SCY cognitive scaffolds and tools
DII.2

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Science Created by You (SCY)

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Executive summary

This document provides an overview of the SCY Tools and scaffolds that have been created within the SCY project. This document is the descriptive part of the deliverable DII.2. The main part of the deliverable consists of the tools themselves, as present within the SCY environment, available through www.scy-lab.eu. The document describes the rationale behind the design of tools and scaffolds, gives an overview of the available tools as well as specific SCY features of tools operation within SCY-Lab. Moreover the development process is described as well as the foreseen consolidation and reuse of the SCY tools within further developments.

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1 Introduction

This document is a description of deliverable II.2, the SCY set of cognitive and social tools. The deliverable consists of the current document, as well as the software version of the tools that is available through the SCY servers. This document provides an overview of the available tools as well as a description of the way the tools work together and interact with the SCY architecture and SCY agents. The work in work package 2 has been based on specifications of the SCYpe tools that, as described in deliverable 2.1. After publication of this deliverable, specifications of the toolsets have been updated, based on requirements stemming from the work of SCY emissions, as well as based on the foreseen interaction between the tools, agents and authoring tools.

The deliverable will start with a list of tools that have been implemented in the SCY toolset, followed by a rationale for changes between this version of the toolset and specification in the earlier deliverable. The deliverable will continue with highlighting specific features and tools, especially those related to interactions between different tools and between tools and agents. An overview of the given on the development process of the tools, including user testing and scrutinising the tools by the SCY team. Finally, an outlook is given to the continuous exploitation of the tools inside and outside upcoming versions of the SCY system.

2 The rationale behind the SCY tools and scaffolds

The SCY project has taken an ambitious stance towards the design of science learning and instruction around the central ideas of (1) ELO-based learning and (2) Advanced pedagogical scenarios. These two main principles in SCY need to be supported in the missions that are developed and evaluated within the project. The leveraging points for this support are SCY-Lab, the main shell for hosting SCY learning activities, described in the SCY deliverable VI.4, SCY Pedagogical Agents, as described in SCY deliverable V.4 and the SCY cognitive tools and scaffolds, described in the current deliverable. We will describe how the tools and scaffolds perform their part, in coordination with SCY-Lab, the agents and the background architecture, in implementing the main SCY principles.

2.1 ELO-based learning

The main idea behind *ELO-based learning* is that learning is externalized as the production, modification and exchange of *emerging learning objects* (de Jong et al., 2010). Emerging learning objects (ELOs) are intermediate and final products of the learning activity, which is modelled as a scientific or engineering endeavour. This yields ELOs such as datasets, intermediate reports, notes, models, designs etc. This focus on the creation of ELOs makes that the main SCY philosophy sees learning and knowledge building as a constructive activity, in the line of constructivism (Jonassen, 1991) and constructionism (Kafai & Resnick, 1996) The specific approach by SCY is includes a shared repository of these ELOs and means to classify and exchange them.

Tools provide a central functionality in the ELO-based learning approach. After all, tools are the main instruments to display, create, and modify ELOs. This means that the set of required tools is defined by the set of ELOs needed within the SCY missions and vice versa, the set of ELOs that can be possibly created is defined by the available toolset. Therefore, within SCY the approach was taken that tools that were available to be reused from existing tools were offered to the designers of the missions and whenever a new ELO type was foreseen based on an emerging mission specification, a tool was created capable of creating such an ELO.

Within respect to the types of ELOs, the relation to the SCY Ontology should be made clear. In SCY deliverable IV.1, different kinds of ELO types are distinguished. For our purpose, the distinction between *technical type* and *functional role* is relevant. The technical type is the type of the ELO itself, irrelevant of its context of use. For instance, a dataset is stored as an XML file containing spreadsheet-like data; an image can be stored as a JPG file. Knowing an ELO's technical type means knowing which tools can open and edit it: SCYData can open ELOs of type scydataset, any image viewing or editing program can open a JPG file, etc. The ELO's functional role determines the position the ELO takes in the pedagogical scenario. A text, with technical type TXT can have a functional role of 'research question', 'hypothesis', 'design of an experiment', etc. In principle the technical type and functional role are independent of each other; an object of any technical type can take on any functional role. In practice there are limitations, as not all technical types will be suitable to play all functional roles.

For the tools the difference between the two kinds of ELO type means that they need to be aware of the functional role the ELO they edit takes. Within the current missions there are no examples of tool behaviour that really changes as a consequence of the functional role, but at least the tool should store the correct functional role in the ELO's metadata. In SCY this is taken care of by always creating ELOs from templates that contain the functional role, and to ensure that data is preserved when saving the ELO.

2.2 Advanced Pedagogical Scenarios

In SCY deliverable I.1, a set of advanced pedagogical scenarios has been described that have in common that they are based on the principle of ELO-based learning and that they model the learning process taking place when performing complex tasks, such as the design of an artefact or performing scientific research. The advanced pedagogical scenarios model the learning process at three levels: the *scenario level*, the *LAS level* and the *activity level*. The scenario level includes the choice for the type of scenario such as "The design challenge" for a design-based learning scenario or "Inquiry learning" for a research based scenario. At the LAS level, the scenario is divided into *Learning activity spaces*, that represent a major subtask in the scenario. The main outcome of a LAS is one or more ELOs, that possibly serve as inputs into the next LAS. LASses are further subdivided into activities. Activities are elementary units of description of the pedagogical scenarios and represent transformative learning processes (Njoo & de Jong, 1993) resulting in new or changing knowledge (e.g. *generate a hypothesis*) or regulative processes that control the learning process (e.g. *form a group*). Combining the set of activities with the principle of ELO base learning, results in the observation that the activities that result in new or changing knowledge result in the production or modification of ELOs. The production of an ELO may be the result of a number of activities each of which leading to new versions of that ELO.

Another observation from the way the advanced pedagogical scenarios are modelled is the fact that each of the LASses may be performed either in collaborative mode or in individual mode. SCY-lab provides communication means to support the collaborative modes, such as a chat connected to each ELO, and the possibility for learners to send ELOs to each other. For the tools this means that, depending on the specific requirements for collaboration, synchronous collaboration on one ELO can be provided, where two or more learners collaborate on an ELO in a i-see-what-you-see modus. Also, tools should be aware of the ownership of ELOs.

Collaborating learners (synchronously, asynchronously or face to face) should be able to share ownership of an ELO and tools should maintain the ownership data when saving ELOs.

The pedagogical scenarios and the activities within them are modelled in terms of the functional roles of the ELOs. This has been done because of their abstract nature. An scenario is not bound to a specific domain, or for instance to a particular learning setting. For instance, an activity *collect data* would need a resource to collect data from and would produce a data set. However, it will depend on the actual mission context whether the resource will be, for instance, a simulation or a hands-on lab experiment and if the resulting data set will be tabular quantitative data or a set of pictures. This means that the scenarios as such do provide a set of requirements to the tools and scaffolds, but the actual choice for a specific tool depends on the mission context.

2.3 Choosing tools and scaffolds

The two basic SCY principles, ELO-based learning and advanced pedagogical scenarios provide indications for the design of the SCY set of tools and scaffolds, but these principles do not prescribe this design. The presence of the tools and the way their use results in the production and modification of ELOs is clearly dictated by the principle of ELO-based learning. The choice for the actual toolset depends on the domains and detailed choices that are made in the design of the missions.

Scaffolding can be seen as supporting specific activities in the pedagogical scenarios. For instance, in the collection of data, learners can be scaffolded to systematically vary the variables in the domain as to obtain datasets that can be used to inform the generation of hypotheses or to test them. As a matter of fact a myriad of possible ways of scaffolding learning activities is possible (e.g. Quintana et al., 2004). Within SCY, several means of providing scaffolding are present: agents can detect problems with the performance of activities and propose interventions. SCY-lab can send scaffolding messages to the learner and the tools are also capable of providing scaffolds in the form of messages and feedback to learner activities as well as by adapting their user interface to match the level of the learner.

Within SCY, it was decided to let the SCY tools be delivery platforms of scaffolds, next to SCY-lab as a whole, and let agents do the diagnosis and proposers of scaffolds. Moreover, teachers have the possibility to set the scaffolding level through the run time authoring view (see SCY deliverable DVII.4). As said, tools can provide two ways of scaffolding: providing feedback messages to learners and adapting the tool user interfaces from simple to complex.

In the tool descriptions that will be provided in the following section, the possible means for scaffolding and how these are realized in collaboration with the SCY agents will be described.

3 The SCY Toolset

In SCY deliverable II.1, an overview was given of the envisaged SCY toolset. In this deliverable the final versions of the tools are described, to the extent to which they deviate from the original specifications. Also some tools that were foreseen were not implemented, or not implemented in the shape that was foreseen originally. For these tools the reasons for such changes will be provided. Finally, some tools that were not foreseen in the original toolset have been created. In those cases the new tool as well as the rationale behind it will be presented. Sections 3.1 through 3.16 follow the original order of the tools as presented in DII.1, subsequent sections represent new tools.

3.1 SCY Simulator

The SCYSimulator is a multi-purpose simulation tool that is able to show and run arbitrary simulations. Within SCY the tool is used to display simulations within the CO_2-mission, the Healthy Pizza mission and the mini mission (SCY demonstrator). It started as a basic player for simulations created with SimQuest[1], and now offers facilities for collecting data generated by the simulation. These data can be saved as *datasets*, ELOs that can be further processed by the SCYData tool. A specific feature is that a live link between SCYSimulator and SCYData can be created, using the SCY collaboration mechanism.

SCY simulator offers scaffolding at four levels, with respect to the data collector. These levels "explore", "explore_simple", "collect_data", and "collect_simple_data". These modes determine whether data can be collected or not (explore vs. collect) and whether the learner can determine which variables to save or see data from (simple vs. free). The mode the simulator is in can be set by the author and can be controlled during runtime by agents and the SCY runtime authoring tools.

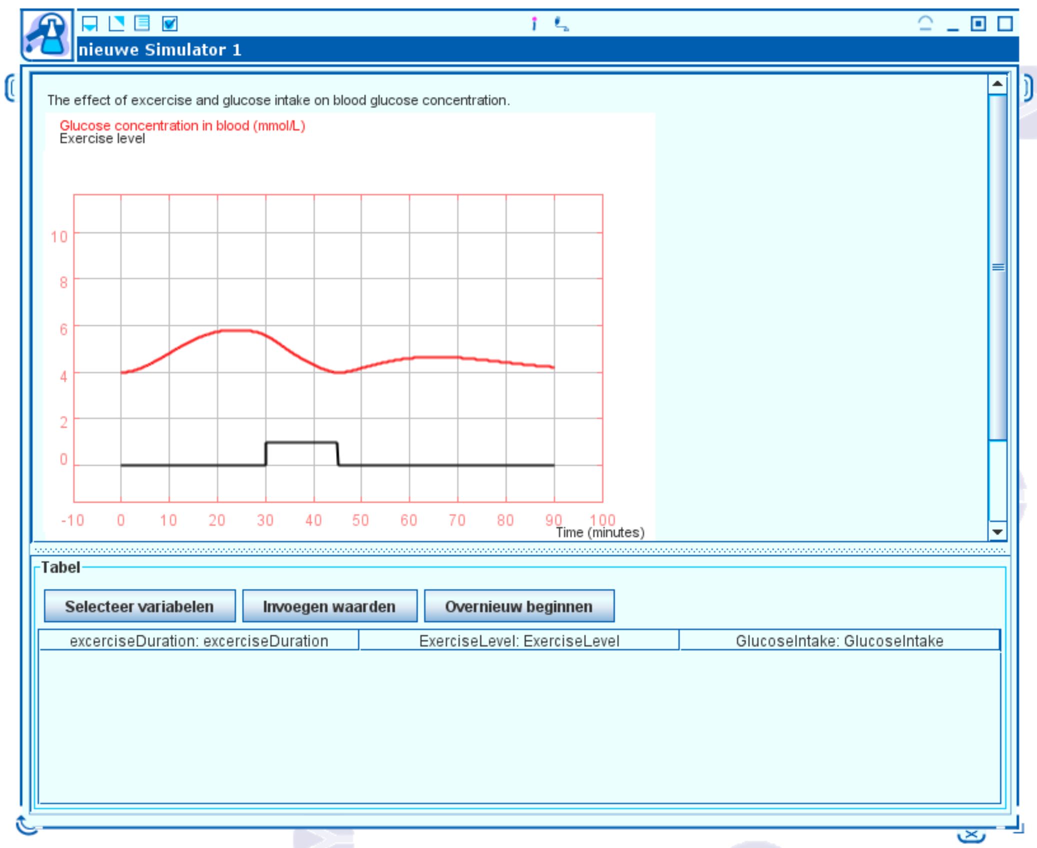

Figure 1: SCYSimulator showing the simulation used in the "Run for your life" mission

[1] SimQuest originates from the project SERVIVE (sponsored by the European Commission under the 4th framework program) and has been designed as authoring and learning environment in the field of discovery learning.

3.2 SCYMapper

SCYMapper is a concept mapping tool that is built for online, collaborative concept mapping. In its pure shape, SCYMapper is a basic concept mapping tool that allows to draw shapes to represent concepts, add text labels to these shapes and create labelled links between these concepts. There are two features that distinguish SCYMapper from most other concept mapping tools:

- It is collaborative: learners can work together on one concept map.
- It allows for pre-set concept maps including shapes and backgrounds, so teachers can set up a concept map with graphics from the domain. This makes the concept mapping tool suitable to serve both as a tool for generating early ideas about the mission and as a tool to summarize information found and conclusions from the mission work.

SCYMapper is completely integrated into SCY-Lab, and hence shares the ELOs on RoOLO, and is capable of exchanging information by agents. As concept mapping plays an important role in all missions, there are three agents that work together with SCYMapper generated data.

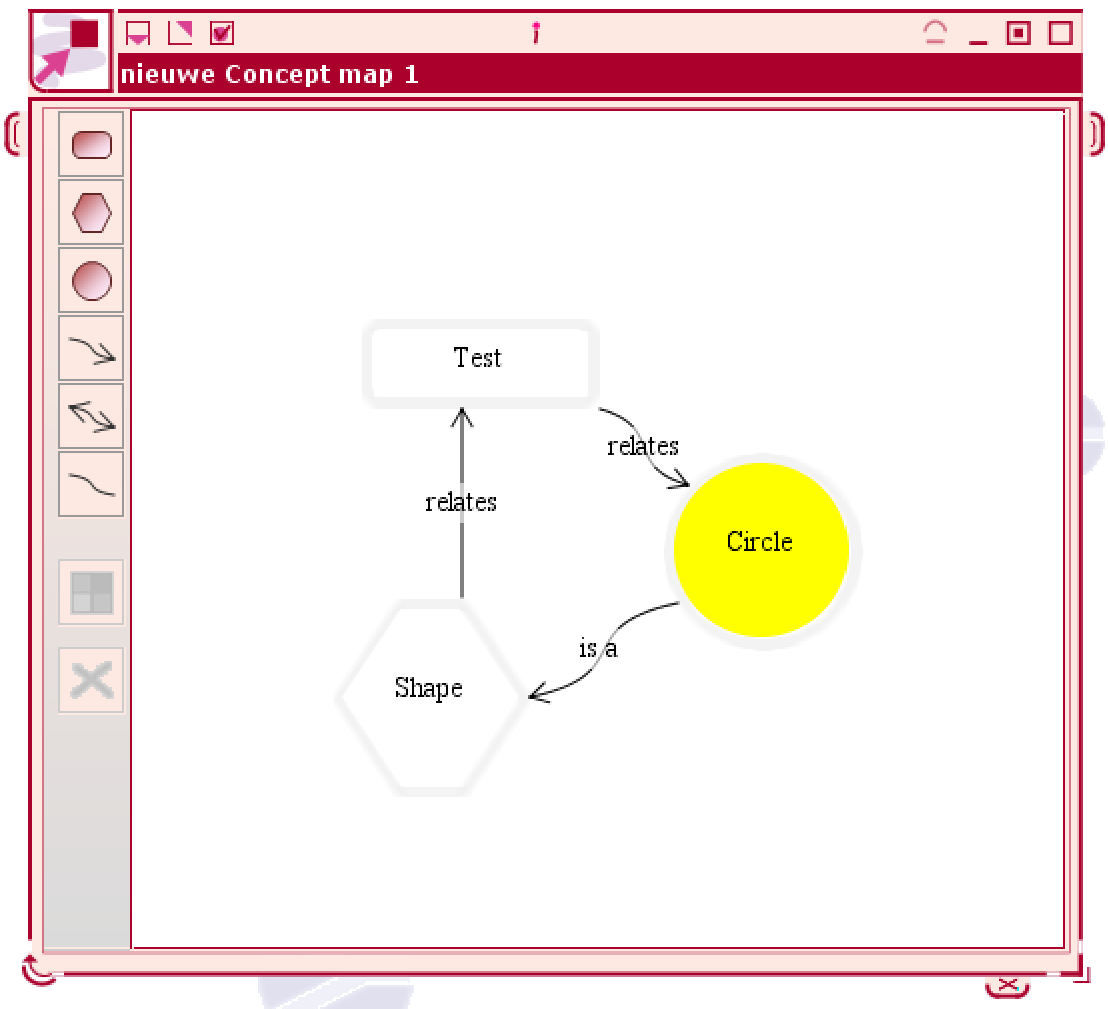

Figure 2: SCYMapper

3.3 Tool for key ideas

This tool was not implemented as a separate tool, as the functionality needed is provided by SCYMapper.

3.4 SCYData, Data processing and visualization tool

SCYData is a tool to process quantitative data collected by learners in the field, using handheld data loggers from simulations, from self-built models or from any other source, using the data entry form. Data can be entered using a spreadsheet-like data entry form, or be opened from other tools that save data set in the SCY dataset format. Datasets can be combined and manipulated. Data can be plotted in various kinds of graphs.

A specific feature of SCYData is its connectivity to other tools. It can use data from various sources and, if those sources provide live updates of the data, dynamically modify the data set.

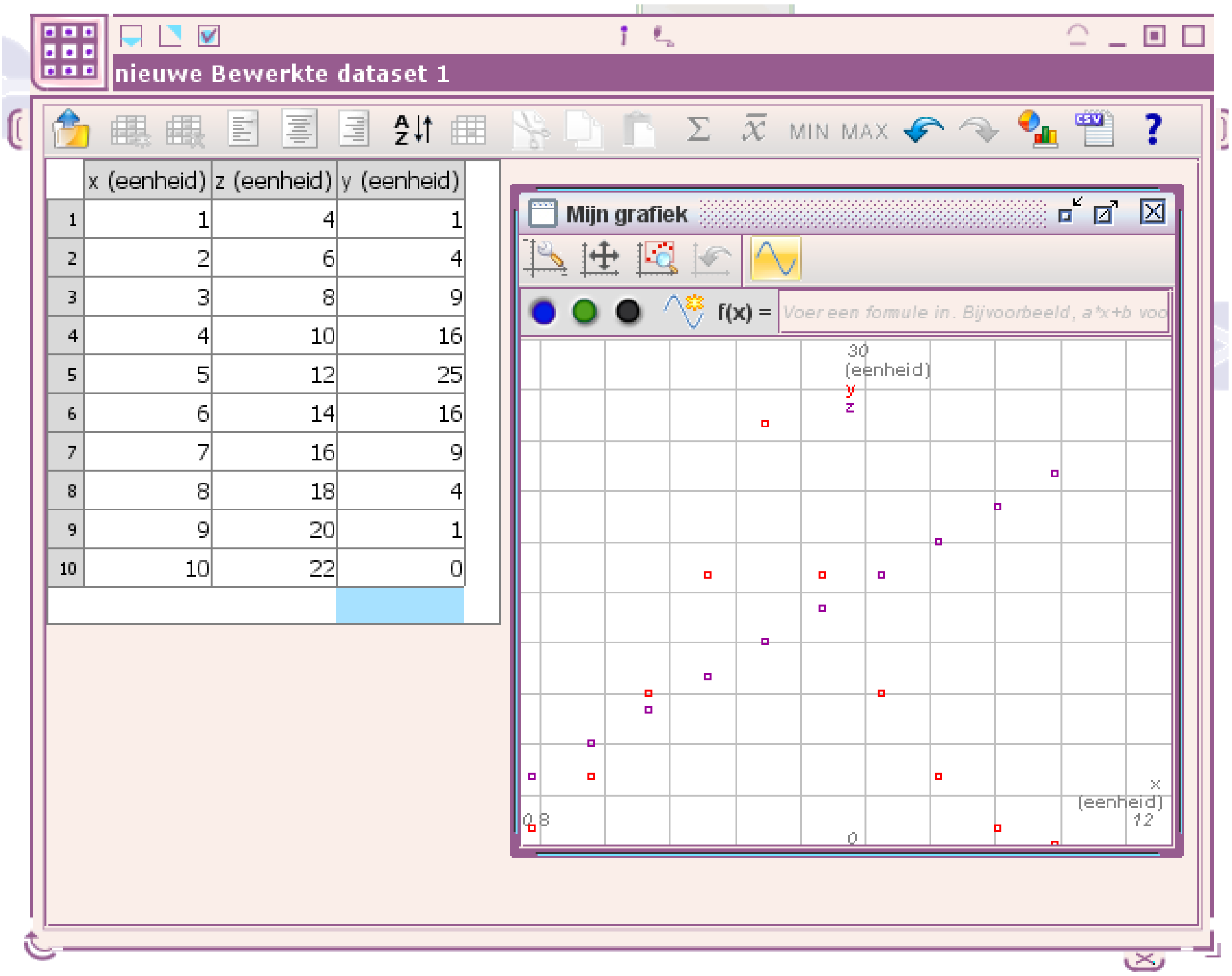

Figure 3: SCYData

3.5 SCYDynamics Modelling Tool

The SCYDynamics Modelling Tool is a means for learners to build dynamic models of a wide range of phenomena. Other than in simulations, where the computational model and a user interface is given and the learner may vary parameters to see and interpret the simulation results, the modelling tool allows learners to create computational models themselves. To this purpose, the tool provides a an interface to build and run System Dynamics models, similar to existing tools like STELLA or the Co-Lab Modelling Tool.

SCYDynamics compared to the SCYDynamics modelling tool as described in earlier deliverables, the tool has undergone some modifications and extensions. While the basic functionality (System Dynamics modelling) remained, the tool experience in terms of available feature, the user interface, and interoperability with other SCY tools and SCY-Lab have improved.

SCYDynamics' primary ELO format for storing and retrieving is the specification of the model (technical format "scy/model"); additionally, it is able to store datasets (i.e. tables of values) as well to be viewed and post-processed by SCYData. Thus, SCYDynamics provides another way of generating datasets in addition to the collection of external data, creating datasets from simulations in SCYSimulator or by manually creating datasets in SCYData, which gives rich opportunities for comparing different data sources (e.g. real world experiment vs. model).

Similar to the feature of synchronized collaboration in SCYMapper, where two learners are able to work on the same representation of a concept map in two different instances of SCY-Lab in a shared-workspace fashion, SCYDynamics supports this kind of collaboration as well. Here, the creation and modifications of the model are synchronized, but not the simulation of the model to create plots or tables, allowing for a joint model creation but a separate model exploration / verification.

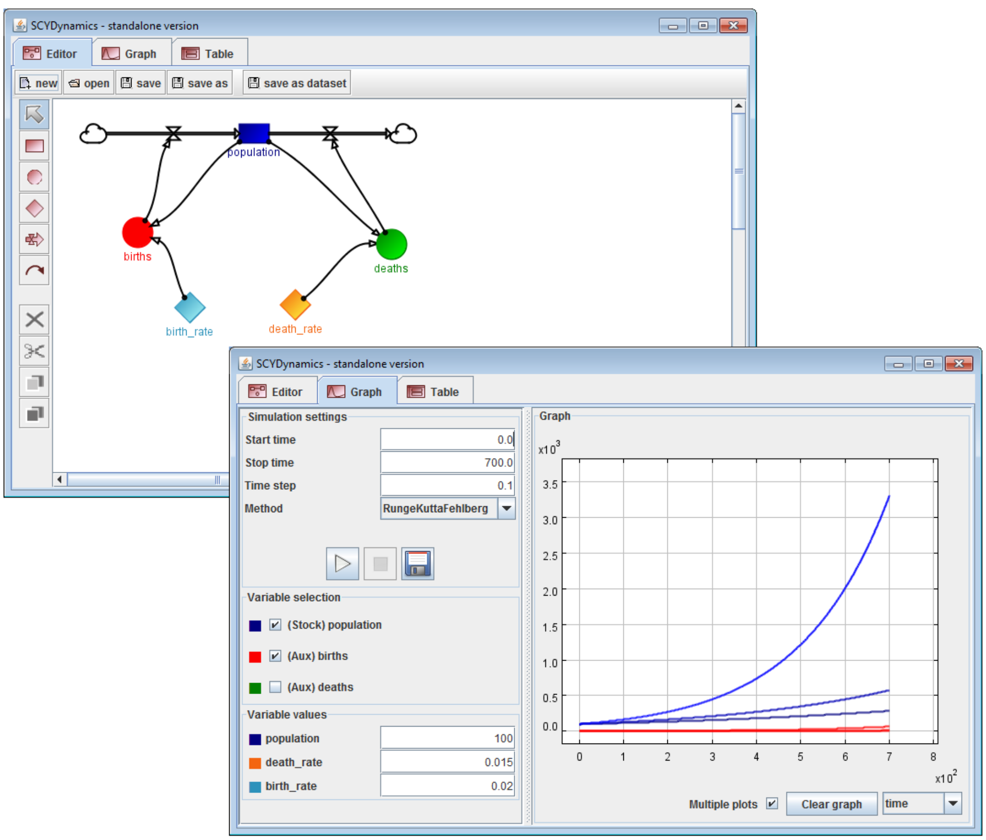

Figure 4: Improved SCYDynamics modelling tool

Figure 4 shows two screenshots of the improved SCYDynamics modelling tool. In the top, you can see the model editor with a new set of icons in the toolbars and an enhanced visualisation of the model. At the bottom, the interface for simulating a model is shown. For easy comparison of different value settings in a model, the learner can now change them instantaneously without going back to the model specification. Additionally, it is now possible to show multiple plots in one graph and to chose other variables than time for the abscissa, thus allowing for phase diagrams to visualise e.g. phase planes in cyclic models like harmonic oscillators or Lotka-Volterra (predator-prey) models as shown in Figure 5.

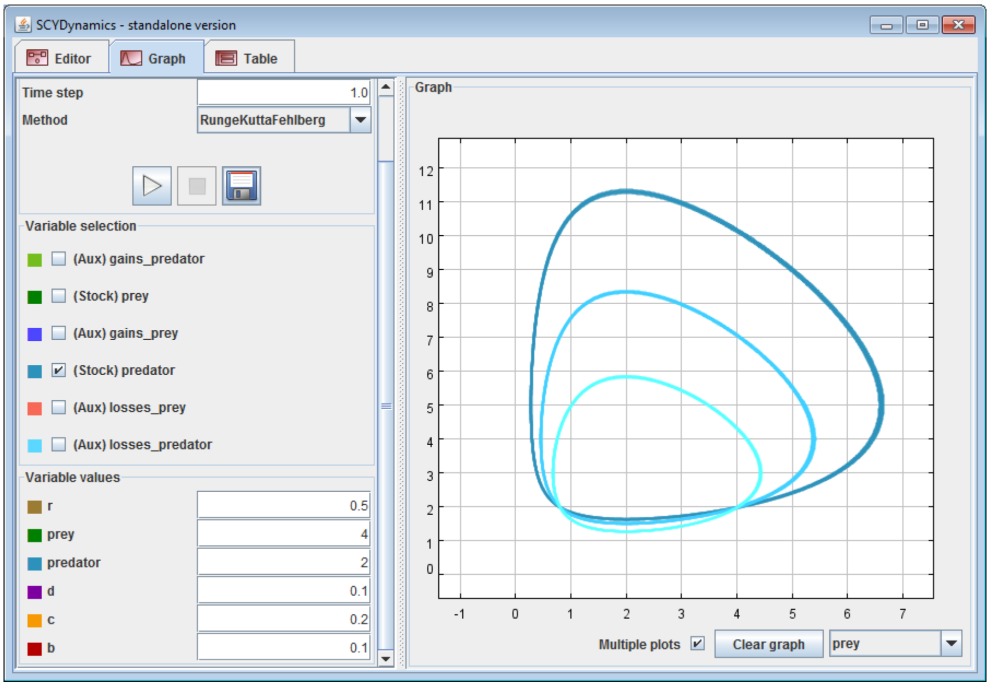

Figure 5: Phase diagram of predator population for different prey birth rates in a predator-prey model

As a reaction to various requirements from mission designers, authors and teachers, a set of different modes of operation has been implemented in SCYDynamics similarly to the modes in SCYSimulator. These modes expose different levels of complexity, features and scaffolds to the learner and are explained in the following section:

- Black box: In this mode, all features to create, inspect or modify a model are disabled. The learner is only allowed to view the overall structure of a pre-defined model and to simulate it to crate plots or tables. This mode is particular useful when should not bother with models or modelling, but when the features of a phenomenon are to be identified and explored.
- Clear box: In "clear box" mode, the learner cannot change or extend the model, but it is possible to inspect the specification of variables and relation to get deeper insight into the details of the model and of the phenomenon.
- Model sketching: During model sketching, a learner is able to create the elements of a model, label them and link them. However, It is not possible to specify the type or exact expression of a relation between variables. Thus, it is not possible to simulate the model e.g. to create plots.

- Qualitative modelling: In “qualitative modelling” mode, the learner can fully create, specify and modify a model. However, in contrast to “quantitative modelling” (see below), the relations between elements of a model are specified in a qualitatively manner, instead of giving a concrete mathematical expression. Examples of qualitative relations are “linear up” (e.g. “if the birth rate goes up, also the number of births goes (linear) up”), “linear down”, “asymptotic” etc. Internally, a quantitative model is being generated to be able to simulate the model and to give a meaningful output in the form of graph plots. One main goal of qualitative modelling is to give learners the opportunity to model complex systems without bothering with mathematical formulas or exact values in first place.
  If the automatically generated expression are not sufficient to create meaningful visualisations of the model’s behaviour, a reference model may be prepared by an expert. A reference model specifies possible elements in a model, along with alternative labels, their mathematical expressions and ranges of values. The learner will be unaware of such a reference model. X shows a screenshot of SCYDynamics in “qualitative modelling” mode.
- Quantitative modelling: The quantitative modelling mode resembles the tool as it has been described in earlier deliverables. All modelling features are fully available; the learner can create, modify and simulate models without restrictions.

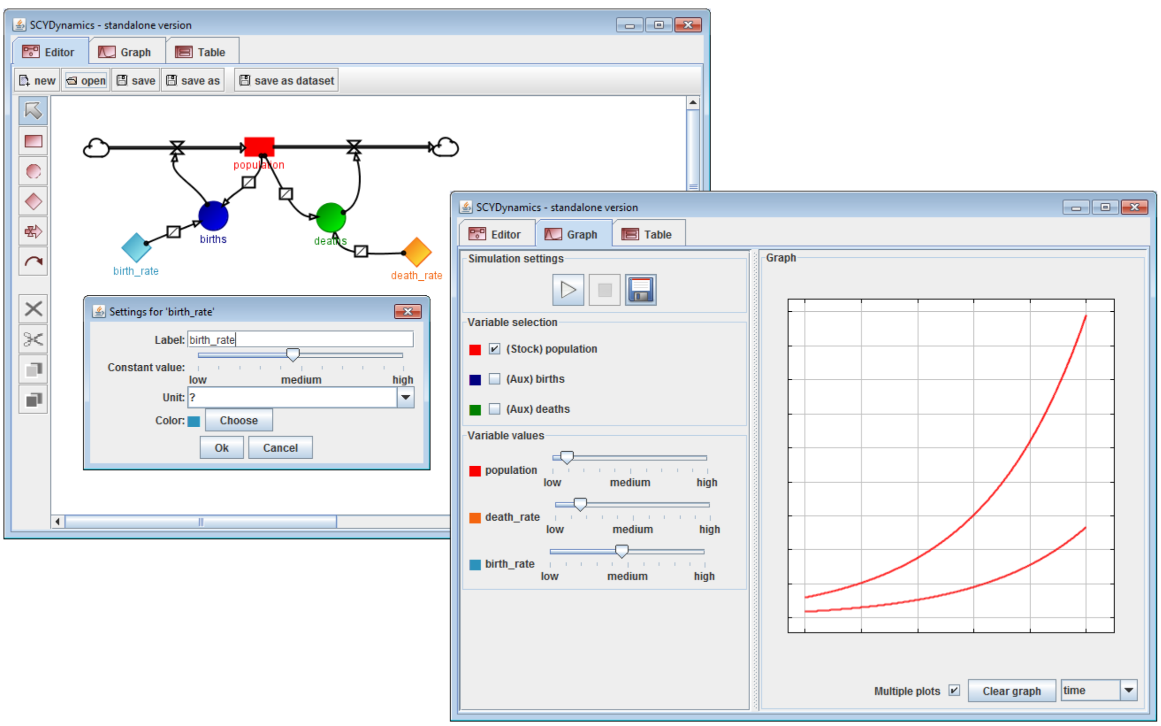

Figure 6: SCYDynamics in qualitative modelling mode

Similarly to the SCYSimulator tool, SCYDynamic’s modes of operation can be set during mission authoring or at runtime for every single, running instance of SCYDynamics.

3.6 SCY Planning Tool and Mission map

The SCY mission map has become an integrated part or SCY-lab and is no longer considered a tool in the SCY sense. The mission map does provide specific planning and monitoring information for the learner.

3.7 Report Tool

As such a reporting tool has not been implemented in SCY-Lab. SCY does include a simple text editing tool and allows to upload external files, such as presentations and word processing documents as report. The by setting the objects "functional role" to report, objects based on such document are recognized and processed as reports.

3.8 SCYInterview: Interview format tool

The interview tool is used in Mission 1, CO_2-house, to allow learners to prepare an interview with an expert. The interview tool lists the stages in preparing the interview, suggests forms for questions and allows the learner to print the interview schedule and take it to the interview.

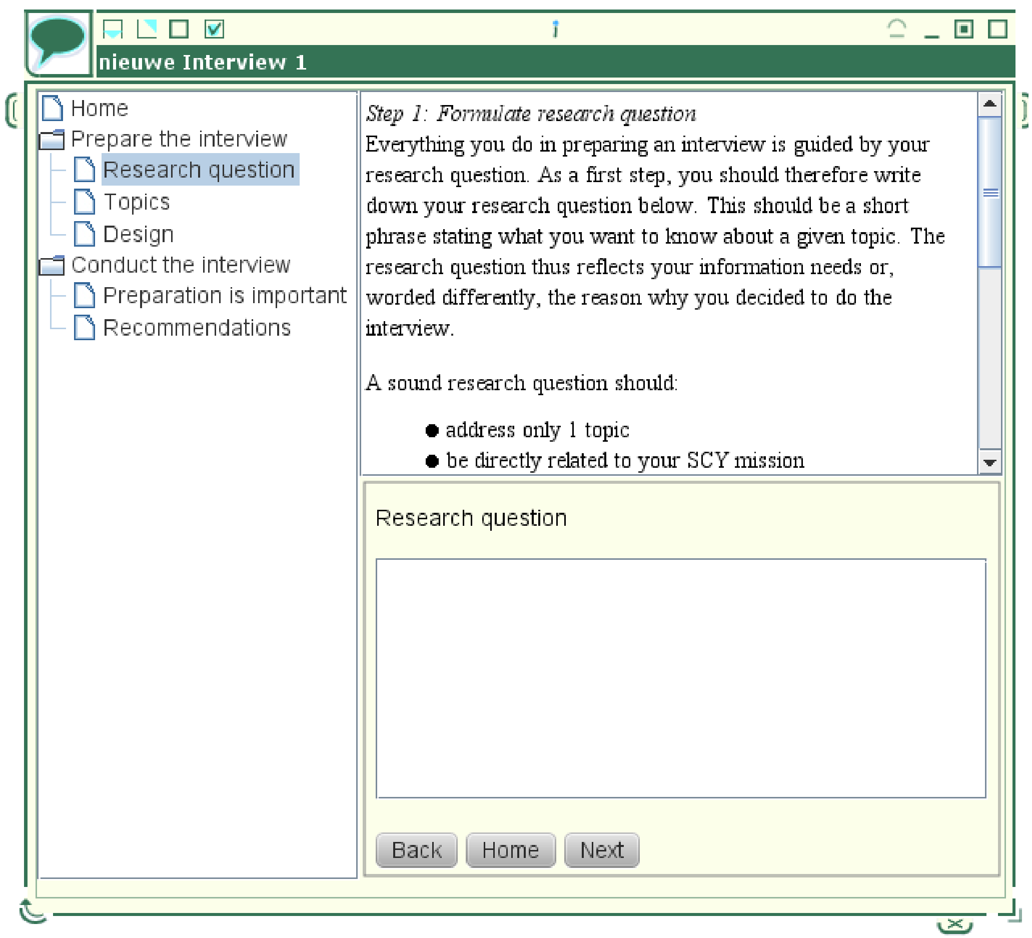

Figure 7: SCYInterview

3.9 SCYLighter: Web browsing tool

The web browsing tool is a means for learners to collect information on the internet and store it in the SCY system. This will be very useful to gather information from web resources to consolidate background knowledge on a mission or during a web quest learning activity. The web browsing tool is neither a web browser itself, nor a replacement for the browser but implemented as a Mozilla Firefox[2] extension. It is supposed to integrate the web browser Firefox into the SCY system and support the learner in collecting relevant information and producing ELOs. Collecting information means browsing a web site, selecting, highlighting and collecting relevant parts from the web site, adding comments and finally saving this data with attached links to the origin of the information.

The web browsing tool can be used within learning activities, where collecting information and resources is required. E.g., in the information learning activity the user is supposed to browse for information, either to get an overview of the mission context or to collect specific information for answering questions in a Web Quest.

The learner will be able to browse the web as he/she is used to, using the web browser Firefox. The SCY specific extension to Firefox is the SCY Sidebar. The learner can, e.g., conforming to mission one, browse for information about CO_2 on Wikipedia. As he/she finds relevant information, he/she can select a text passage and highlight it. This section will automatically be added to the list of selected items (cf. Figure 8, *Selection* list in the SCY Sidebar). The learner can highlight and collect several items on the page, provide a title for this selection and add a comment. The web browsing tool will automatically add the URL as a source for the selected items, thus making it possible to get back to the full resource later on. Finally, the learner can save the ELO into the repository and use it later as an information resource.

[2] Mozilla Firefox, http://www.mozilla-europe.org/en/firefox/ (19.08.11)

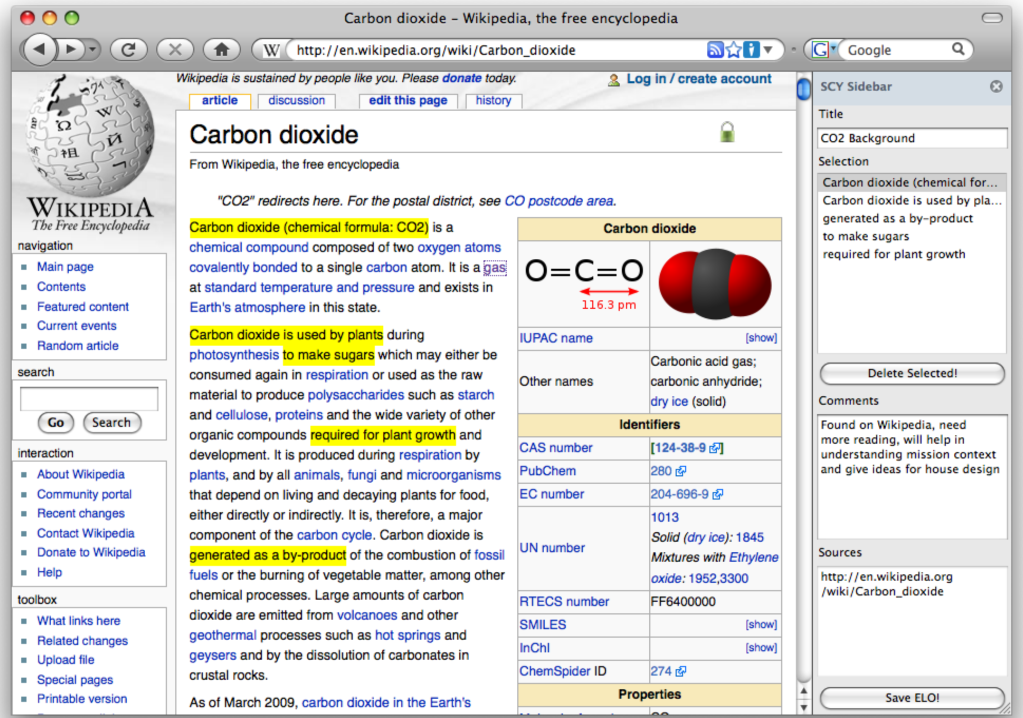

Figure 8: Firefox with SCY web browsing tool extension

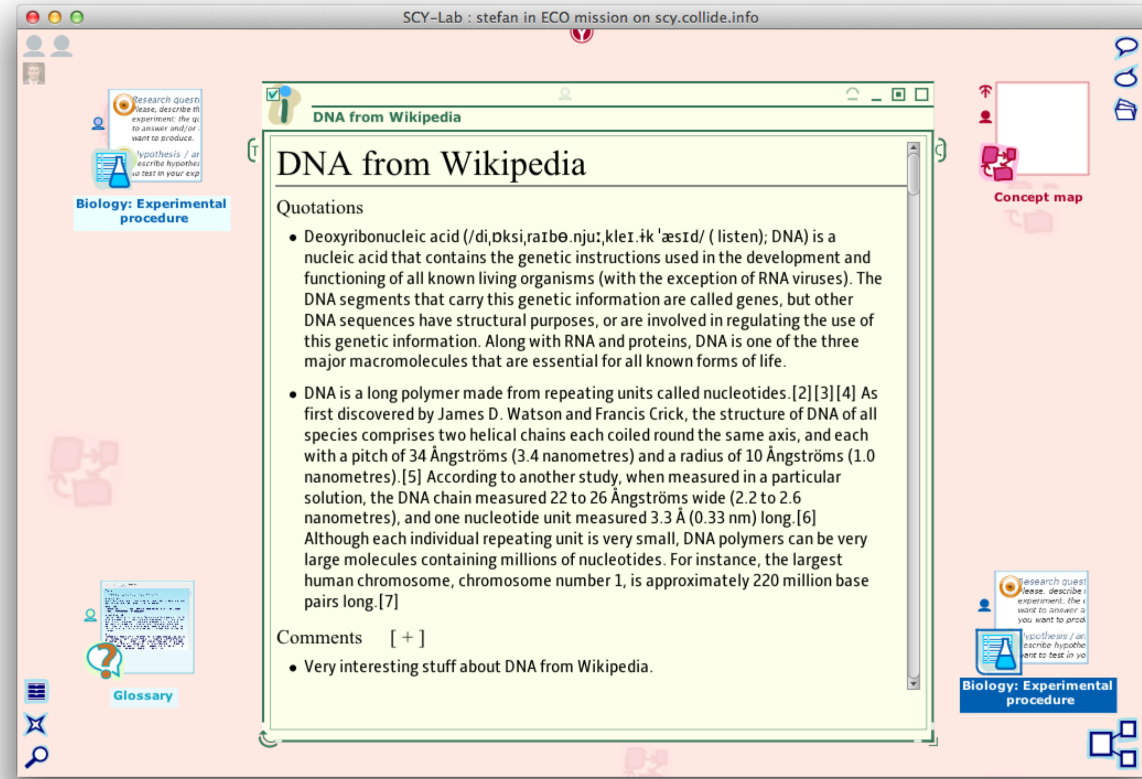

Figure 9 Picture of the web information collected with SCYLighter and displayed in SCY-Lab

3.10 SCYED: Experiment design tool

With SCYED, learners can create plans and procedures for experiments. Experiments within SCY are all activities to collect data from a phenomenon that is being investigated. The experimental plan starts from a research question specified by the learner. Usually this research question is defined in an earlier stage of the mission work. Based on this question and knowledge and information learners may have, they state a hypothesis. Then, learners elaborate the materials they need for the experiment, such as measuring equipment and ingredients and elaborate a step by step procedure. The procedure can be stored as a PDF in order to print it and take it to the lab, if applicable.

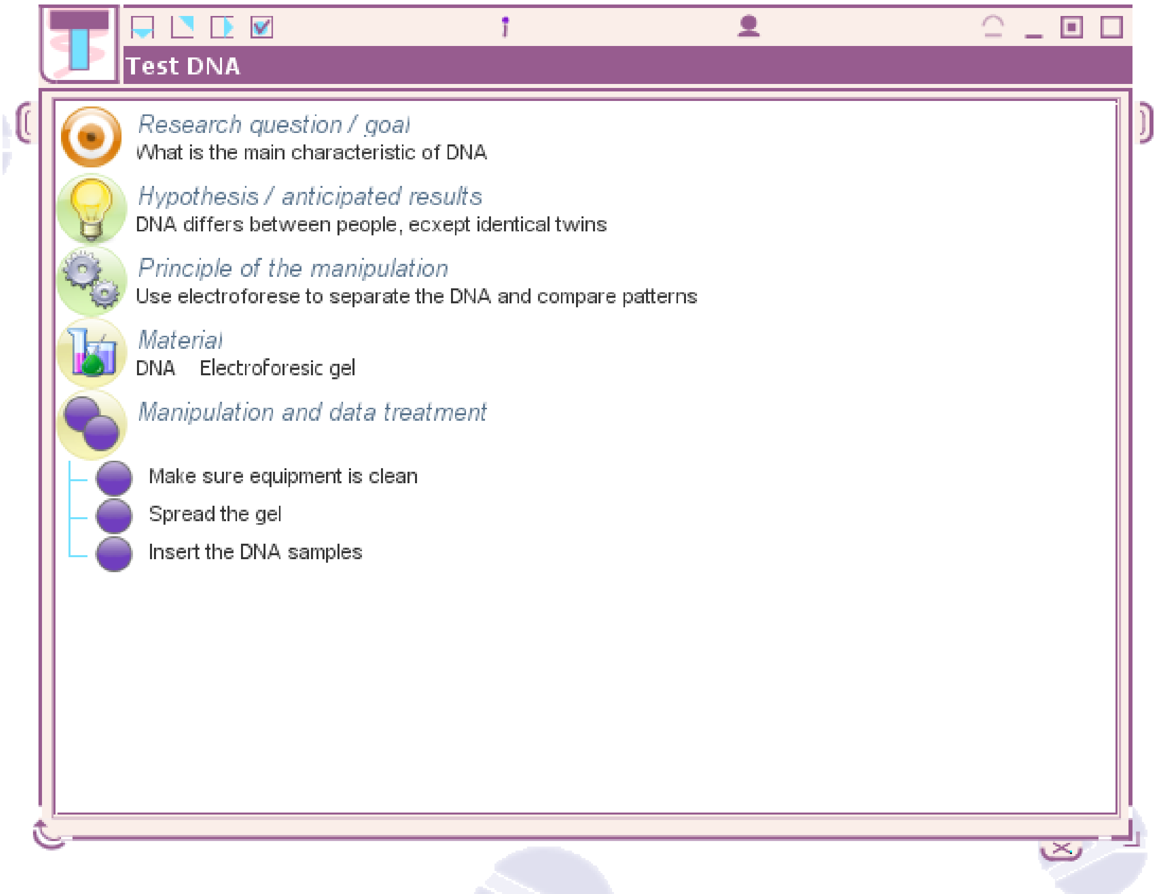

Figure 10: SCYExperimental design

3.11 SCYDraw: drawing tool

For creating simple drawings, SCY contains a drawing tool with elementary drawing capabilities: shapes, freehand drawings, importing images. This tool is used in Mission 1 for creating drawings of the house that learners design. In most of design a simple drawing tool is not powerful enough. Specifically for missions in which technical artefacts have to be designed, learners need to create their designs in dedicated tools. SCY did not foresee the development of such elaborate tools (which would be a project in its own) but does foresee importing and analyzing the products of these tools as ELOs. For instance, for technical drawings created using Google Sketchup[3], an easy-to use 3D drawing tool, can be imported as ELO.

[3] www.google.com/sketchup

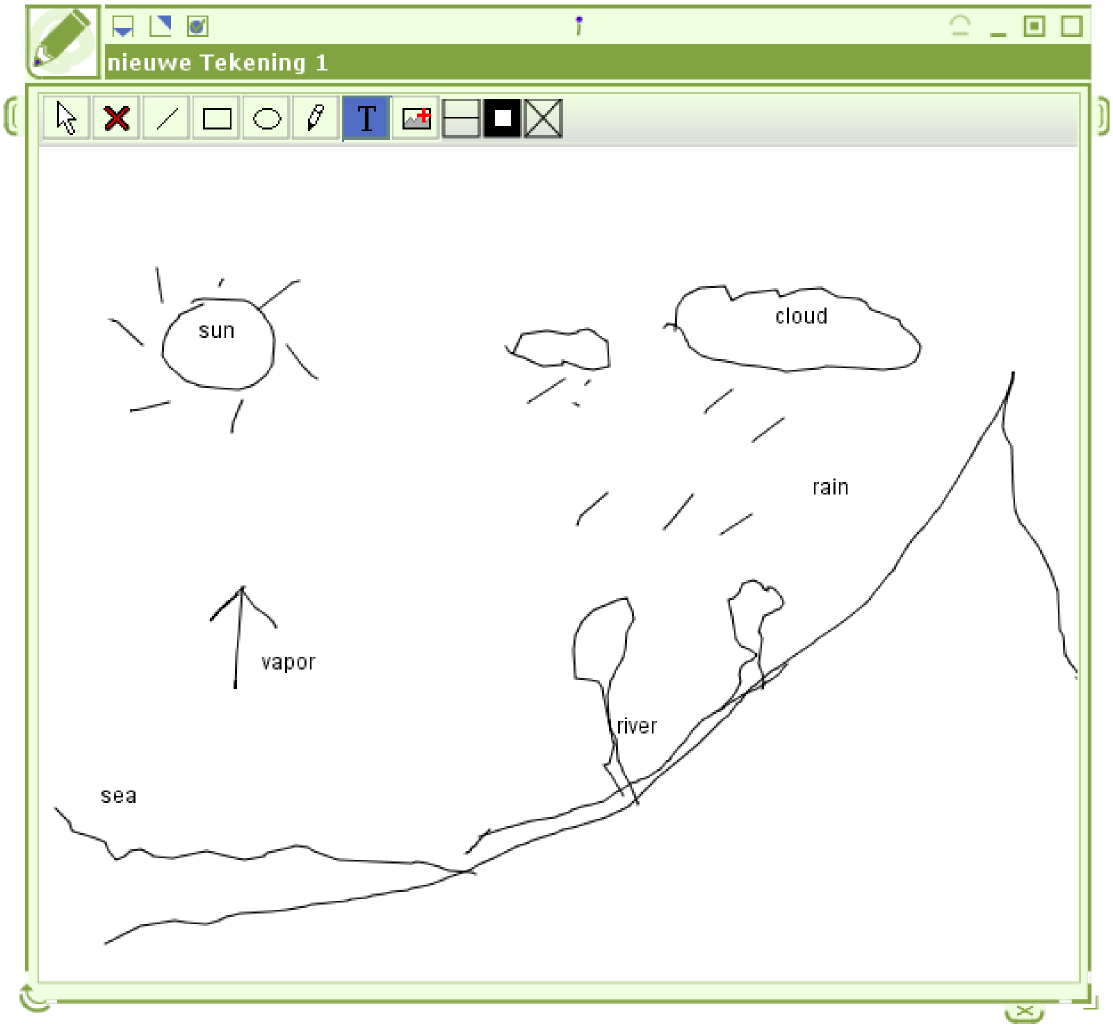

Figure 11: SCYDraw

3.12 SCYDataCollector and SCYFormAuthor: collecting mobile data

The mobile data collecting tool is a means for learners to collect numerical and multimedia data in the field with their mobile devices (based on the Android platform) and store the collections as ELOs in RoOLO. The concept of collecting the data has been based on forms that can be created by teachers or by students themselves inside SCY-Lab using the form author tool. The basic idea of forms for collecting data is to standardize and structure the data collection. This has the advantage that data can be compared between collections based on the same form(s), furthermore data have a defined meaning and a type identified by the form entry and are therefore better readable and understandable in later post-processing.

There are two types of forms: the *template forms* created by the authoring tool and the *instantiated or filled forms* with actual data. The lifecycle of forms starts with the template that is later on being filled with data during the activity and can also further emerge, i.e., by refilling and modifying it afterwards. In general, forms have a *title*, a *description* and a *version number*. The description can be used to describe the data to be collected by this form or, if created by a tutor or teacher, to formulate a task for the students. The version number identifies the version of the form during iterative modifications.

Forms consist of several fields. Each field has specific parameters, i.e., *field name, field type, field cardinality, events* and the actual *value.* The name describes the field, e.g., *"height of plant in cm"*. The *field type* defines the data type of the value, e.g., the height would be entered as a *number*. Currently the following data types are supported: *text, audio, photo, time, date, number, counter* and *GPS location.* The *field cardinality* defines the quantity of values that can be collected in this form field, e.g., a cardinality of "3" on a field with the type *photo* would allow to take three photos and store them as the value of this field; a cardinality of "0" means unlimited amount. Finally, *events* can be defined to be fired *before* and *after* the data has been captured. These events can store the *GPS location*, *date* and *time* and allow for complex configurations with location, time and date annotated data collection series within one field.

The mobile data collector tool and the form author tool produce and consume ELOs of the technical format scy/formauthor. The workflow is as follows: The form author tool produces a template ELO. This template ELO does not contain any data and is consumed by the mobile data collector tool. The mobile tool fills the template with data and produces a filled form ELO. The filled form ELO is then consumed by the form author tool for visualization and further work.

The form authoring tool is fully integrated into SCY-Lab and can be used to create forms for data collecting activities. It can produce and create ELOs as well as log user actions. The user can use it as a tool for creating form templates as well as a tool to review the filled forms, i.e., work with the collected data.

The tool provides a simple way to author forms and store them into the repository. Figure 12 shows an example form inside SCY-Lab for the previously defined research question. On top of the tool, the title and the description can be provided for the form. The rows in the below represent the form fields and can be flexibly added, removed and reorganized. The properties field name, type and cardinality can be set as well as the events (using the button at the end of a row). Finally, this form can be stored as an ELO into the SCY repository.

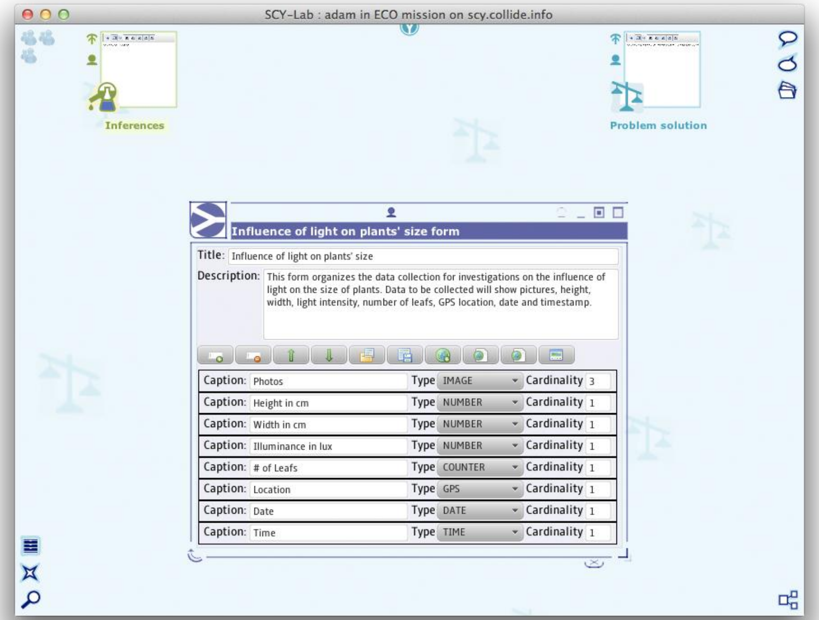

Figure 12: Form authoring tool in author mode inside SCY-Lab

The mobile data collecting tool is running on a mobile Android device and is therefore external to SCY-Lab. The user can load form templates from the repository fill them with data and finally upload the results for further processing. The applications starts with the main screen presented in Figure 13. Here the user can select a form to work, download new templates from the repository or configure some parameters.

Figure 13: Main Screen of SCY Data Collector

In the form selection screen the user can browse through locally stored forms, open or delete them, or finally save the forms filled with data to the repository (cf. Figure 14).

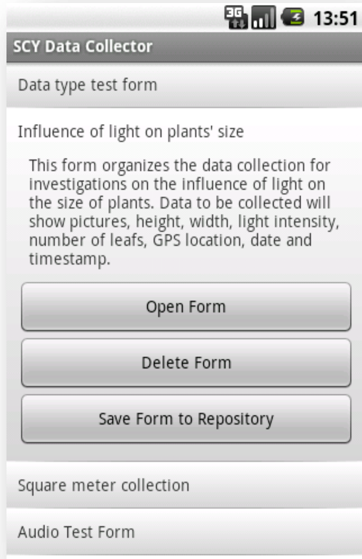

Figure 14: Form overview

Once the user opens a form, s/he will find an interface for entering the form data. The user interface has been designed to be similar to the authoring environment. The fields are being mapped to rows. Each type has a particular representation in the UI, with appropriate UI elements to fire the data collection actions, e.g., increase the numerical counter or set the current date or time. Finally, the user can confirm the form an save the collected data to the mobile device.

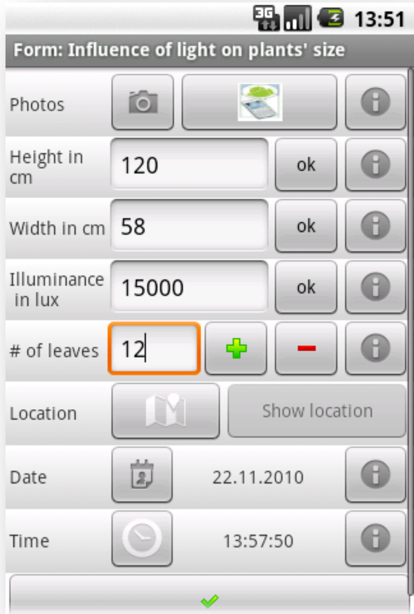

Figure 15: Different Views of SCY Data Collector

Once the learner has finished the data collection, s/he can save the form from the mobile device to the ELO repository and retrieve the data using the form authoring tool in the viewer mode. In this mode, all data will be visualized and can be further elaborated by the user.

3.13 Reflection tool

This tool has not been implemented because its functionality would double that of the ePortfolio.

3.14 SCYText: Text Editor

The Text editor is used to create all kinds of text based ELOs. The main content of many ELOs will be text, for instance in the case of Research Questions, Hypotheses, Arguments and reports. SCY obviously needs to facilitate the writing of text. SCY offers two solutions for this: external tools, such as Microsoft® Word or OpenOffice can be used to write the text which can be imported as an ELO. The SCYText editor is foreseen for producing short texts.

In order to support the creation of specific texts, the text editing and processing tools authors offer *templates* for texts, and text will be processed by agents at save time. For instance when a learner produces a hypothesis, a template can already provide some basic text (an if… then… text, a place for providing justification, etc.). Moreover, agents analyse the text and – for instance – detect if it meets the requirements for being a hypothesis (syntax, use of variable names, testability). Agents and templates can work together by storing metadata in the template that can serve as a starting point for analysis by the agent. A pivoting role is setting the *functional role* of the text in the template, which is used by the agents to detect if the text should be interpreted as a hypothesis, a research question or something else.

3.15 Presentation tool

A presentation tool as such has not been developed, according to plan. Instead SCY allows for uploading presentations created in other tools.

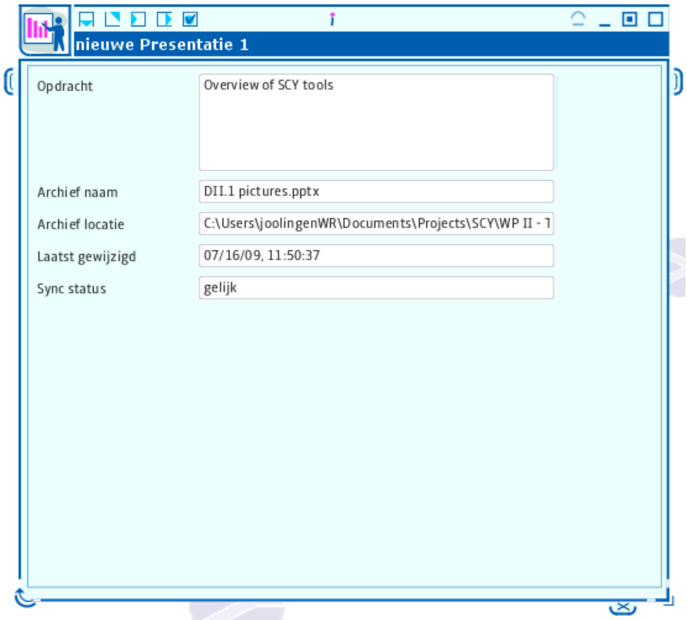

Figure 16: Tool to upload external presentations

3.16 Awareness facility and communication tools

The awareness facility is not implemented as a single tool but as a set of features of SCY-Lab and the SCYTool environment. In SCY-Lab learners can see who are their contacts and who of those contacts is online. For each ELO that learners open, learners can see who is the owner. Learners can chat with each other using a chat tool. This tool can be attached to a specific ELO that is co-owned by the learners or can be free-floating. Chat conversations are saved as ELOs themselves, so learners can retrieve what they have said earlier, if they like.

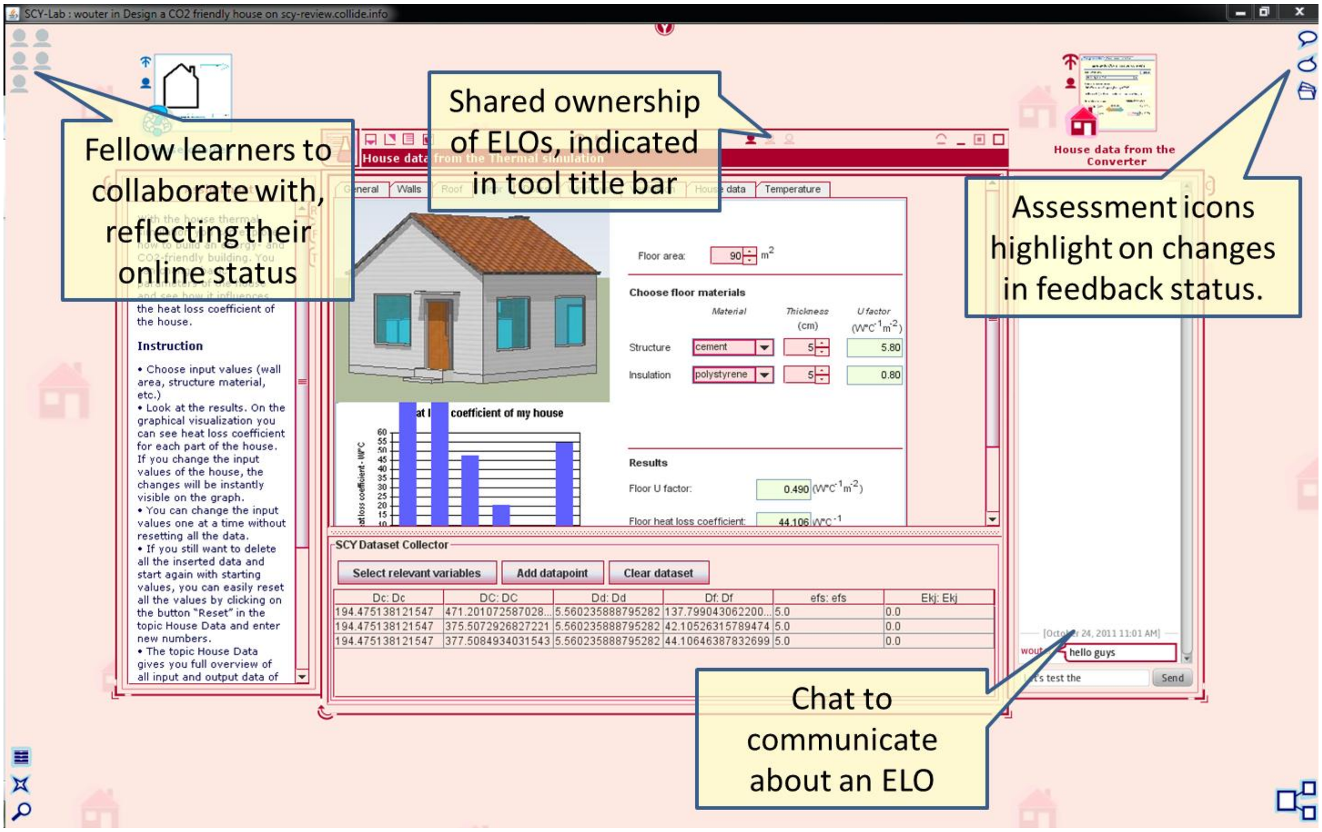

Figure 17: Awareness features in SCY-Lab

3.17 SCYSearch: The search tool

At the outset of SCY it was clear that there should be a possibility for learners to search the collection of ELOs in RoOLO to find relevant work by themselves or by other learners. The search facility has been a part of SCY-Lab from version 1. However, in earlier versions, the searches themselves did not result in ELOs that could be exchanged and reused. There is a benefit in retrieving older searches and exchanging search specifications. In ELO-based learning as promoted by SCY, navigation through the space of ELOs as offered by a search tool is of paramount important.

As a result the SCYSearch is now a full-bodied tool with the option to save, retrieve and exchange search queries and results. Searches can be specified in two ways:

- Keyword based search offers a Google-like search in which learners can type in key words that are then used to search RoOLO, the database of ELOs.
- Similarity search, in which learners base their search on an existing ELO and the search tool tries to find similar ELOs, based on title, keywords and content.

In both kinds of search, learners can apply filters, such as “find only my own ELOs” or “Find ELOs older than a given date”. Keyword search also connects to the query extension agent that suggests extending the search to similar keywords.

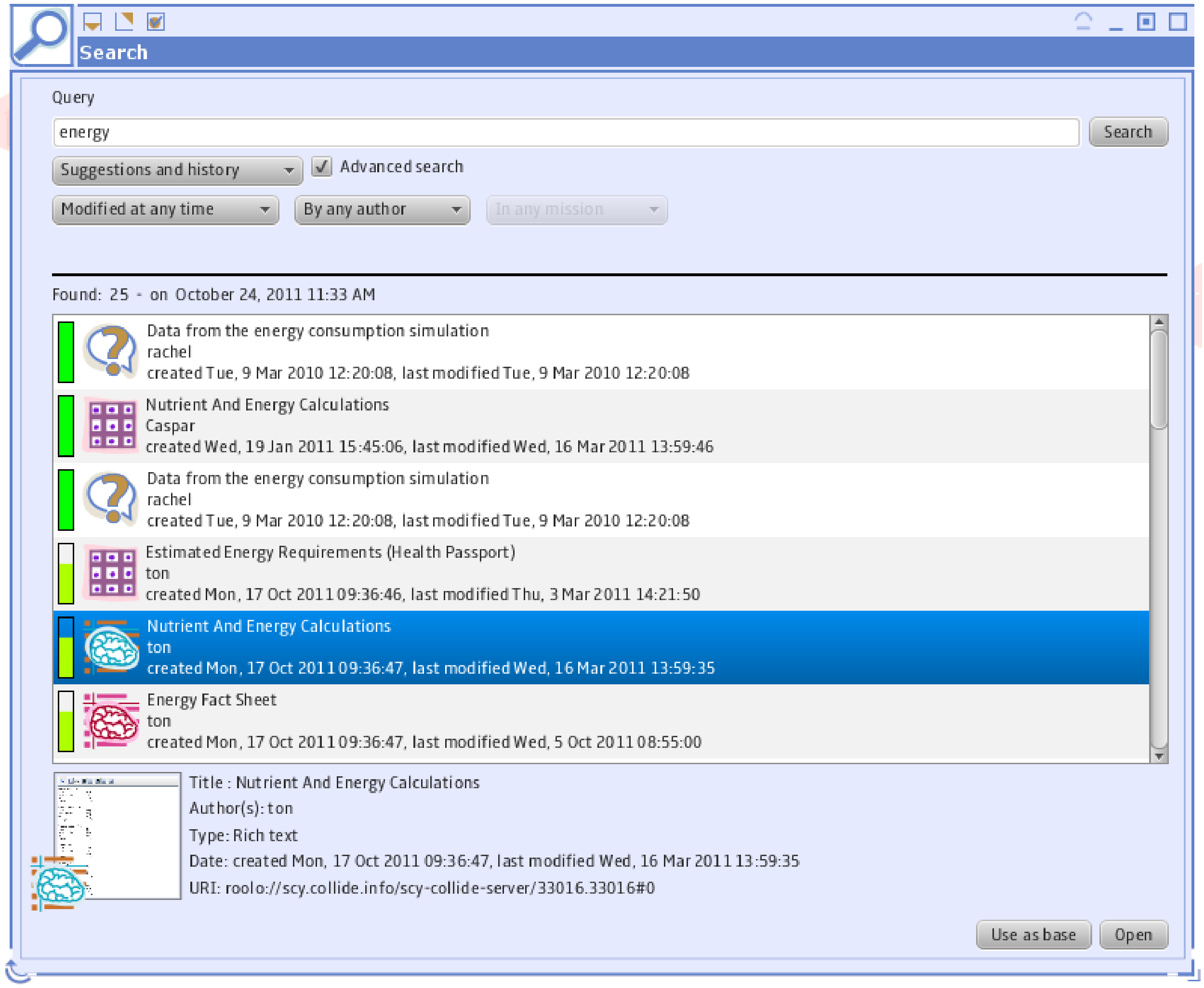

Figure 18: SCYSearch

3.18 The SCY Health passport

The SCY health passport is a tool specifically created for the healthy pizza mission. This tool summarizes data collected by learners on their diet and exercise habits, combined with data on their age, height and weight. The health passport draws upon data collected and summarized in data sets that are imported by the health passport tool.

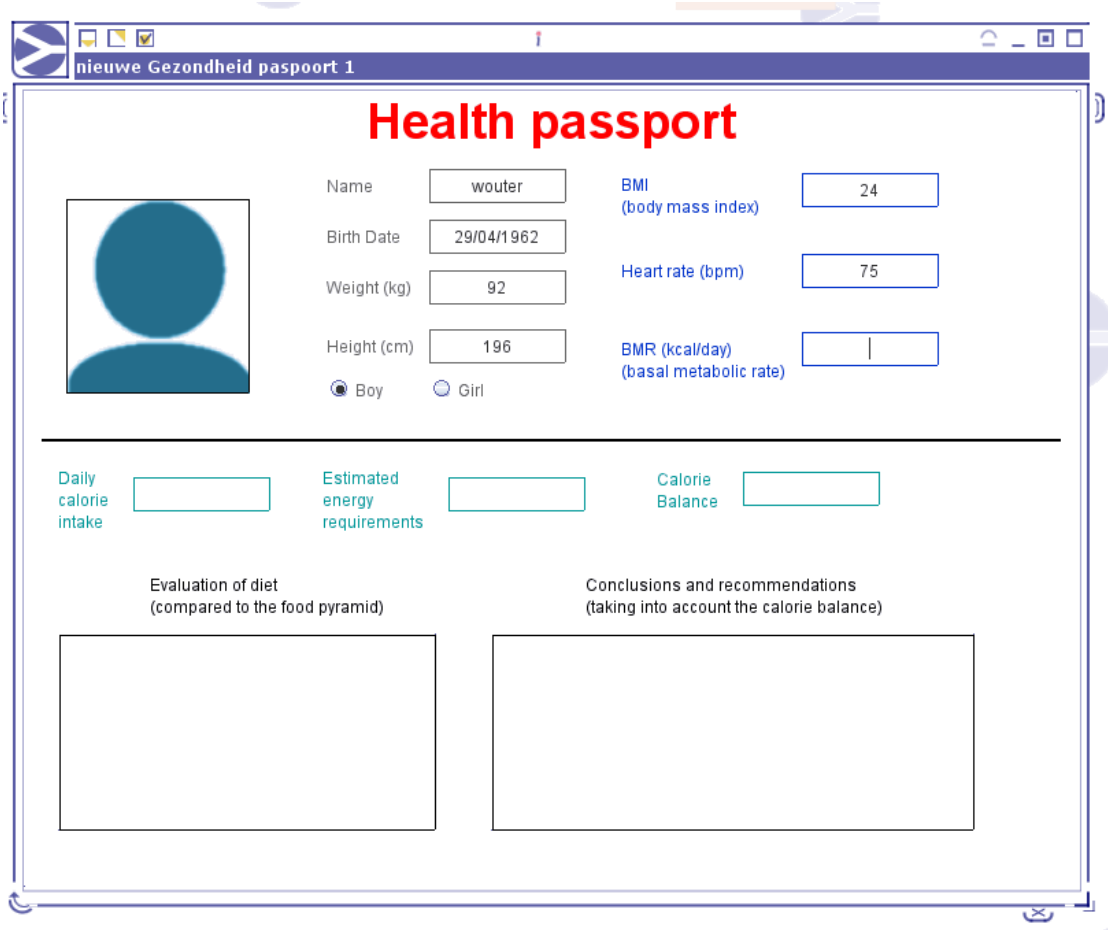

Figure 19: The SCY health passport

4 Specific inter/tool features

Of most tools, the main task is to produce ELOs of a specific kind, to represent learner's work. In some cases, it is important that tools can work together as learners need to combine data or as learners need to work together on an ELO. SCY tools offer three possible options for such connections between tools: real time collaboration between users, real time data exchange between tools and the possibility to compose en combine ELOs.

4.1 Real time collaboration

Real time collaboration means that two or more learners, working on two different computers work together in real time on a single ELO. Changes that one learner makes are propagated to the other learners and vice versa. The resulting ELO is owned by all learners who collaborate. Learners can invite others to collaborate by dragging the person's icon over the tool. The other learner receives a request to accept or deny the collaboration. On accept the ELO is opened for the other learner and collaboration starts. On a Save As action, learners save their own copy of the ELO and collaboration is ended.

Real time collaboration is implemented for SCYMapper, SCYDynamics and SCYText.

4.2 Real time data exchange

In some cases data flows continuously, for instance in the case of a running simulation. Tools need to update their status based on these incoming data. SCY offers this facility to link the SCYSimulator and SCYDynamics to SCYData, where SCYData displays and processes the data as it arrives.

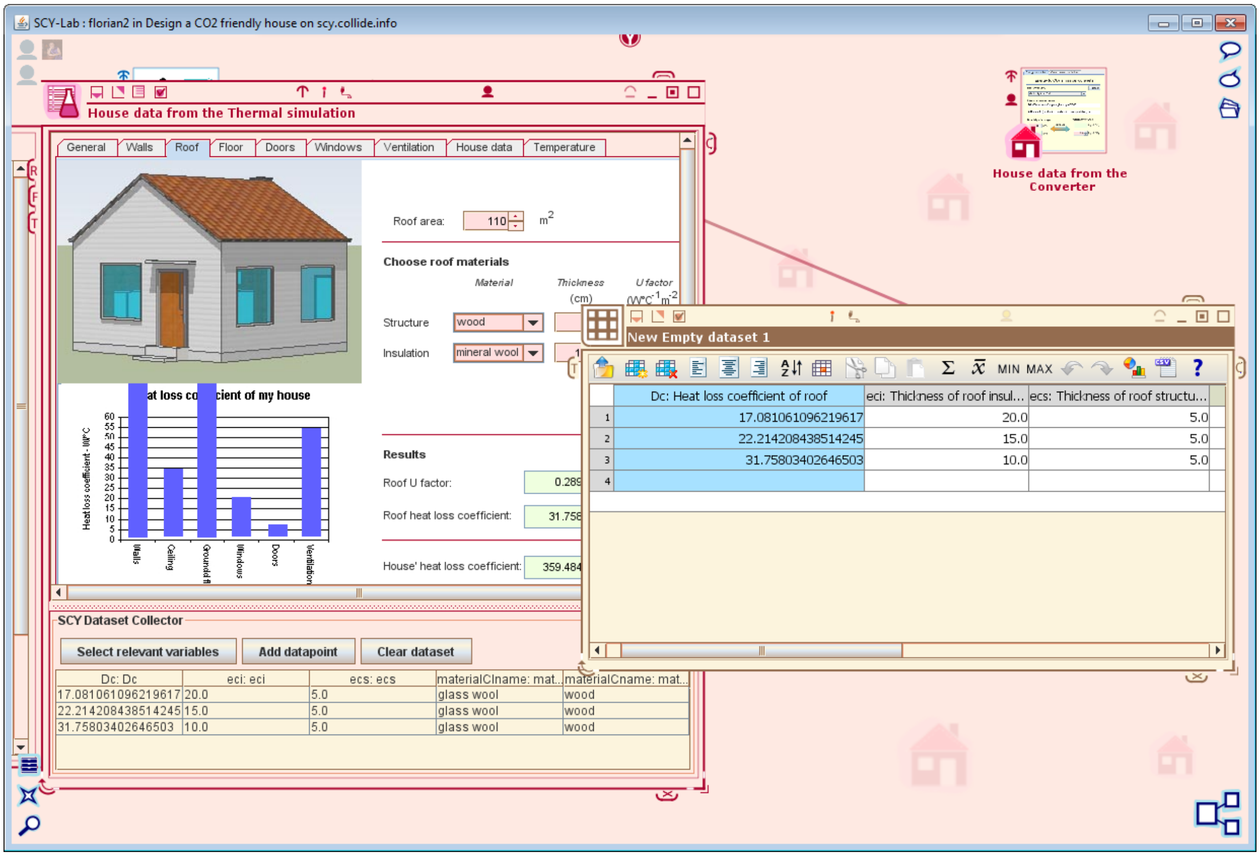

Figure 20 SCYSimulator and SCYData connected. The table in SCYData and the simulation are synchronized

4.3 Composition and combination of ELOs

Some ELOs emerge as a combination of two or more other ELOs. For instance, an experimental design can emerge based on an earlier stated research question and hypothesis. In order to make this explicit, it is possible to drag a text ELO containing a hypothesis over SCYED. SCYED recognizes the functional role of the text ELO. If it is of type "Hypothesis", it will adjust the hypothesis field in the experimental design. This also applies for the research question. A similar connection exists between SCYData and the Health passport, where the health passport is computed based on the basis of data from several data sets. Also, SCYData can combine dataset with each other, by incorporating data from one dataset into another by adding new rows or colums, depending on the structure of both datasets.

5 The development process

In order to arrive at the SCY set of tools that is capable to support the demands of the missions and is in itself innovative, development of SCY tools took place in close collaboration between the developers and the pedagogical designers. At the start of the project an initial set of tools was put together based on the initial set of scenarios as well as on an investigation of tools that were readily available. Based on internal discussion this resulted in a first list of tools to be developed/adapted for SCY.

For each tool a "tool team" was installed consisting of a developer and a pedagogical designer to elaborate the tools' specifications. The developers then implemented the first versions of the tools that were subsequently pilot tested and adapted based on these pilot tests.

At the start of the development of Missions 2 and 3, the available set of tools was reviewed, in order to investigate whether the toolset could cater for the needs emerging from the design of those missions. This review did not result in many new tools but it did lead to adaptations and extensions of existing tools, such as the possibility to import data from Vernier measurement tools into SCYData, links between SCYDynamics and SCYData, as well as between SCYText and SCYED. Also the possible uses of SCYMapper and the SCYCollector mobile tools were extended to support group formation (SCYMapper) and the collection of diet information (SCYCollector). One new tool, the SCY Health passport was added to the list. It was also decided that the functionality of the SCY assessment tools, in particular the ePortfolio plays a similar role as the planned reporting tool. For this reason, the decision was made to not implement the reporting too.

In a final round of internal review of the missions, the decision to strengthen the ELO-based nature of learning in SCY led to the creation of SCYSearch to replace the existing search facility. This enables learners to better manage the sets of ELOs created by themselves and others for use within the production of editing of other ELOs.

6 Consolidation of tools

The tools in the SCY toolset have been designed to last beyond the lifetime of the SCY project. Therefore, they have not been developed as integrated part in the SCY-Lab environment, nor as being dependent on specific implementation details of the SCY architecture. This has been controlled from the outset is often project and has consistently been maintained throughout the work on the tools. As a consequence, all SCY tools can function both inside the context of the SCY missions and outside, as independent tools. The level of independence from the SCY architecture varies a little between the several tools.

6.1 Single tool SCY-Lab

All tools that are integrated in SCY-Lab can run on their own using a specific modes implemented in SCY-Lab. This so-called single tool mode, allows tools to run independent of any other tool well still connected to the SCY architecture, allowing the tool to store and retrieve ELOs, and to exchange information with other components of SCY. The purpose of this mode is to allow configurations where students were, ELOs and contexts other than the full SCY-Lab. For instance, learners can work on ELOs integrated on a webpage that contains an instructional text about the subject of the mission. As a consequence, the flexibility of working with SCY has increased as the learner is no longer bound to put the focus of the work in the SCY-Lab environment. In this mode is, of course, SCY-Lab still running in the background and providing tools and SCY architecture with all the necessary information to operate. The single tool SCY-Lab modes makes it possible to open ELOs from hyperlinks on a web page. This mode is already used in the SCY teacher tools where teachers can open learner created ELOs from the links on the web-based overview. Also, learners can inspect the ELOs they added to their portfolio from their web-based portfolio overview.

In the single tool SCY-Lab note, tools store their ELOs in RoOLO. As a consequence, in this mode, tools are still dependent of the presence of SCY server. This also means that in this situation tools can still exchange information between each other, and also collaborative modes of tools remain available.

The single tool SCY-Lab mode of tools is particular useful for tool reuse within the context of a SCY-mission, existing or future, or in broader contexts where ELO-based learning plays a role. Apart from operating within a single given mission, ELOs can play a role in longer stretches of educational time, where, for instance, learners keep ELOs created in one science project to use in another, maybe weeks separated from each other.

Single tool SCY-Lab mode is available for all tools.

6.2 Independent applications

Most tools that have been developed within the project can also be used independent from SCY-Lab. They run as JAVA applets, or independent – often web-startable applications. Also, one application runs on Android smartphones, whereas another, SCYLighter runs as a firefox extension. SCY tools running independently. Tools that run independently store the ELOs they produce as a file on a place chosen by the user. When tools run as independent applications, the SCY Tools have no access to SCY servers, and hence will not offer specific SCY functionaliy such as dynamic scaffolding, collaboration or information exchange with other tools.

Out of the current SCY tools that also run inside SCY-Lab, SCYDATA, SCYDynamics, SCYED, SCYInterview and SCYMapper are also available as independent tools. SCYSimulator is also available externaly under the name of SimQuest viewer, which does not contain the SCY-specific data collection functionality.

6.3 SCY-Specific tools

Some tools are really specific to SCY itself. An example is the search tool, that allows learners to search RoOLO. Such tools may be used in SCY-specific contexts, such as in existing or future missions, or any ELO-based learning context, but reuse of such tools is not foreseen in other situations. Apart from the search tool, also the health passport is considered to be SCY- and even mission specific.

6.4 Code reuse

The code of the SCY tools will be published under the lesser GNU open source licence. This means that components of tools functionalities, models, simulation engines etc. will be available for reuse in future products. The interfaces of tools and tool components are documented in such a way that reuse is not only possible but also feasible.

7 Conclusions

This document presents the SCY toolset. The major part of the deliverable is of course the software that can be reviewed through the SCY servers, available at www.scy-lab.eu/scy-lab. In this document we outlined the major properties of the tools as well as the way they interoperate. The SCY toolset has proven capable of supporting the five (four major and one mini) missions.

Apart from that, the tools are ready for a life of their own, inside or – for most tools – outside SCY contexts.

de Jong, T., van Joolingen, W. R., Anjewierden, A., Bollen, L., d´Ham, C., Dolonen, J., et al. (2010). Learning by creating and exchanging objects: The SCY experience. *British Journal of Educational Technology, 41*, 909-921.

Jonassen, D. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development, 39*, 5-14. doi: 10.1007/bf02296434

Kafai, Y. B., & Resnick, M. (Eds.). (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mawhaw, NJ: Lawrence Erlbaum Associates.

Njoo, M., & de Jong, T. (1993). Exploratory learning with a computer simulation for control theory: Learning processes and instructional support. *Journal of Research in Science Teaching, 30*, 821-844. doi: 10.1002/tea.3660300803

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Duncan, R. G., et al. (2004). A scaffolding design framework for software to support science inquiry. *Journal of the Learning Sciences, 13*, 337-386.