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Integrated Environmental Impact Assessment as an e-Learning Module for Sustainable Development

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Based on the recognition that ecosystems provide the basis for life on Earth, it is the sustainable development (SD) and management of these services that enables continued human health and welfare. However, prosperity also depends on continued economic development whereby industrial growth and the expansion of built-up areas and their associated infrastructures often exert negative impact on people and their social and natural environment.

To be sustainable, development needs to balance the environmental, social and economic interests and expectations of societies. This is a complex, multi- and cross-disciplinary process which is based on many determinants rendering the understanding and therefore acceptance of SD a difficult task for most people.

In order to make the ordinary person aware of some of the issues that need to be considered in SD and to illustrate the complexity involved in achieving its aims, the NaturNet-Redime (NNR) project seeks to demonstrate the role and interaction of some of these interests and parameters that are so important for SD through the example of the integrated Environmental Impact Assessment (iEIA) methodology.

This educational objective will be achieved with the help of an e-learning module for SD that deals with the topical example of the construction and assessment of the potential impacts caused by a wind generator. The user will be able to select and interpret a variety of data, perform simple analyses of the impacts the environmental, social and economic parameters are exposed to and enter the results in the corresponding conflict matrices. These impacts can be judged “Zero”, “Low”, “Medium” or “High”– see examples in Figures 1-3.

	Zero	Low	Medium	High
Air Quality, Microclimate	○	○	○	○
Hydrology, Water	○	○	○	○
Geology, Geomorphology, Soils	○	○	○	○
Biodiversity, flora, fauna	○	○	○	○
Land use	○	○	○	○
Noise and Vibration	○	○	○	○
Nature Conservation	○	○	○	○
Landscape and Visibility	○	○	○	○

Fig. 1: Example conflict matrix with environmental parameters

	Zero	Low	Medium	High
Recreation Facilities	○	○	○	○
Wildlife Experience	○	○	○	○
Public Outdoor Sports	○	○	○	○
Access Visitor Management	○	○	○	○
Educational and Interpretive Value	○	○	○	○
Visual Amenity	○	○	○	○
Cultural Assets	○	○	○	○

Fig. 2: Example conflict matrix with social parameters

	Zero	Low	Medium	High
Traffic Access	○	○	○	○
External Material Asset	○	○	○	○
Material Availability	○	○	○	○
Construction Duration	○	○	○	○
Reliability	○	○	○	○
Safety	○	○	○	○
Risk	○	○	○	○
Energy Consumption	○	○	○	○

Fig. 3: Example conflict matrix with economic parameters

This module is specifically designed for Internet users such as ordinary citizens, pupils or students and is using standardised e-learning software. Based on a broad introduction into SD, this practical e-learning module will provide focussed tasks for the user investigating and assessing examples of related environmental, social and economic parameters – whereby the assembly and interactions of these parameters represent the approach that conforms with the concept of SD. Opportunities are also provided for additional investigation by those users who wish to develop their interest in SD in more depth.

This SD e-learning module will guide the user through a simplified iEIA process, whereby s/he will be able to gather information on the context and detail of the environmental, social and economic parameters that form the background of the proposed infrastructure development. The user will be supported by pertinent multi-media information - such as environmental, socio-cultural and economic data, which is presented as text, links, photographs, movies, sound, etc. Relevant geographical information will be provided by one of the regional administrations that is participating in the NNR Project. This information will be made accessible through the newly-developed distributed web services of the NNR Internet Portal and the analysis of this geographical data may be carried out as part of the learning activity online, demonstrating the application of geographic information in sustainable development in Europe. The potential for the provision of facilities for the use of mobile devices in an outdoor environment is being discussed at present enabling the verification and/or adding of actual data to the iEIA database.

An example of the application of such geographic information is the analysis of the visual impact of a wind generator with a height of 100 m as shown in Figure 4. The analysis is conducted by calculating visibility based on elevation data and overlaying this information with a further geographic layer containing the adjacent urban area. As a result, the user can interpret the visibility of the wind generator in respect to the area it covers (highlighted in blue). The user will be able to interpret the selected data, perform a simple analysis of the impacts the multiple parameters are exposed to and enter the results in a conflict matrix. These impacts can be judged “Zero”, “Low”, “Medium” or “High”.

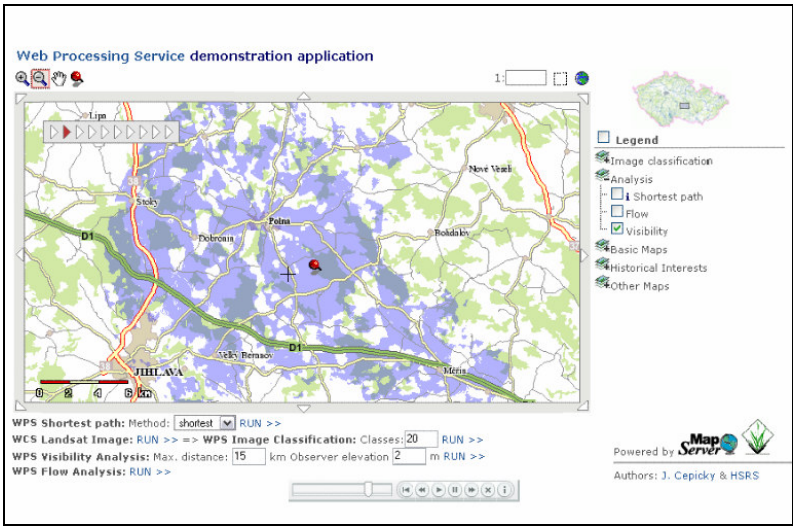

Fig. 4: Visibility analysis for a wind generator with the height of 100m

The result indicates that due to topographic conditions the vast majority of the citizens of Jihlava cannot see the wind generator and allows a conclusion as to the level of impact this causes. On the basis of the preceding study made by the user of the issue of the parameter "Landscape & Visibility" and depending on the importance s/he attributes to the resulting impact, the correspondent rating is entered into the conflict matrices as shown in the example of Figure 5, below.

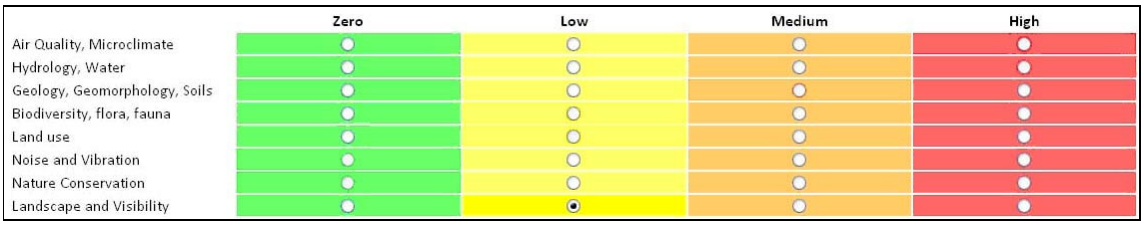

Fig. 5: Environmental conflict matrix showing impact rating entered

The combined impact ratings selected by the user for all the parameters contained in the environmental, social and economic conflict matrices will provide an overview of the overall impact of the assumed development and present one of a series of possible outcomes which in its totality represents a particular state of SD. As these possible outcomes directly relate to the particular preferences selected by the user they will be highly instructive as to the status of SD envisaged.

Sharing and Reuse of Conceptual Models

Jochem Liem and Bert Bredeweg

One of the goals of the NaturNet-Redime project is to empower stakeholders with means to manipulate cause-effect models. Being able to easily inspect the contents of models, take parts of those models as needed, and assemble them into a new model context are among those goals. Hence, there is a desire to share and reuse (parts of) qualitative models, as the community building qualitative models is growing. Within the NaturNet-Redime project, multiple river ecologists are performing case studies about how factors influencing certain rivers affect sustainable development. It is important for them to be able to reuse parts of each other's models, and of other existing modelling efforts. There is also the wish to be able to evaluate the relevance of models without having to download and open them in the workbench first.

To address issues such as these, we are developing a qualitative model repository (see Figure 1 , http://hcs.science.uva.nl/QRM/models/repository/) [1].

Users can upload qualitative models in a Web Ontology Language (OWL) format. Based on the contents of these OWL files, an index is created of all the model ingredients in all models. This index is used to create a search engine, which shows all the ingredients in all the models. Selecting an ingredient from this list refines the amount of matching models, which in turn reduces the items within the model ingredient list to only the model ingredients in the matching models. This allows users to refine their search, and find only those models that are potentially interesting for them. Selecting a model shows the meta-data belonging to that model (author, title, abstract, etc.) and allows users to download the model. Users can also rate models, and get overviews of the top downloaded and top rated models.

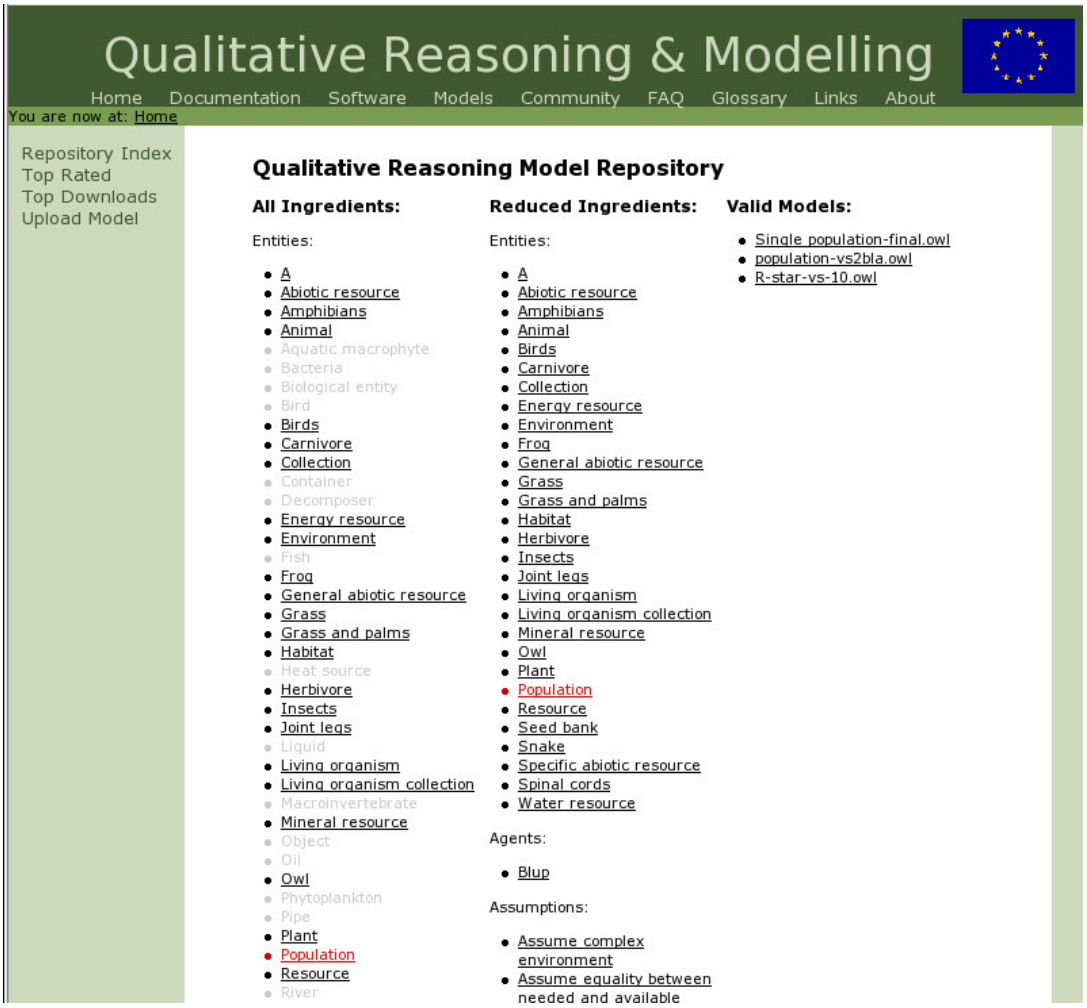

Figure 1: Online qualitative model repository

To formalise qualitative models in OWL we formalised the QR vocabulary (and the usage restrictions of these model ingredients) in OWL [3,4]. Based on this vocabulary a template for qualitative models was created, which was evaluated using OWL editors and inference engines. In addition, functionality was added to the Garp3 workbench (http://www.garp3.org) to export and import models [2]. Each of the exported models refers to concepts defined in the vocabulary, which allows models uploaded to the qualitative model repository to be properly indexed.

The OWL functionality and the repository address the need of community for sharing and searching. To further enable re-use, functionality was added to the Garp3 workbench to allow users to copy/paste model definitions, or even complete aggregates of model ingredients between models. The software takes care that all the interdependencies between model ingredients are properly maintained, which means that if an aggregate is copied to another model, the software also copies the model ingredient definitions that this aggregate uses. To implement this functionality the architecture of Garp3 had to be changed to allow users to open multiple models at the same time (see Figure 2). The model repository, OWL, multiple model and copy/paste functionality [5] allows users to share, search for, and re-use (parts of) qualitative models to support them in articulating and constructing conceptual knowledge.

Figure 2: Garp3 workbench with multiple models

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2. B. Bredeweg, A. Bouwer, J. Jellema, D. Bertels, F. Linnebank, and J. Liem. Garp3 - A new Workbench for Qualitative Reasoning and Modelling. *20th International Workshop on Qualitative Reasoning (QR-06)*, C. Bailey-Kellogg and B. Kuipers (eds), pages 21-28, Hanover, New Hampshire, USA, 10-12 July 2006.

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The Qualitative Reasoning and Modelling Portal

Elinor Bakker, Jochem Liem and Bert Bredeweg

The Qualitative Reasoning & Modelling (QRM) portal (http://www.garp3.org) is the central place on the web where information about the Garp3 workbench and related theoretical and practical issues is presented. The website has been active and online since October 2005 and has recently been extended to include several new features and an improvement of the internal structure and overall layout.

The portal includes documentation about the development and usage of the single user and collaborative version of the Garp3 workbench and also has a section where the software can be downloaded. In addition to this, the portal offers access to published deliverables of the NNR project which describe best practices when building models and a curriculum for learning about QR.

In the Models section, several well-documented example models can be found. A model repository has been added as an online feature to support collaboration between model builders. The collaborative version of the Garp3 workbench, released in September 2006, makes it possible to save and load model files in a Web Ontology Language (OWL) format. To create a platform for sharing these files between model builders, the model repository (http://hcs.science.uva.nl/QRM/models/repository/) is added to the portal under the Models section. The model repository makes it possible to upload, download and search models and also offers the possibility to rate available models and look into the metadata that has been provided by the model builder.

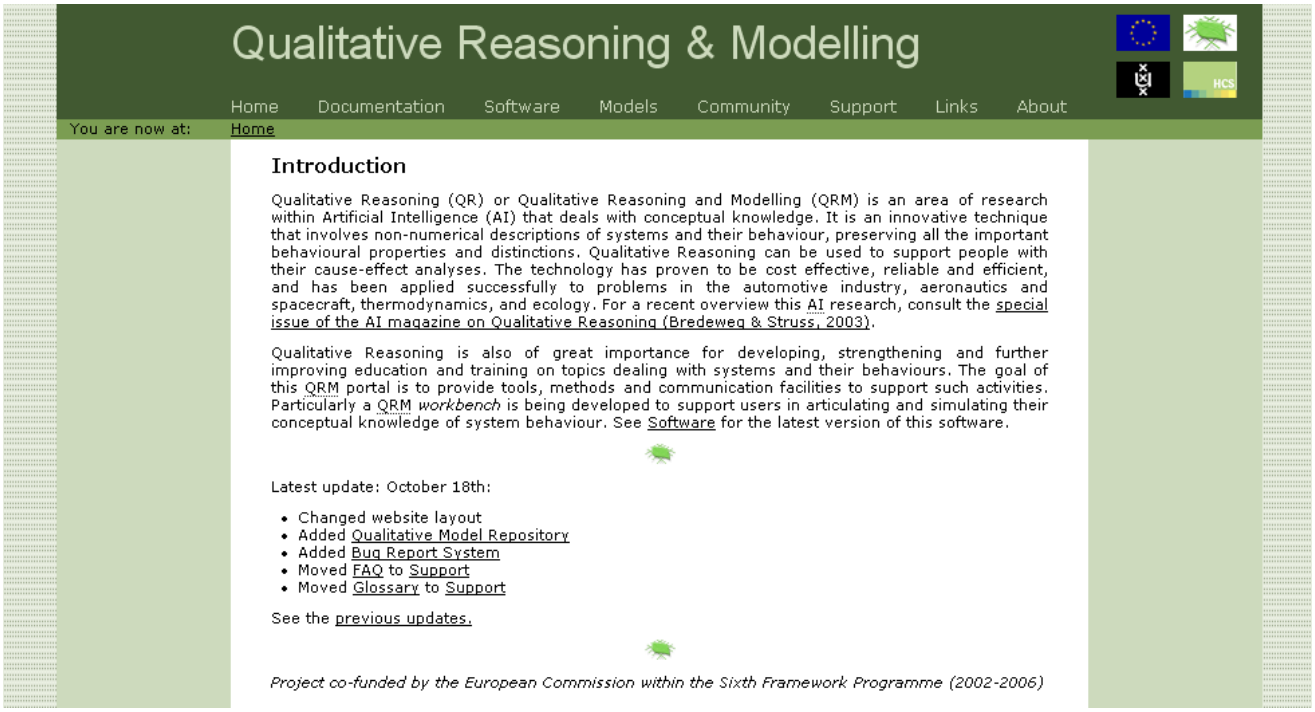

Figure 1: The QRM Portal, with improved structure and layout.

In the Community section, information can be found about subscribing to the QRM mailing list. On this list questions can be asked about model building issues and the software. Also, there is an explanation of Skype and VNC, two frequently used platforms to support communication between people over the internet, which are used to facilitate communication within the QR community.

The Support section focuses on giving 'help' to users working with the Garp3 workbench. The Frequently Asked Questions (FAQ), Glossary and Bug reports sections can be accessed from here, and in the near future the Garp3 online help pages will be added to this section. Answers to common problems can be found in the FAQ section and explanations of QR concepts are available in the Glossary. The online bug reporting system has recently been added to the portal. Since the Garp3 workbench has recently come out of development status and is still being improved, bugs may occur while working with it. These discovered bugs can now be brought together in the open source Mantis bug tracking system by anyone who finds them, which will support the solving of these problems. To complete the portal the Links section provides web references to related pages and the About section provides information about the partners of this project.

The Sketch Environment within Garp3

Anders Bouwer and Bert Bredeweg

To support users in the early phases during the model-building process, the Sketch environment has been implemented as an integrated part of the Garp3 collaborative workbench [1]. It offers a series of seven editors that allow users to represent their ideas about a domain in increasing levels of detail:

- In the Concept map editor, users can represent what they think are the important concepts in a domain, and the relationships between them.
- In the Structure editor, users can be more specific about what are the entities, agents, and assumptions of the system of interest, leading to a structure model.
- In the Process definitions editor, users can specify the important aspects for each of the processes that may cause changes to the state of the system, such as the entities involved, the quantities involved, the start conditions under which the process applies, the effects, the stop conditions, and relevant assumptions.
- In the Agents and external influences definitions editor, users can specify the important aspects for each of the agents and external influences that may influence the system from outside, in a similar fashion as for the Process definitions.
- In the Causal model editor, users can draw a graph with quantities as nodes, and influences and proportionalities as directed connections between them, to describe the causal dependencies in the system.
- In the Scenarios editor, users can specify different scenarios to be considered, each of which is described in terms of the entities, agents and external influences involved, the quantities involved, the initial values and (in-)equality statements, and relevant assumptions.
- In the Behaviour graph editor, users can draw a directed state-transition graph of the expected behaviour of the system, in which each state is characterized by typical quantity values, or (in-)equality statements.

Working through this set of editors structures the model building process (following the framework for structured modelling [2]), and the resulting sketches can be shared as intermediate modelling results. This helps to establish a common understanding of the domain between modellers, before building a final simulation model.

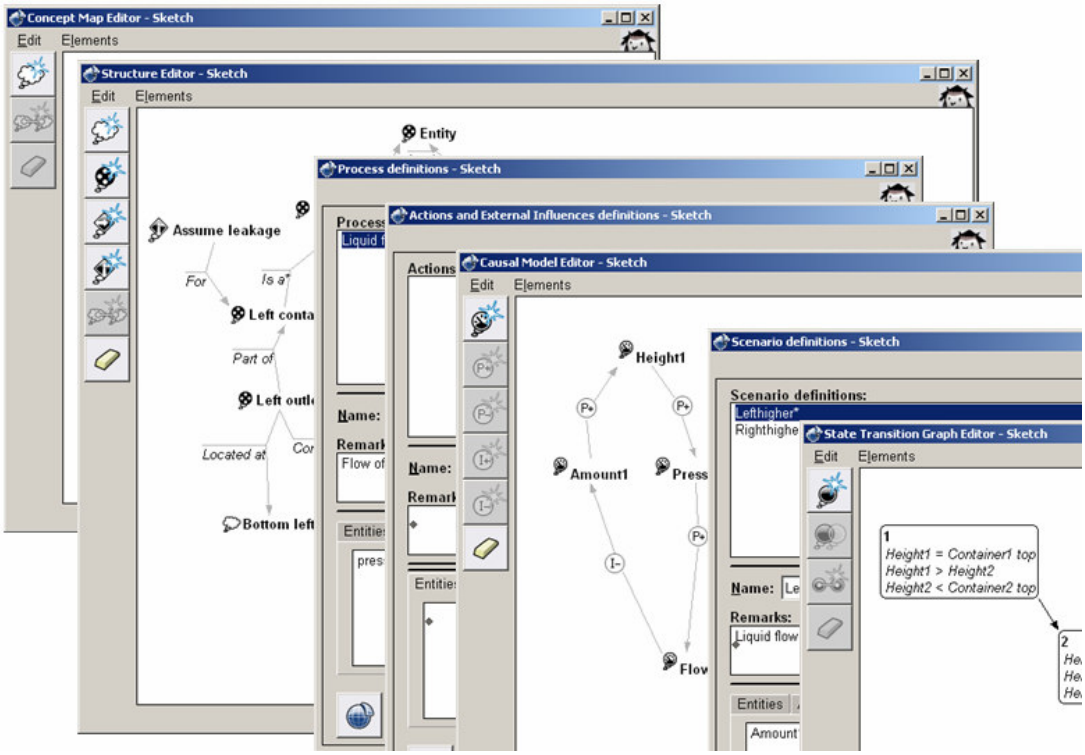

Figure 1. Screenshots from the different editors in the Sketch environment.

During the Krimulda workshop in September 2006, six project participants (in work package 4 and 6) have tested the basic Sketch environment functionality by using it to represent knowledge about their river ecology case studies. The participants welcomed the addition of the Sketch functionality and provided useful comments for further improvements. Current work concentrates on functionality for importing information from one sketch to another, which will further facilitate creating sketches that form a consistent and coherent set of representations about the domain. In conclusion, the Sketch environment explicitly structures the model building process, and will support users in the model building process by refining initial ideas into detailed representations of expert knowledge. Visit http://garp3.org for further details and for downloading the Sketch software (Garp3 version 1.3.1).

[1] J. Liem, A. Bouwer, and B. Bredeweg, 2006. Collaborative QR model building and simulation workbench, Naturnet-Redime, STREP project co-funded by the European Commission within the Sixth Framework Programme (2002-2006), Project no. 004074, Project Deliverable Report D4.3.

[2] B. Bredeweg, Salles, P., Bouwer, A., and Liem L, 2005. Framework for conceptual QR description of case studies, Naturnet-Redime, STREP project co-funded by the European Commission within the Sixth Framework Programme (2002-2006), Project no. 004074, Project Deliverable Report D6.1.

Successful Use of Garp3 by Stakeholders

Bert Bredeweg, Paulo Salles, Anders Bouwer, Elinor Bakker and Jochem Liem

The Garp3 software is developed to be a workbench for stakeholders to advance their conceptual ideas on cause-effect analysis of systems' behaviour, particularly concerning phenomena related to sustainable development. By using this workbench users can investigate the logical consequences of their common sense ideas and use expert knowledge to improve their own understanding of phenomena.

But how useful is the Garp3 software actually for such purposes? Recently the Garp3 workbench was presented to two groups of Latvian students from the University of Latvia and from the Vidzeme Regional University. These students were Bachelors (final year) and Masters (first year) and had no prior knowledge of the Garp3 Qualitative Reasoning (QR) technology. These students were therefore well suited to investigate the usability of the software with real novice stakeholders, which was the main goal of the event.

The software has many features that can be used to design potentially interesting and useful knowledge discovery events. Participants may build their own model from scratch, individually or collaboratively interact with existing models, make sketches of initial ideas, discuss a causal model within a group, and many more. For the interaction with the Latvian students we opted for a traditional experimental setting that investigates whether the software can be used effectively to learn something in the first place. After all, due to its many options the Garp3 software may appear complex and testing all functionality in one experiment is infeasible.

As domain knowledge we focussed on the Millennium Development Goals (MDG) as defined by the United Nations (see e.g.http://www.un.org/millenniumgoals/). More specifically, the knowledge dealt with the notion of *deforestation* in the context of the MDG number 7, which is concerned with 'ensuring environmental sustainability' (cf. Salles et al., 2005). A model was created in Garp3 that captures some of the key ideas relevant to deforestation. The causal model resulting from that is shown in Figure 1 and the accompanying value history in Figure 2. Summarising, at the start of the cause-effect chain is the *deforestation rate*, which reduces the *land with vegetation*, which in turn causes the *biodiversity* to decrease and consequently reduces the chances of finding *new food and medicines*. It also causes *erosion* to increase, which leads to less *agricultural production* and less *water contained in reservoirs*. Ultimately, all these factors come together in the *gross domestic product* (GDP), reflecting the human wealth, which decreases (when deforestation is active).

For the experiment the full model was rearranged into six sub-models, ranging from simple (addressing only wood cutting and land with vegetation) to complex (including all details as shown in Figure 1). The students who used the software during the experiment interacted with each of these models while working through a set of assignments (with questions such as: Which quantity is influenced negatively by deforestation? If land with vegetation decreases, what will happen to biodiversity? What is the value of biodiversity in state 1 and 4? Which quantity is increasing?)

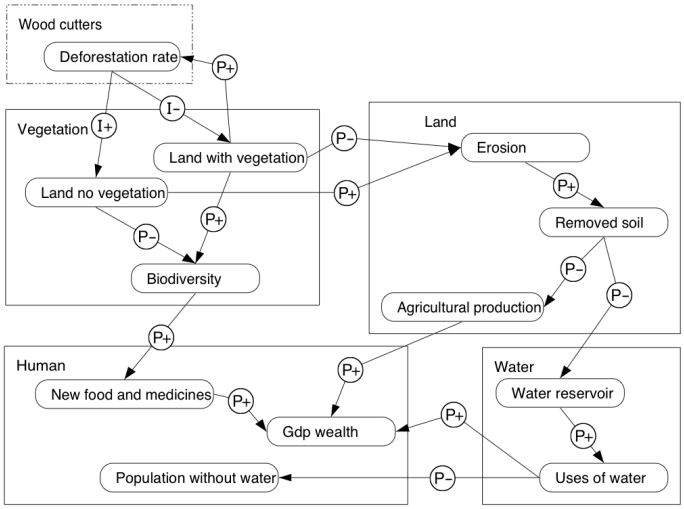

Figure 1: Causal model generated by Garp3 for the deforestation model

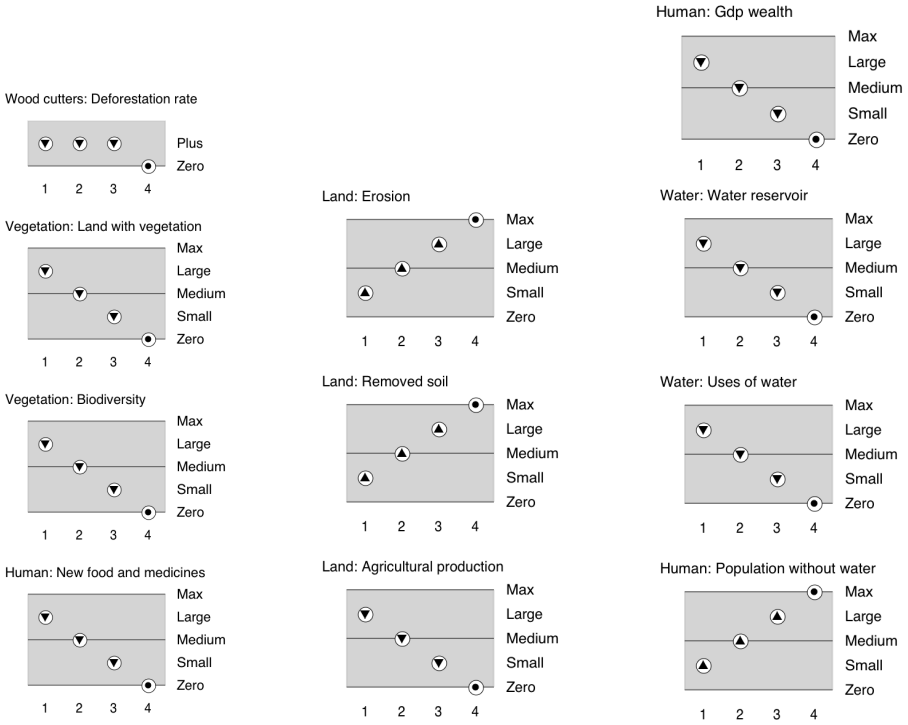

Figure 2: Value history of the quantities in the deforestation model

In the experiment a group of 24 subjects was assigned to the treatment condition and a group of the 22 subjects was assigned to the control condition (Table 1). To assess the pre-knowledge of the subjects a questionnaire was administered consisting of 36 questions about issues captured in the model on deforestation as discussed above. The questionnaire contained different kinds of questions, such as True/False questions (e.g., IF agricultural production decreases, THEN GDP, wealth, decreases), questions that required students to fill out the missing word (increasing or decreasing) (e.g., IF erosion increases, THEN agricultural production ……?), etc. After this pre-test the students in the treatment condition worked through the models (as described above) and the students in the control group attended a lecture on the use of computers for education. Both of these lasted approximately one hour, after which a post-test was administered to both groups. The post-test was in principle similar to the pre-test, but consisted of a different set of questions on the same subject matter. Finally, the experiment was closed by briefly explaining the overall goal and organisation of the event. In the control group this of course required some additional effort in order to ensure that they would also appreciate the experience (e.g., interested students were given a brief overview of the Garp3 software and related research issues).

Table 1: Experimental set-up

	15 min	*15 min*	*60 min*	*15 min*	*15 min*
Treatment	Introduction	Pre-test	Working with Garp3	Post-test	Closing
Control	Introduction	Pre-test	Lecture on ICT	Post-test	Closing

The results of the experiment turned out to be very encouraging. Students in the treatment group could easily operate the software, that is open the models, run them, and inspect the simulations. Apparently the interface of the Garp3 software behaves in a way that is intuitive for this generation of students. The treatment was also effective in creating a significant learning effect. Particularly, after removing the subjects who scored very high on the pre-test (≥ 30 correct), the subjects in the treatment group (N=16) scored an average of 26.95 points on the post-test (with 23.25 points on the pre-test), while the subjects in the control group (N=21) scored an average of 21.05 points on the post-test (with 20.24 points on the pre-test). This turned out to be a statistically significant difference using a t-test ($P<0.001$). Being able to achieve this result within the short duration of the experiment creates promises for the impact the Garp3 software may deliver when it is used systematically on a variety of topics in an educational context.

Acknowledgement

We are grateful to the students who participated in the experiment, and to Maris Alberts, Una Bike, Peteris Bruns and their co-workers for providing us the opportunity to work with Latvian students to test our ideas and software.

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Events of interest

NATURNET - REDIME workshop - Tools And Methods For Raisining Awareness of Sustainable Development

Bruxelles, 29th November 2006, INTEREL, Avenue de Tervuren 402, Brussels, 1150 Belgium. Organized by The Vysocina Region (CZ) & the NaturNet-Redime Team

Contact: ccss@ccss.cz

5th International Conference on Ecological Informatics ISEI5

December 4th-6th, 2006 Santa Barbara, CA, USA. Novel Computational Techniques for Improved Management, Understanding and Forecasting of Complex Ecological Data

http://www.isei5-conference.elsevier.com/

International European 1st EAAE Forum on Innovation and System Dynamics in Food Networks

15-17 February 2007 INNSBRUCK - IGLS – Austria. The objective of this Forum is to provide an interdisciplinary discussion environment that supports creativity and exchange to foster the development of new ideas for innovative and interdisciplinary research in the agri-food sector.
Contact: Melanie FRITZ Email: m.fritz(a)uni-bonn.de

http://www.uf.uni-bonn.de/innovation2007/

15 th Conference in Agricultural Labour Science

5 – 6 March 2007 Vienna
The conference is organised by Max-Eyth-Society for Agricultural Engineering of the VDI and the University of Natural Resources and Applied Life Sciences in Vienna.

Contact: Prof.Dr.J.BOXBERGER
E-mail: josef.boxberger(a)boku.ac.at

http://www.nas.boku.ac.at/akal-seminar.html

SIXTH FRAMEWORK PROGRAMME

Educational programmes on social, economic, and environmental
tools for the implementation of the EU Strategy on Sustainable Development
at both EU and international levels

NATURNET-REDIME

New Education and Decision Support Model for Active Behaviour in Sustainable Development Based on Innovative Web Services and Qualitative Reasoning

Project no. 004074

Instrument: SPECIFIC TARGETED RESEARCH PROJECT

Thematic Priority: SUSTDEV-2004-3.VIII.2.e

Start date of project: 1st March 2005 Duration : 30 months

Web : http ://www.naturnet.org

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Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)

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