learning process of students already, but still can be improved on several aspects. Due to this, the research question "How can the observation tool in Go-Lab be improved, to optimize the learning process for primary students?" is stated. Based on literature, it can be noticed that because of the observation tool, students are more likely to keep a better structure and overview of the task. In this way, the children can focus on the information given, instead of the process of implementing. Still, the tool can be improved by gathering even more structure for the students and by the activation of prior knowledge, which will help to remember more information and provides a better integration of the information. Recommendations for improving the observation tool are to add a scratchpad, cue button and improve technical aspects of the website, which will improve the learning process of the target group. Despite the advantages of the observation tool, the process of learning can still be improved by integrating the mentioned aspects.

To involve modern technologies into learning and improve teaching quality by conducting experiments online Go-Labs website was created. This essay discusses advantages and disadvantages of the design and digital media concept of the observation tool from Go-Labs for 10-year-old primary school students. The pros and cons are discussed grounded on logical arguments and scientific literature. Theories based on digital media and the target group – 10-year-old

students are examined. The essay also provides suggestions for improvement and compares observation tool with input box.

Maran Voskes

The goal of this article is to evaluate the Observation Tool, an assisting app used in the online learning ecosystem Go-Lab. The Observation Tool aids the students with making observations while conducting an experiment. Because the focus of teaching is shifting from direct teaching to inquiry-based learning, it is important to do research about these assisting apps. The evaluation is based on three core concepts; inquiry-based learning, scientific thinking, and the skills of primary school students aged from nine to eleven years old. Advantages of the app according to these theories are the support of the conceptual change approach and the obligation to write down observations. Disadvantages are the lack of clear instruction, guidance, and structure. Additions to the app in order to improve these drawbacks could be the provision of an instruction before the start of the experiment, providing guidance throughout observation making, and abilities to structure the observations, e.g. by creating tables or categorizing observations, and projecting the hypothesis in the Observation Tool. According to this essay, the Observation Tool has strong and weak points, what makes the overall evaluation moderate. With some improvements, the app will probably score higher.

This essay analysed the observation tool, used to aid 10-12 year olds in the online inquiry learning environment Go-Lab, so suggestions could be made how to optimize it. Integrating inquiry learning with technology, like the Go-Lab does, benefits inquiry learning (Wang, Kinzie, McGuire & Pan, 2009). The observation tool should be suitable for all ages, however little attention was yet paid to the needs of this age group to be able to observe and structure their experiments. Therefor it was analysed which parts of the observation tool are (un)suitable for this age group, how guidance can be offered and how technology can support making observations. Advantages of this tool are the simple lay-out, the usability and the prompts given to actively take notes. However, disadvantages are that no (content) feedback is given, no structure is offered and process and content support are limited. To optimize this, more process and content support should be offered as well as guidance how and when to plan, structure and reflect on data. Several suggestion were made how to concretize this and generalizability of suggestions to the hypothesis scratchpad were scrutinized. Wang, F., Kinzie, M.B., McGuire, P. & Pan, E. (2009). Applying technology to inquiry-based learning in early childhood education. Early Childhood Education Journal, 37 (5), 381-389. doi: 10.1007/s10643-009-0364-6

There are several kinds of education. One is inquiry learning, which empathizes students questions, ideas, and analyses. In inquiry learning, the student plays an active role and is instructed to experience the to be learned aspect themselves (DeJong, 2006). The online platform GoLab aims to facilitate the use of online laboratories and inquiry learning applications for science education in schools, by means of several apps. One of the apps it the Observation tool. This tool allows students to record observations made while preparing, conducting and analyzing experiments and refers to the second and third phase of the inquiry learning cycle, conceptualization and experimentation. This essay investigated the question 'To what extent can the Observation tool of Go-Lab, aid primary education students inquiry in an online lesson?'. Hence, several positive as well as negative factors have been revealed. The Observation tool manifested itself as straightforward and simple in the usage, and especially the connection with the Conclusion tool manifested itself as crucial to support the children. Nevertheless, some aspects,

which support meaningful learning for primary education students, like inter alia a feedback function, were missing. Consequently it was recommended to include a feedback function, in order to make the tool the most efficient. Moreover, in order to increase the effectiveness of such a function to a maximum, the feedback should be very concrete and specific (Trowbridge & Cason, 1932).

De Jong, T. (2006). COMPUTER SIMULATIONS: Technological Advances in Inquiry Learning. Science, 312(5773), 532-533. doi:10.1126/science.1127750

Trowbridge, M. H., & Cason, H. (1932). An Experimental Study of Thorndike's Theory of Learning. The Journal of General Psychology, 7(2), 245-260. doi:10.1080/00221309.1932.9918465

This essay concerns the EU co-founded project 'GoLabz', more specifically the app 'Observation Tool' and its usability for third grade students in primary school. The aim of this paper is to investigate to what extent the observation tool supports third graders in their inquiry learning process and how the app can be further improved. The app can be used by students to take notes during their inquiry process, which can then be reused again later in other apps. Furthermore, the target group of this essay, third grade students, show problems in the activity of note-taking and are still developing their planning abilities. Moreover, the main findings are that the app shows a number of disadvantages and advantages for the target group, because it can support them in their process of inquiry, but if the target group does not engage, since they lack planning abilities, then they will fall behind, and the app misses its aim. In conclusion, the observation tool is rather ambiguous, concerning its usability for third grade students, but if certain improvements are made, then it has the potential to really support them during their inquiry process.

The aim of this paper was to find out if the app 'Observation Tool' of the 'Go-Lab ecosystem', an online platform for inquiry-based learning, can aid children in year five in their inquiry. Inquiry-based learning methods have shown to be effective in enhancing students' motivation and interest (Suduc, Bizoi, & Gorghiu, 2015). Further, there is evidence that inquiry-based learning increases the understanding of a subject (Kanuka, 2007). The target group of this paper, children in year five aged eight to nine, in not yet able to engage in abstract thought processes (Storck, 2013). However, inquiry assignments require some sort of abstract thought (de Jong, 2006). Therefore, the app 'Observation Tool' was analyzed in detail regarding if it is suitable for children aged eight to nine. Overall, the app was regarded as useful for them. However, it was outlined that it is only suitable if teachers provide enough guidance during students' learning process (Lazonder & Harmsen, 2016). Otherwise, it is likely that children do not understand the abstract symbols the app 'Observation Tool' includes. They first need to understand the concrete actions that stand behind these symbols before being able to use the app. It was suggested to add more forms of guidance to the app, such as additional information the teacher can include and a feedback form. To conclude, the 'Observation Tool' was regarded as useful for children aged eight to nine, but not sufficient itself. A teacher needs to guide students in year five throughout their learning process, to make sure that meaningful learning can take place.

de Jong, T. (2006). Technological advances in inquiry learning. Science, 312, 532-533.

Kanuka, H. (2007). Inquiry-Based Learning with the Net: Opportunities and Challenges. New Directions for Teaching and Learning, 2006(107), 55-62. doi: 10.1002/tl.244

Lazonder, A. W. & Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning. Review of Educational Research, 86(3), 681-718. doi: 10.3102/0034654315627366

Storck, C. (2013). Entwicklung, Sozialisation und Identität – Normen und Ziele in der Erziehung. Freising: Stark Verlag.

Suduc, A. M., Bizoi, M., & Gorghiu, G. (2015). Inquiry Based Science Learning in Primary Education. Procedia - Social and Behavioral Sciences, 205, 474-479. doi: 10.1016/j.sbspro.2015.09.044

Nowadays, inquiry learning has proven to be a good way of learning, which holds true for the online inquiry-learning environment "Go-Labz". There, children can solve problems scientifically on their own, which is good for STEM education. In Go-Labz is an app called "Observation tool" which is used during investigating an experiment and discussing related hypotheses (Pedaste et al., 2015). This app is analyzed in terms of inquiry-application and how well it is designed towards 10-year-old children, where STEM education is in a crucial beginning phase. Based on the analysis, improvements of the app are suggested relating to inquiry-learning and the target group. The biggest advantage and disadvantage of the app is that the app is designed to be easy. This makes the app very easy to use because no unnecessary cognitive load is used (Sweller & Cooper, 1985) and children feel self-efficacious to use the tool which increases motivation (Zimmerman & Martinez-Pons, 1990; Schunk & Hanson, 1985). But also, it may be too easy so 10-year-old children are unmotivated to use it, because no structural features are appealing enough, and no perceived usefulness of the app is fostered for children (Harackiewicz et al., 2016). In general though, just writing down observations in a text box is no challenge for 10-year-old children because of their a little advanced cognitive capacity (Casey, Giedd, & Thomas, 2000) and working memory (Gathercole, Pickering, Ambridge & Wearing, 2004). To make the app more challenging, a manipulatable map (Martin & Schwartz, 2005; Nesbit & Adesope, 2006) with multiple text boxes should be included, as well as a map of underlying principles related to the observations to make it more challenging for the children (Quilici & Mayer, 2002). In conclusion, based on these changes the app can be improved to be of better use in inquiry-learning for 10-year-old children, so they can receive better STEM education.

Casey, B. J., Giedd, J. N., & Thomas, K. M. (2000). Structural and functional brain development and its relation to cognitive development. Biological psychology, 54(1-3), 241-257. doi:10.1016/S0301-0511(00)00058-2

Gathercole, S. E., Pickering, S. J., Ambridge, B., & Wearing, H. (2004). The structure of working memory from 4 to 15 years of age. Developmental psychology, 40(2), 177. doi:10.1037/0012-1649.40.2.177

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. Policy insights from the behavioral and brain sciences, 3(2), 220-227. doi:10.1177/2372732216655542

Martin, T., & Schwartz, D. L. (2005). Physically distributed learning: Adapting and reinterpreting physical environments in the development of fraction concepts. Cognitive science, 29(4), 587-625.

Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. Review of educational research, 76(3), 413-448.

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. doi:10.1016/j.edurev.2015.02.003

Quilici, J. L., & Mayer, R. E. (2002). Teaching students to recognize structural similarities between statistics word problems. Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 16(3), 325-342. doi:10.1002/acp.796

Schunk, D. H., & Hanson, A. R. (1985). Peer models: Influence on children's self-efficacy and achievement. Journal of educational psychology, 77(3), 313.

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem

solving in learning algebra. Cognition and instruction, 2(1), 59-89.

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. Journal of educational Psychology, 82(1), 51.

11 Appendix C

5 Tips for beginners

1. Where do I start in Go-Lab?

When you start using Go-Lab, you might wonder what the possibilities are. A good start is by looking at the spaces (online lessons) that were created by others. These spaces are premade and you can view them all.

How to view spaces

1. Go to www.golabz.eu.
2. Go to Spaces.
3. Click on one of the spaces that are listed.
4. Go to Preview.

2. Where do I start building my own space (online lesson)?

There are two approaches when building your own space. The first is to find one you like and start adjusting it. First you have to copy the space, so you can adjust it.

How to copy a space

1. Go to www.golabz.eu.
2. Go to Spaces.
3. Find and go to the space you like.
4. Go to Duplicate Space.
5. You are redirected to Graasp, where you can start adjusting the space

   The second approach is to create one from scratch. In this case, it is advisable to start with a lab. The lab determines the topic of your space and what your students can do and learn in this space. Later you can add apps and other content as you like.

How to use a lab to create a space

1. Go to www.golabz.eu.
2. Go to Labs.
3. Find and go to the lab you like.
4. Go to Create Space
5. You are redirected to Graasp, where you can start creating the space.

3. How do I find apps, labs, and spaces in my language?

For your students to be able to understand the space and the apps and lab within the space, it is important that it is in their language. The spaces are in one language, but some have translations that can be found as a separate space. The labs and apps often have support for multiple languages. For all three options (apps, labs, and spaces) you can search for specific languages.

How to search Go-Lab in my language

1. Go to www.golabz.eu.
2. Go to Apps, Labs, or Spaces.
3. Find Languages in the right side menu.
4. Go to the language of your choice.

4. How do I find apps, labs, and spaces for my students' age?

Another important thing to keep in mind when creating an online lesson for your students is their age range. Their age range is an indicator of what their needs and talents are. In Go-Lab the age range is specified where possible.

Labs and spaces do have an age range specified. To use this do the following:

How to find labs and spaces for a specific age range

1. Go to www.golabz.eu.
2. Go to Labs or Spaces.
3. Find Age Ranges in the right side menu.
4. Go to the age range of your choice.

5. How do I use apps?

The apps have been created to support specific processes. Some of these are suitable for primary education, such as making an observation (use the Observation Tool), while others are not suitable, such as finding chemical elements (use the Periodic Table). Therefore, it is up to you to choose the apps you think are suitable for your students. Note that there is a list of examples of app that are suited for primary education (see tip 1 for advanced users). Also note that you can add explanations of the apps (see tip 2 for advanced users: how do I set up apps?). If you want to find and use an app, follow the how to below:

How to find apps

1. Go to www.golabz.eu.
2. Go to Apps.
3. Find Categories in the right side menu.
4. Go to the category of your choice.
5. Go to the app of your choice.

How to use the app

1. Find an app using the how to above.

2. Go to www.graasp.eu.

3. Go to the space where you want to add the app.

4. Go to the phase where you want to add the app.

5. Click on the + icon: Create item.

6. Go to Add App.

7. Go to Select app.

8. Find and go to the app of your choice.

5 Tips for advanced users

1. What are good apps for primary education?

The following list of apps are examples that can be used for primary education. This does not mean that apps that are not listed cannot be used in primary education.

- The Concept Mapper to let students think about what they already know or what they learned.
- The Quiz Tool to check what students know or learned.
- The Hypothesis Scratchpad to assist students in formulating expectations.
- The Experiment Design Tool to foster designing of experiments (and keeping track of results)
- The Observation Tool to allow students to write down what they found when conducting investigations in a lab.
- The Table Tool to let students write down what they found or keeping track of results.
- The Viewer to show content of other apps to aid students' memory of what they have done previously.

2. How do I set up apps?

After you have chosen an app, you have to prepare it for use. For some apps this is not the case, such as the Input Box, but for others there are settings you can adjust, such as the Hypothesis Scratchpad. It is important to do this for two reasons. First, to make sure the content of the app is in line with the content of the space (and the lab). Second, to make sure the app offers the support you want or on the other hand that the app offers the freedom you want. Let us use the Hypothesis Scratchpad as an example. The settings of the app can be changed in Graasp.

How to change the settings of an app

1. Go to www.graasp.eu.

2. Go to the space you created.

3. Go to the specific phase where the app is in.

4. Go to the app.

5. Go to Settings by clicking on the gears icon.

The Hypothesis Scratchpad comes with default terms. These terms can be used to create a hypothesis. Therefore, you have to change the terms to match the lab. An example is when you study photosynthesis. In this case, you need terms like: water, light, and air. It is important to keep

in mind that for primary education a term like 'water' might be better understandable than 'H2O' or that 'light' or the 'amount of light' is more informative than Lumens.

Another feature of apps, including the Hypothesis Scratchpad, is that you can also provide an example in the app. You could use the first line in the Hypothesis Scratchpad to show a hypothesis as an example. In this case, prepare the hypothesis in Graasp when creating the space. You could leave the second line of the Hypothesis Scratchpad empty and instruct the students to create their own hypothesis on this line.

3. What are good labs for primary education?

There are almost 200 labs for primary education available on Go-Lab. Feel free to find the lab of your choice. If you want some inspiration, the following list consists of examples that can be used in primary education and these are available in multiple languages.

- Balancing Act (https://www.golabz.eu/lab/balancing-act) about forces in balance on a seesaw.
- Gearsketch (https://www.golabz.eu/lab/gearsketch) allows students to draw gears, which is very suitable for tablets or other devices with a touchscreen.
- Density And Buoyancy (https://www.golabz.eu/lab/density-and-buoyancy) about floating and sinking with some predefined objects that help students' investigation.
- Area Builder (https://www.golabz.eu/lab/area-builder) introduces the concepts of area and perimeter.
- Rate Of Photosynthesis Lab (https://www.golabz.eu/lab/rate-of-photosynthesis-lab-html5) deals with plants and growth.
- Water Cycle Lab (https://www.golabz.eu/lab/water-cycle-lab) about the effect of sunlight on the water cycle.
- Building With Blocks (https://www.golabz.eu/lab/building-with-blocks) about the shape of three-dimensional figures.
- Gravity Drop Lab (https://www.golabz.eu/lab/gravity-drop-lab) about air, atmosphere, and dropping objects.

4. How can I give feedback to my students?

If you want your students to see your feedback in the space they are using, add the Teacher Feedback app. Add this app wherever you want to give feedback. It shows an input box to you, as a teacher, and the student sees the text. You can type feedback for individual students.

How to use the Teacher Feedback app

1. Go to www.graasp.eu.
2. Go to the space where you want to add the app.
3. Go to the phase where you want to add the app.
4. Click on the + icon: Create item.
5. Go to Add App.
6. Go to Select app.
7. Find and go to Teacher Feedback.
8. Go to Members in the right side menu.
9. Find and go to the student you want to give feedback to.

10. Go to the phase where the Teacher Feedback was added.

11. Type your feedback.

5. How can I combine offline (classroom) and online (Go-Lab) teaching?

Go-Lab can be combined with your classroom activities. There are two main approaches to this. The first is to do the introduction and/or discussion in the classroom. The introduction consists of introducing the topic and providing information. In the classroom you can ask students what they know about the topic and/or what they want to know. The discussion consists of sharing results. Students can tell the class what they have found out in the lab. The second approach is to prepare the experiment in Go-Lab and conduct it in the classroom. In this case, students prepare their hypothesis in Go-Lab and think about their experimental design. After the investigation, they return to Go-Lab to write down what they have found and draw a conclusion. This means that students can return to their assignment in Go-Lab. If they log-in to the space you created with the same name as the first time, they can see what they have done in previous sessions.

5 Technical tips

1. Are the answers filled in by my students saved?

Whenever students accidentally log-out, run out of battery of their laptops, etc., do not worry. Go-Lab retrieves the information whenever the student logs in to the space with the same name. This applies to the apps that are used. Currently, labs do not support this feature.

Students can also create their own password for their log-in. If you want to use this enable logging in with a password.

How to enable student log-in with a password

1. Go to www.graasp.eu.

2. Go to the space where you want to allow logging in with password.

3. Go to Sharing in the right side menu.

4. Find and click on Nickname only under Standalone view settings.

5. Change this by clicking on Nickname and password.

2. How do I add images and edit the size?
Images can be added to your space and their size can also be adjusted.

How to add an image

1. Go to www.graasp.eu.

2. Go to the space where you want to add the image.

3. Go the phase where you want to add the image.

4. Click on the + icon: Create item.

5. Go to Add File.

6. Find and open the image you want use.

How to change the size of an image

1. Go to www.graasp.eu.

2. Go to the space with the image.

3. Go the phase with the image.

4. Find Change view in the middle panel. There are three options, see the Figure below.

5. Click on the large square in the middle.

6. Click on the gears icon at the top right of the image.

7. Click on the preferred setting (Large, Medium, Small) under Preview size.

3. How do I upload other content?

You can use your own content in a space. You can upload it by creating an item.

How to upload files

1. Go to www.graasp.eu.

2. Go to the space where you want to add the file.

3. Go the phase where you want to add the file.

4. Click on the + icon: Create item.

5. Go to Add File.

6. Find and open the file you want use.

Files, such as images, audio, video and text files can be viewed or listened to in Go-Lab. However, for text files, it is recommended to copy the text in Graasp, because when you upload it as an file, it is rather narrow and requires a lot of scrolling. To copy the text in Graasp, create a document.

How to create a document

1. Go to www.graasp.eu.

2. Go to the space where you want to add the document.

3. Go the phase where you want to add the document.

4. Click on the + icon: Create item.

5. Go to Create Document.

4. What are the options to share the space with my students?

If you want to share the space you created with your students, you should give them a link. You can find the link in Graasp, as well as a short link. Also you can change the language settings of your space. This affects the language of the apps and lab in the space.

How to get the short link to your space

1. Go to www.graasp.eu.

2. Go to the space you want to share.

3. Find and go to Sharing in the right side menu.

4. Click on Get short link

5. Copy the link.

How to change language settings of a space

1. Go to www.graasp.eu.

2. Go to the space you where you want to set the language.

3. Find and go to Sharing in the right side menu.

4. Find and click on English only under Standalone view settings.

5. Click on the language you want to use.

5. How do I use phases and spaces in Graasp?

Phases exist within an inquiry learning space. The most common phases are Orientation, Conceptualisation, Investigation, Discussion, and Conclusion. These can be used to structure your students' investigation from start to end. Do not create (sub)spaces within these phases. They will not show.

Inquiry learning spaces exist within your Graasp account. You can create an inquiry learning space with phases to use with your students. If you want, you can also create a space with several inquiry learning spaces in it, for example you can create a space called 'Plants and Growth' and add an inquiry learning space, called 'Plant nutrition', and another called 'Photosynthesis'.