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Abstract

This deliverable (D7.3.5) documents the results of the evaluation of an advanced version of DynaLearn (DL) software conducted by BOKU in Austria. Because the final software was not available, versions 0.8.2 and 0.8.8 of the DL software were evaluated. Both, the DL software and semantic technologies (repository, grounding, recommendations...) were still developing versions, and evaluations had to be conducted before the deadline for the final software. Therefore potential bugs or unfinished functionalities were expected.

Nevertheless, as a basis to guide further development and evaluate what was available, the first goal of the evaluations was to test the additional technical functionality made available in versions 0.8.2 and 0.8.8 of DL like *'Basic help'* provided by *'Virtual Characters'*, the *'Recommendation'* function based on Semantic Technology and *'Grounding'*.

The second goal was the formative assessment of the application of the DL software in educational settings, with a special focus on the efficiency of different educational strategies and assignments, temporal aspects like support and scaffolding needed from teachers and social interactions of students. Furthermore the use of moodle to serve as platform for supporting self-oriented learning activities by providing assignments and as pool to collect intermediate and final modelling results was tested.

Evaluations with regard to the above issues were run at an Upper Secondary Technical High School (i:HTL Bad Radkersburg, Styria) with two undergraduate students and at BOKU, Vienna with 31 students. The assessment methods included detailed video-monitoring of modelling activities and social interactions, motivation questionnaires, pre- and post-tests and detailed evaluations of the models produced by the students.

Finally, as third goal to assess the potential and needs for DL to be applied in real world settings, the two most important institutions with regard to the implementation of new IT supported learning technologies in environmental education in Austria, the Environmental Education Forum Austria, and the V/3 section of the Austrian Federal Ministry for Education, Arts and Culture, IT-Systems for in Education, were involved in expert evaluations of the DL approach.

Internal Review

- Esther Lozano (UPM), Universidad Politécnica de Madrid – Ontology Engineering Group.
- Adriano Souza (FUB), University of Brasília – Institute of Biological Sciences.

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1. Introduction

1.1. Evaluation techniques

Because the final software was not available, versions 0.8.2 and 0.8.8 of the DL software were evaluated during the second round of evaluations. These evaluations primarily aimed at providing information on

- the functionality, appreciation and efficiency of newly available features like *'Basic help'* (Wißner et al., 2010), *'Grounding'* (Gracia et al., 2010) and *'Recommendations'* (Lozano et al., 2010),
- the appreciation of the software, the modelling approach and the new features by students and their impressions as well as potential ideas for increasing usability,
- the changes in knowledge and knowledge structure influenced by the activities with DL, and
- the formative assessment of the applicability of different pedagogical strategies of an application of the DL in classrooms.

Accordingly, lesson plans (sections 8.2.1 and 8.2.2 in the Appendix) were developed and appropriate evaluation instruments and approaches for analysing the data were chosen.

Several software tools were used for analysis of the different kinds of data gathered during the evaluations. (described in detail in Deliverable 7.2.5, sections 10.1. and 10.2. of the Appendix).

For the analysis of pre-and post-tests, quantitative text analysis (Roberts, 2000) was applied, and was used to characterise changes in knowledge and knowledge structure (Dresner and Elser, 2009, Ruiz-Mallen et al., 2009). This evaluation strategy proved to be very helpful during the evaluations of the prototype of the software and is usually based on coding and counting keywords and relationships used to characterize a phenomenon before and after learning activities. The extraction of mental maps from pre- and post-tests was used to provide additional information on how the network of knowledge changed due to the learning activity (Ruiz-Mallen et al., 2009, Abernethy et al., 2005, Kinchin et al., 2001, Fellows, 1994).

Atlas.ti was used for a quantitative as well as for a qualitative approach (Lewis, 2004), and was applied for the analysis of pre- and post-tests in the DL evaluations.

Furthermore, qualitative methods like observation with video and/or motivation questionnaires were used to capture behaviour during software use as well as attitudes and motivations of the students towards modelling and scientific learning (Zeyer, 2010, Wang and Reeves, 2006, Mavrou et al., 2007, Rich and Hannafin, 2009). Video analysis was, as described in D7.2.5, was performed using qualitative analysis software *Transana*, which was chosen here for its useful features, its ability to deal with a wide variety of video formats, and not least for the relatively low-priced single user license.

Finally, the chosen methodologies follow the 'grounded theory approach' (Strauss and Corbin, 1998, Glaser and Strauss, 1999). *'Grounded Theory'* (GT) can be understood as a systematic qualitative research methodology accentuating the generation of new theories from observational data in the process of analytical research. Following this methodology, the first step is data collection through a variety of methods. From these data, key elements are identified and coded by key words arising from the analytical work. The codes are then tried to be unified into similar concepts, from which finally categories are formed representing the basis for the creation of a theory, or a so called '*reverse engineered hypothesis*'. The application of the GT approach within the evaluations of the DL software allows for induction and the emergence of new theories with regard to learning with the unique and new combination of features of the DL software.

2. Participating institutions and evaluations conducted

For the second evaluation period at BOKU again the two same educational institutions as during the first evaluation period were chosen to evaluate the DL software: the International HTL Bad Radkersburg (i:HTL), an Upper Secondary Technical High School for electrical engineering in Styria, and the University of Natural Resources and Life Sciences (BOKU), Vienna. Furthermore the two most important institutions in Austria with regard to the implementation of new learning software programs in environmental education, the Environmental Education Forum Austria, and the V/3 section of the Austrian Federal Ministry for Education, Arts and Culture, IT-Systems for in Education were involved for expert evaluations about the potential for application of DL in real world settings.

2.1. i:HTL

The International HTL Bad Radkersburg (i:HTL) is a co-operation between the municipality (borough) of Bad Radkersburg and the BULME Graz-Göstling, one of the most renowned higher technical learning institutes (upper secondary technical colleges) in Austria. This cooperation aims to provide young people from Austria, Hungary, Slovenia and Croatia with a common training to become engineers. As a result of this the graduates should be able to establish and develop a cross-border market and help to promote the economy and culture of the Adria-Alpe-Pannonia Region. The students are trained in electrical engineering and from the third form on they are offered an in-depth consolidation course in plant management and medical technology.[1]

At the i:HTL the following evaluation was conducted:

1) Detailed assessment of the modelling behaviour and motivation of two students working with different *'Learning Spaces'* (LSs) of DL software via video analysis and motivation questionnaires.
2) Assessment of the effect of the DL software on causal understanding using pre- and post-tests.
3) Formative assessment of the efficiency of different design strategies for learning units.

2.2. BOKU

The University of Natural Resources and Life Sciences, Vienna, the Alma Mater Viridis, sees itself as an education and research centre for renewable resources, which are a necessity for human life. With its wide range of areas of expertise it is the task of BOKU to contribute significantly to the protection of life resources for future generations. With a connection between natural sciences, engineering and economics, BOKU is trying to deepen the knowledge of an ecologically and economically sustainable use of natural resources in a cultivated landscape.

At BOKU the following evaluation activities were conducted:

1) Evaluation ran with 31 students at two afternoons exploring LS1 and LS2 focusing on changes in causal understanding using the DL workbench via pre- and post-tests and testing the '*Recommendation'* as well as the *'Grounding'* function.
2) Assessment of *'Basic help'* and the additional support needed from teachers.
3) Formative assessment of the efficiency of different design strategies for learning units, also using moodle as exchange platform.

[1] International HTL Bad Radkersburg – www.ihtl.at

2.3. Forum Umweltbildung (Environmental Education FORUM Austria)

FORUM Umweltbildung (Environmental Education FORUM)[2] is an initiative of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Austrian Federal Ministry for Education, the Arts and Culture. It combines more than twenty years of experience in environmental education with innovative educational approaches especially in the field of education for sustainable development.

FORUM Umweltbildung offers educational support via publications, websites, events like conferences and workshops, innovative flagship projects, educational networks, educational funds and personal contact. FORUM Umweltbildung works for a target group of educators in the formal (school and university) and non-formal (further education, adult education) educational sector in Austria.

The BOKU team had the possibility to present the DL software at the Environmental Education Forum in front selected representatives.

2.4. Federal Ministry for Education

DL was also presented at the Austrian Federal Ministry for Education, Arts and Culture, V/3 IT-Systems for in Education[3]. Aim of the meeting was the discussion of the general possibilities to establish DL in schools with representatives of the Ministry.

2.5. Education Group

The BOKU Team also presented DL at the meeting "Gegenstandsportal" of the Education Group[4] The Education Group aims at the provision and distribution of educational media, at the organization of information and educational events as well as at the collection and distribution of scientific information and at the conduction of research and development projects in the field of information techniques, new media in education and also provides related services to the public. Aim of the meeting was the discussion of the needs and possibilities to establish DL in schools with teachers interested to apply IT in education.

The following chapters describe the individual evaluation settings, results expected, and some considerations for data interpretation, data evaluation methods and final results. Additional material related to methodology and results can be found in the Appendix.

[2] http://www.umweltbildung.at
[3] http://www.bmukk.gv.at/schulen/index.xml
[4] http://edugroup.at

3. First evaluation study: i:HTL

3.1. Setup

Date:	28.03. - 31.03.2011
Place:	i:HTL Bad Radkersburg, AT
Responsible person:	Andreas Zitek, Michaela Poppe, Michael Stelzhammer
Participating students:	2 students, one male and one female (the same as last year- see DL 7.2.5)
Age of students:	17 years old
Topic:	About nuclear radiation, using of nuclear power and its effects on the environment and on humans.
Activity:	3 days of modelling, with LS2 LS4, LS5 with a final public presentation at school. Use of *'Recommendation'* and *'Grounding'* features.
Evaluation instruments:	Videotaping of the modelling activity and questions, pre- and-post-test, motivation questionnaire.

3.1.1. Expectations from this setting

- Videotaping of computer screens will provide feedback on usability and problems learners encounter with the software. This will help to focus *'Basic help'*, *'Recommendation'*, *'Grounding'*, *'Virtual characters'* etc.
- Specific testing of the functionality and appreciation of *'Basic help'*, *'Recommendation'* and '*Grounding'*.
- Assessment of different pedagogical strategies
  - to support self-organized learning, e.g. the identification of the adequate Learning Space (LS) for a model,
  - to create engagement and motivation, e.g. by using the *'Recommendation'* function to let the students exchange and discuss differences in their models.
- The pre-/post-test (content test) will prove if students increased their content knowledge during their modelling activities and if the structure of their knowledge was influenced by the activities with DL.
- A motivation questionnaire will help us knowing if students liked what they did and will collect their impressions and ideas.

3.1.2. To be considered

The group participating in the evaluation was very small and consisted only of two students, one female and one male; both participated also in the past evaluation run the year before. But these students were very motivated and represented the best students of their school. Due to their recent education they already had experience with energy production and nuclear radiation and the potential negative effects of these technologies on environment and human health. The evaluation procedure envisaged to explore one or two LSs per day.

3.2. Data analysis i:HTL

The data gathered in the four days of evaluation at the i:HTL consisted of four components:

1. Observations during the assignments, and the assignment results themselves.
2. Video recordings of the modelling (working) activities of the two students on their computer screens, their social interactions, questions and answers, which were analysed using *Transana* software.
3. Textual data gathered by pre- and post-tests (see section 8.1.1 in the Appendix) and quantitatively analysed with the *Atlas.ti* software.
4. Motivation questionnaires concerning the use of the software, the modelling process, *'Virtual Characters'*, *'Grounding'* and *'Recommendation/Feedback'* (the questionnaire can be found in section 8.1.7 in the Appendix).

3.2.1. Observations during the assignments

The observation of the students during the assignments and the assignment results themselves yielded important information about the problems students have with using DL for learning, and also important formative information for the future design of effective and engaging learning units.

3.2.2. Transcription and coding of video recordings

Analysed **video data** comprised 15 hours in total, approx. 5 hours per day, 2,5 hours per person per day. The *Transana* software[5] allowed for a transcription of the video tapes and for an identification of analytically interesting clips and assignment of descriptive keywords and codes to these clips that were finally grouped into higher hierarchical concepts.

The transcript-based analysis allowed us to elaborate:

- Conversation Analysis: about talks and questions/answers between students and between students and teacher.
- Action Analysis: about student modelling activities visible on their screens.

24 main keywords concerning students' behaviour, content and basic help with regard to the DL software and the domain knowledge (topic) during the modelling processes were identified and used as codes in the video analysis (Fig.3.1).

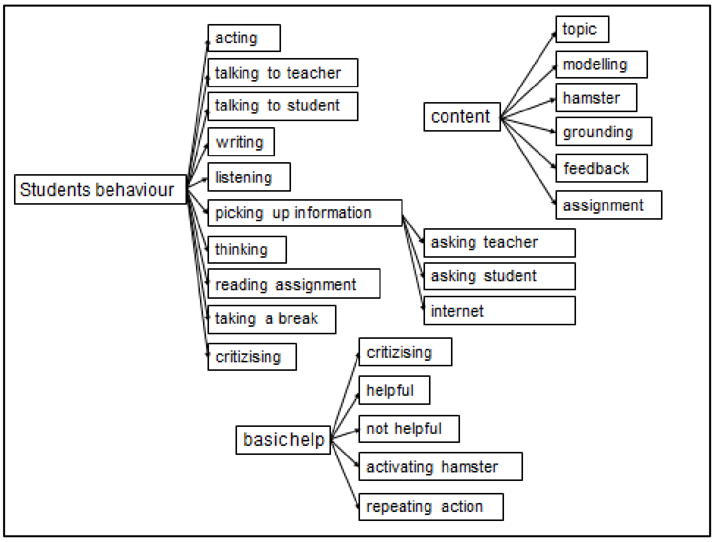


Figure 3.1: Keywords used for coding the videos of software use and social interaction at the I:HTL.

[5] A qualitative analysis software for video and audio data. http://www.transana.org

By means of these keywords we wanted to focus around three main concepts:

1) Modelling & social behaviour: *'acting'* (each type of modelling), *'talking to teacher', 'talking to student', 'writing', 'listening', 'picking up information'* (with a description of the source of information), *'thinking'*, *'reading assignment'*, *'taking a break'*, *'criticizing' (improvements)*

- How was the behaviour and social interaction during the modelling work?
- Did students modelling & social behaviour differ per LS?

2) Detailed behaviour: sub-categories of *'content'*

- Which questions were asked during modelling and when was help needed?
- What were the students talking about?

3) Basic help (*'hamster'*)

- How often did the students activate the *'Virtual Character'* for *'Basic help'*?
- Were the answers from the hamster helpful or not helpful? (Helpful means, that students proceed in their modelling activities after listening to the hamster`s answers; not helpful: Students repeat their actions or ask teachers for help)
- Did the students criticise the *'Basic help'* functions?

3.2.3. Transcription and coding of pre- and post-tests

To use the filled pre- and post-tests for structured analysis in *Atlas.ti*[6] they had to be scanned, stored digitally as pdf-files and imported into the software. Handled as Primary Documents (PD), it is possible to create quotations (Q) by marking words or sections of interest in the test, capturing keywords/concepts and linking them with the according codes (C) (e.g. `radiation´, `nuclear power plant´, `thyroid´, etc., see Fig.3.2). For assessing the amount of concepts and keywords mentioned, each keyword was counted only once in each test ('single mention'). The linkage of Qs and Cs helped to classify the quotation/concept information and allowed counting them in pre- and post-test situations for comparisons and to connect them to networks, reflecting the mental model of the students. Thereby altogether 287 quotations were marked and connected to 147 codes. All classifications were double-checked by two different experts.

Furthermore, the causal relations have been tagged in the PDs and classified by linking them to three codes:

- verbal causal relations
    - A list of causal verbal statements collected from pre- and post-tests can be found in the Appendix (see chapter 8.3.3 in the appendix).
- graphical causal relations,
- and wrong causal relations considering both, graphical and verbal expressions.

Additionally, two questions were used to qualitatively judge the students understanding on the topic:

- How much do they know about the *effects of nuclear radiation*?

[6] A qualitative data analysis software - http://www.atlasti.com

- How established is their *principle understanding* about radioactivity and nuclear power plants?

For comparing the students' answers to experts' knowledge the answers to the above questions were classified into a 5-tiered-scheme - 1 (very low), 2(low), 3 (medium), 4 (high) and 5 (very high) – for their convergence to experts' knowledge.

Finally, the *number of words* being used to give an answer had been counted per test and the *degree of abstraction* was also classified qualitatively (in a 5-tiered-scheme as well) and stored as codes in *Atlas.ti* linked to the accordant PDs.

To calculate sums and means of the numbers of mentioned codes (sorted by pre- and post-tests) the code list was exported to Excel (see chapter 3.3.4).

For visualizing the students' knowledge of the treated topic and the complexity of their thinking and understanding before and after the learning activity with DL, mental/cognitive maps were created using *Atlas.ti*. For this purpose the codes (concepts) were connected by so called code-code-relations. The output was a network view of nodes (codes) and links (relations) representing the mental maps of the students.

3.2.4. Motivation questionnaires

At the end of the evaluation session the students filled in **motivation questionnaires** (see Fig. 8.23 to Fig. 8.25 in the Appendix). 33 of the 39 questions allowed ticking applicable answers in a 5-tiered scheme, and the remaining six had to be answered qualitatively by writing textual answers. The selected ratings per question were analysed for each individual student in Excel. The content of the written textual answers was extracted and collected separately.

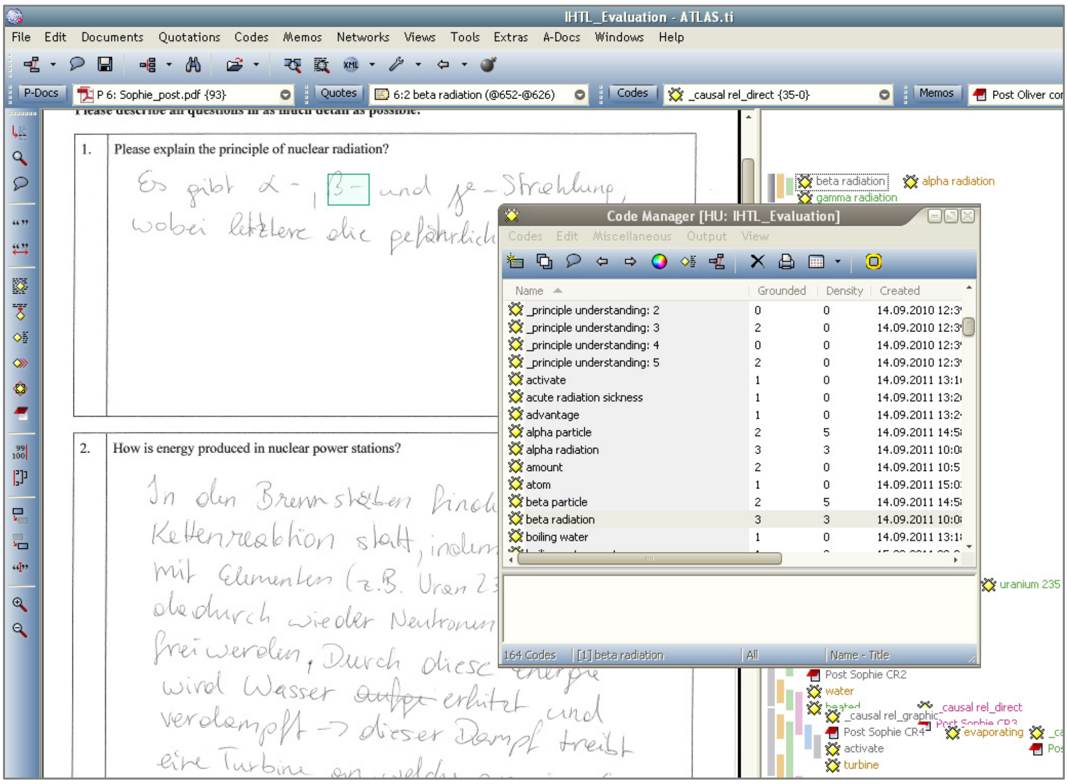


Figure 3.2: Screenshot of *Atlas.ti* network view and code-code-relations editor.

3.3. Results i:HTL

3.3.1. Assignments

The students worked on 5 assignments over three days (assignments can be found in section 8.1.4 and course and lesson plans in section 8.2.1 of the Appendix). The time intervals spent for each is assignment are summarized in Tab. 3.1. Student 1 was the female student, and student 2 was the male student.

Before the assignments started, a pre-test was conducted at day 1. At day 3, after the completion of the modelling tasks, a post-test was performed. Assignments were developed along defined learning goals for domain specific knowledge and modelling, and evaluation goals. The assignments targeted at providing interesting and actual content (nuclear energy production, and its potential effects on the environment and humans) making use of the different new technical features available, especially *'Recommendation'* and *'Grounding'*. Furthermore the students were instructed to make as much use of the *'Basic help'*-function as possible, and only ask the teacher if the help provided by the *'Virtual Characters'* was insufficient. The aim was also to provide a set of assignments that help the students to explore the different possibilities of DL and to provide an engaging and motivating framework for learning.

Assignments (all assignments can be found in section 8.2.1 of the Appendix):

28/3/2011: **Assignment 1:** LS1: Model nuclear radiation and its effects on the environment

Identification of the adequate LS by identifying basic model ingredients from a text.

LS2: Accident at a nuclear power station and its effects on environment and human health.

29/3/2011: **Assignment 2:** LS2_Feedback (FB) and grounding

FB1 from expert model

FB2 from the other student`s model

Assignment 3: LS4: Iodine uptake - detecting questioned issues in the ready-made LS4 model

Assignment 4: LS5: Nuclear radiation uptake and human heath - detecting questioned issues in the ready-made but incomplete model

Completion of model and setting a conditional statement.

30/3/2011: **Assignment 5:** LS4: Nuclear power plant – pressurized water reactor – incomplete model.

Table 3.1: Working time of both students (female student = student 1, male student = student 2) and mean value per assignment.

	Student 1	Student 2	mean
LS1	95 min	93 min	94min
LS2	71 min	76 min	73,5min
LS2_FB1	41 min	34 min	37,5min
LS2_grounding	38 min	42 min	40min
LS2_FB2	25 min	24 min	24,5min
LS4	73 min	70 min	71,5min
LS5_incomplete	33 min	32 min	32,5min
LS4_incomplete	109 min	66 min	87,5min

3.3.2. Assignment results

Before the assignments started, a pre-test was conducted and a short introduction into DL by Power Point slides was provided subsequently (*'The World in DynaLearn'*, see Appendix 8.1.3, Figs. 8.6-8.10).

3.3.2.1. Assignment 1 – LS1 model and Identification of the adequate Learning Space

Target concepts and goals of Assignment 1 were:

- development of a first understanding of the topic by building a LS1 model, based on a short story and additional guiding questions, also by using the internet.
- expression of their semantic understanding of the issue in LS1.
- development of an initial understanding of the generic modelling elements used in DL to express causal knowledge (by the cards with model ingredients).
- development of a basic causal model in LS2 describing the negative effects of a nuclear accident.
- Testing the need and use of the *'Basic Help'*-function provided by virtual characters.

Guided by the text and some additional questions during Assignment 1 (Fig. 8.11 in the Appendix) students were asked to build a LS1 model dealing with a nuclear accident and its specific effects on humans. Students were allowed to use the internet as additional source of information. Fig. 3.3 and Fig.3.4 show the result of this activity.

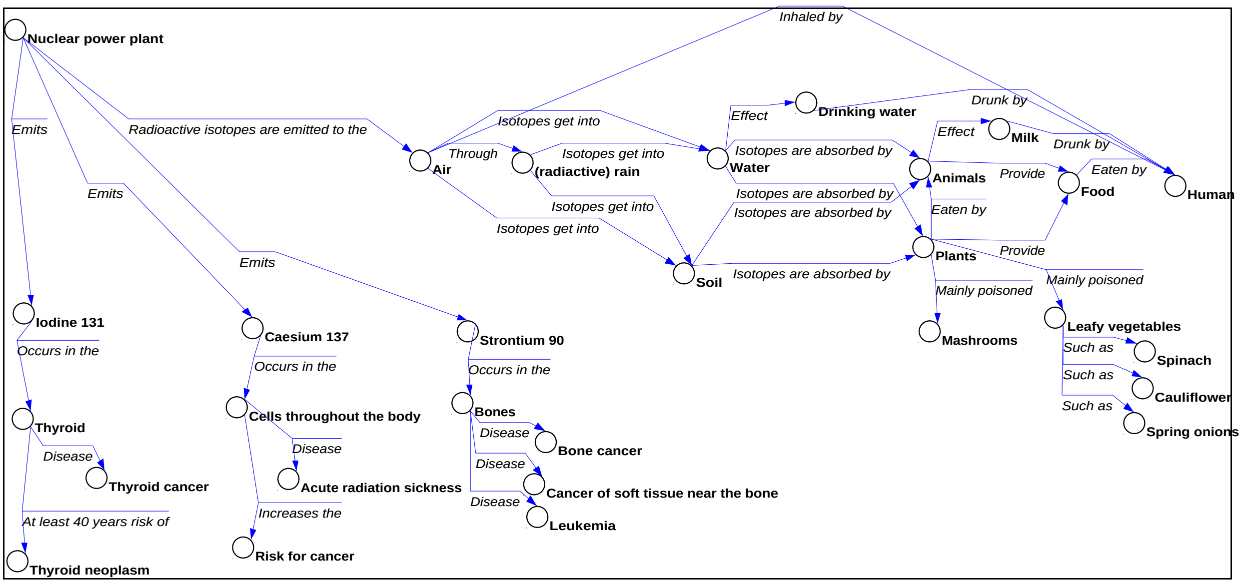


Figure 3.3: LS1 model of student 1.

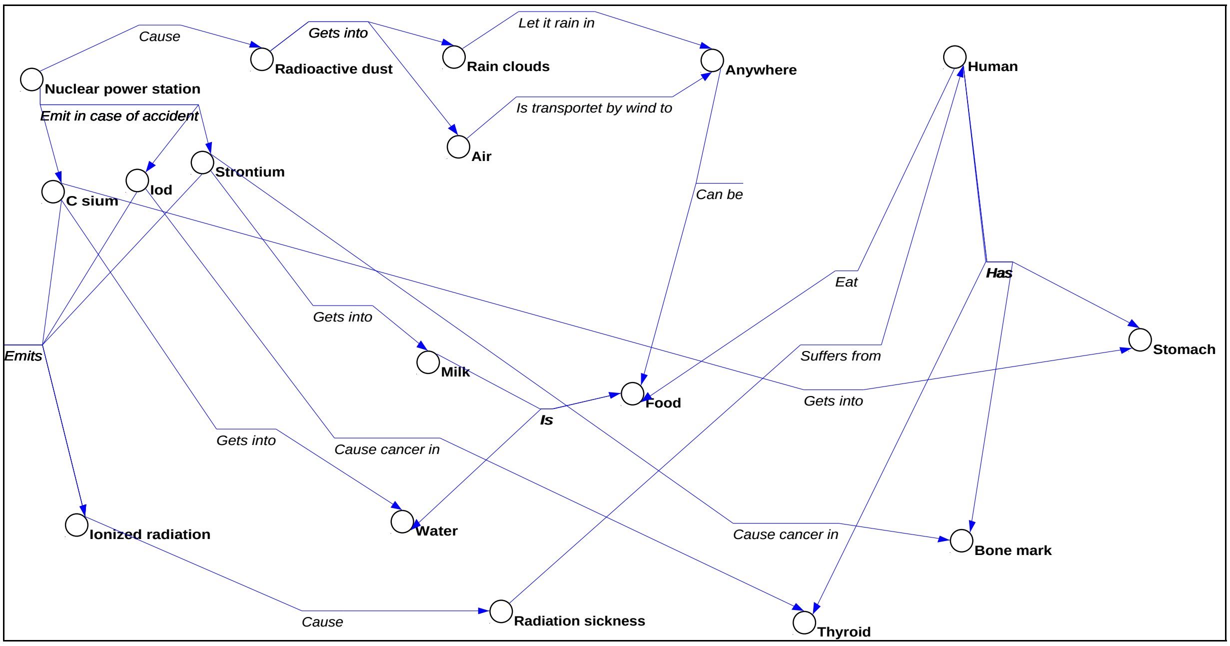


Figure 3.4: LS1 model of student 2.

After having completed the LS1 task, students were provided with the introductory slides.

As an additional task in Assignment 1 the students had to identify the modelling elements needed to express the story provided (Fig. 3.5). The use of vocabulary within the text tried to match the capabilities of LS2 as good as possible (only using the words 'increase', 'decrease' etc.).

For this purpose, laminated cards containing all elements available in DL, a look-up table containing all elements per LS, and a verbal description of the possibilities offered by the different LSs were provided. The cards, table and verbal description can be found in Tables 8.1 to 8.3 of the Appendix.

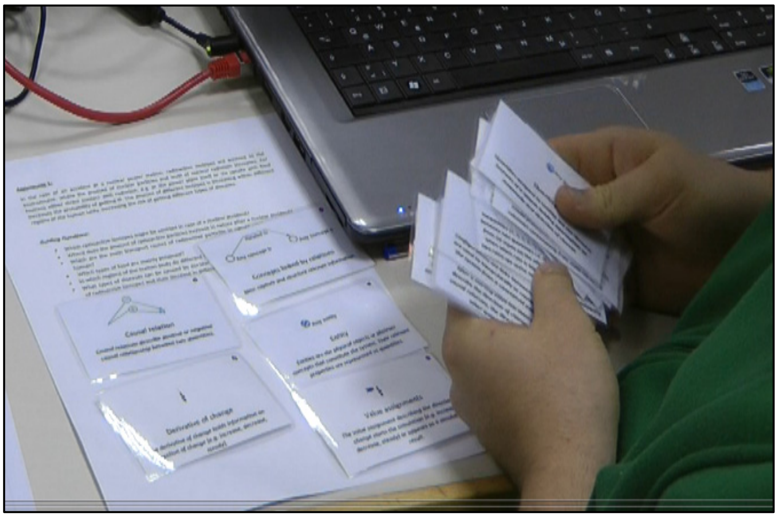


Figure 3.5: Identification of model ingredients needed to express the story provided in DL, with subsequent determination of the adequate Learning Space (LS).

Both students were able to identify the elements needed to construct a LS2 model based on the textual description: entity, configuration, derivative of change, causal relation and value assignment. One student was looking for an *'Agent'*, setting the starting point of the simulation at LS2, and used a *'Condition'* instead. The *'Condition'* was understood as the starting point of the simulation ('a condition that something happens').

Finally they had to build a model in LS2, based on their LS1 model considering the basic elements mentioned in the story.

3.3.2.2. Assignment 2 – Recommendation and Grounding

Target concepts and goals of Assignment 2 were:

- testing the use of the *'Recommendation'*-function:
    - assessing the differences between learner models and one selected expert model from the repository and adaptation of models where needed,
    - testing the reaction of students during getting *'Recommendation'* from each other's model.
- testing of the *'Grounding'*-function.

Students gained recommendations for their LS2 model built during Assignment 1 dealing with the uptake of radiogenic emissions into humans and their effect on health (Assignment 2, Fig. 8.12 in the Appendix) from one expert model. After *'Recommendation'* from the repository (by a single expert model), some significant elements especially related to the uptake of radiogenic emissions in different regions of the human body (bones, gastrointestinal tract) and the different types of radiogenic emissions (e.g. Plutonium) were added to the learner models. The *'Recommendation'* significantly improved the models of the learners. The missing terms functionality (based on ontology matching) worked well and was especially useful to determine missing entities and quantities. The recommendations with regard to dependencies were mostly completely arbitrary and wrong. Fig. 3.6 shows the *'Recommendation'*-window available in versions 0.8.2 and 0.8.8 of DL.

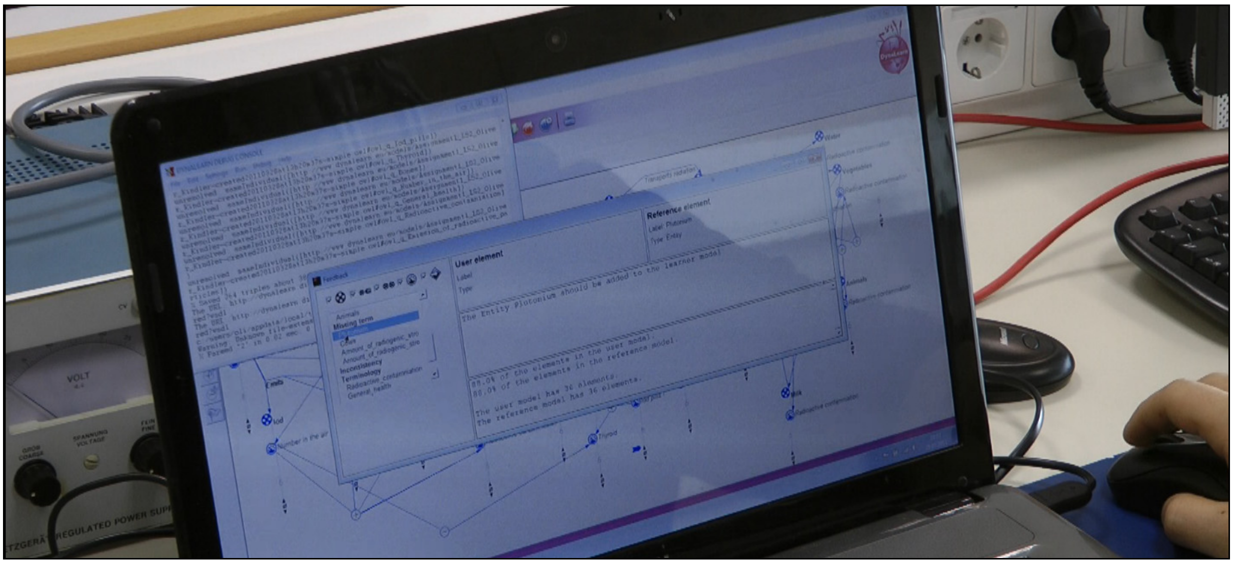


Figure 3.6: The structure of the *'Recommendation'* window available with versions 0.8.2 and 0.8.8 of the DL software; the Ontology Based Feedback (OBF) provided the relevant information on missing terms (entities and quantities distinguished) when the learner model was compared to a single expert model selected from the repository.

The students had to ground three terms using the grounding options provided by the system and to ground three other terms to new anchor terms that they previously created with the *'New Anchor Term'* function. Fig. 3.7 shows the *'Grounding'*-window available in versions 0.8.2 and 0.8.8 of DL.

Finally, the students had to upload their own model and get recommendations from each other. This yielded a very dynamic and positive reaction of the students that got very involved discussing their model terminologies and additional/missing terms.

Some selected additional elements were implemented based on these recommendations. The students intensively discussed the meaning of different vocabulary, and missing terms. This session had to be interrupted at a certain point, as students enjoyed it very much to discuss each other's models.

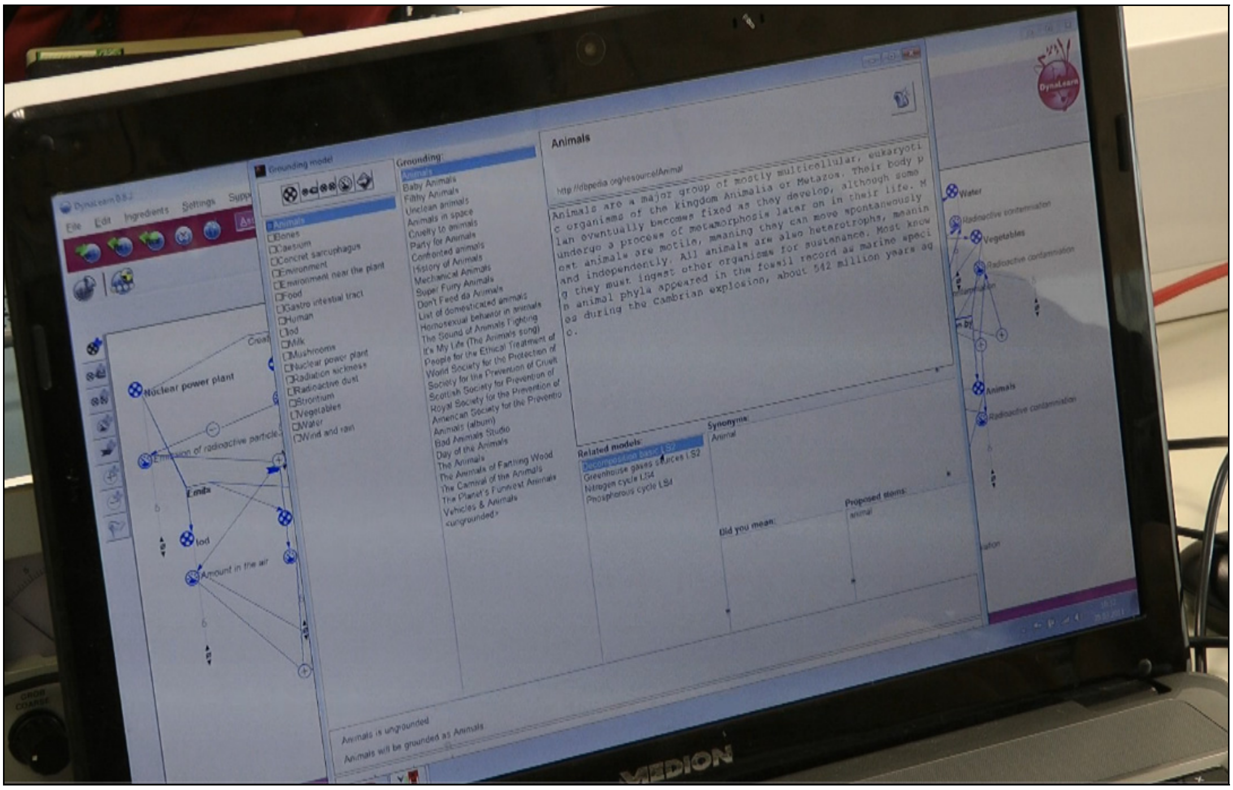


Figure 3.7: The structure of the *'Grounding'* window available with versions 0.8.2 and 0.8.8 of the DL software.

3.3.2.3. Assignment 3 – Simulation

Target concepts and goals of Assignment 3 were:

- introduction of LS4 with its model ingredients.
- introducing simulations with state graphs.
- fostering the inspection of simulation paths and value histories.
- testing the efficiency and need for *'Basic Help'* provided by '*Virtual Characters*'.

The students had to interpret simulation results of an LS4 model (Fig. 3.8), and identify relevant states using a model downloaded from repository (Assignment 3, Fig. 8.13 in the Appendix). Both students were able to complete this assignment successfully.

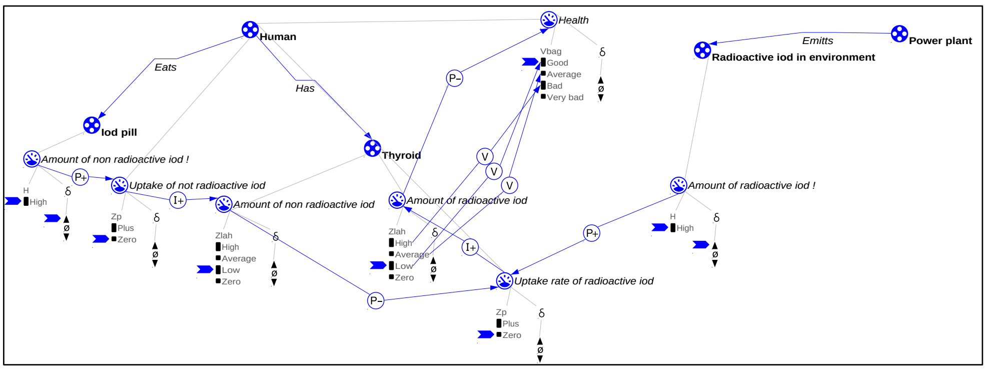


Figure 3.8: The structure of the model 'LS 4 Iod uptake'; specific questions had to be answered by simulation results.

3.3.2.4. Assignment 4 – Model completion

Target concepts and goals of Assignment 4 were:

- introduction of LS5 with its additional model ingredients, especially the possibility to set conditional statements.
- introducing the model structure of LS5, especially the creation of multiple fragments for setting conditional statements.
- testing the efficiency and need for *'Basic Help'* provided by '*Virtual Characters*'.

The students had to download an incomplete LS5 model from the repository, and to find out why the model was not working (Assignment 4, Fig. 8.14 in the Appendix). An expression fragment with a missing conditional statement and subsequently missing causal relations (one '*Proportionality*' - *P*, one '*Direct Influence*' - *I*, both becoming active after a critical value is reached) (Fig. 3.9), and the initial values were provided to the students, whereas the conditional expression was missing. Students had to identify the critical benchmark value for the yearly uptake of nuclear radiation by humans, and to set the conditional expression (Fig. 3.10). They were told also to use the introductory slides containing the complete conditional expression in LS5 of the same model (Fig. 8.10 in the Appendix).

After looking up the information with regard to the critical value in the web, both students tried to set the conditional statement. Although both students identified the missing '*Influence*' and *'Proportionality'*, they were unable to set the conditional expression. Both, *'Basic help'* provided by the software and the introductory slide showing the same model with the conditional statement set, were not helpful enough for the students to support them creating the conditional statement. The *'How to'* part of the *'Basic help'* lacked a statement about *'How to add a conditional statement'*.

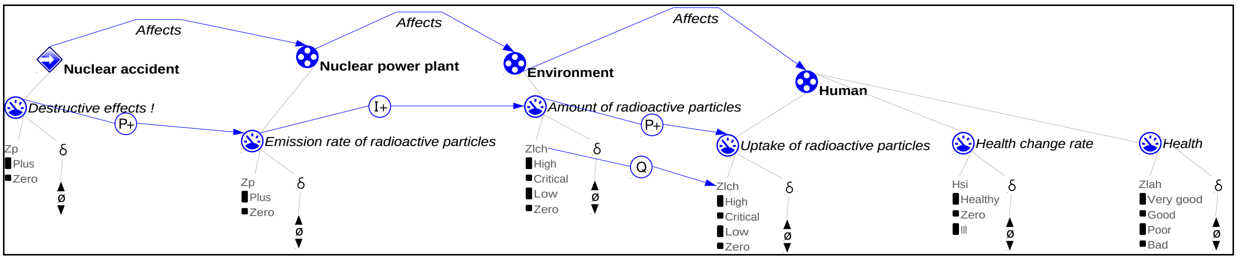


Figure 3.9: The structure of the model 'LS 5 nuclear emissions and health incomplete'; the model had to be completed by setting the conditional statement and the subsequent causal relations for causing the health to change.

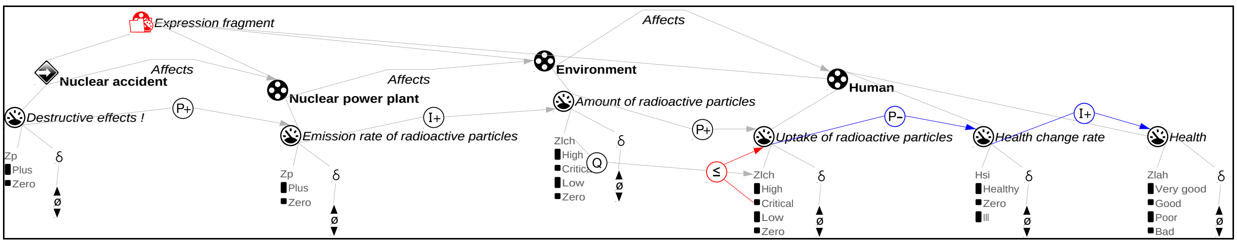


Figure 3.10: The conditional statement to be set in the model 'LS 5 nuclear emissions and health incomplete'; both students were not able to set the conditional statement based on the help provided by the software although they were able to identify the missing causal relations (P- and I+).

3.3.2.5. Assignment 5 – Model completion

Target concepts and goals of Assignment 5 were:

- introducing two different types of nuclear reactors, especially the pressured water reactor.
- introducing the different elements of a nuclear reactor, especially the roles of different loops in the pressured water reactor.
- introducing the central role of control rods in the nuclear fusion process.
- complex model completion based on additional information, mostly web-based.
- introduction of LS4 with its model ingredients.
- introducing simulations with state graphs.
- fostering the inspection of simulation paths and value histories.
- testing the use of the *'Recommendation'*-function:
    - assessing the differences between learner models and one selected expert model from the repository and adaptation of models where needed.
- testing the efficiency and need for *'Basic Help'* provided by '*Virtual Characters'*.

The students had to download an incomplete LS4 model from the repository (Fig. 3.11) dealing with the controlled production of energy based on nuclear fission (Assignment 5, Fig. 8.15 and Fig. 8.16 in the Appendix). Two different types of nuclear power plants (the boiling water reactor and the pressured water reactor) and the function of control rods for a controlled production of nuclear energy were introduced.

They had to identify the missing elements based on a provided story, and additional information looked up in the web (some relevant web-links were provided, especially one showing the function of a pressured water reactor and the effects on the river water temperature and its associated organisms).

The students added the missing information as good as possible (missing: *'Entities'* 'Steam turbine' with the *'Quantities'* 'Turbine rotation' and 'Energy produced' and the 'Entity' 'River' with the *'Quantities'* 'Water temperature' and 'Negative effects on aquatic organisms') and then gained recommendations from an expert model in the repository.

Student 1 was able to develop the model more detailed than the expert model before *'Recommendation'* from the repository (adding the *'Entity'* '*Generator'* with the *'Quantity'* 'Energy produced' linked to the *'Entity'* 'Steam turbine') based on knowledge gained during earlier modelling activities, whereas the other student did not include the *'Quantity'* 'Water temperature' of the *'Entity'* 'River' (that is causally linked to the effects on aquatic organisms) in his first attempt, but included it after *'Recommendation'* from the expert model (Fig. 3.12).

Finally they had to run a simulation, and answer some questions related to the production of nuclear energy. Both students were able to answer these questions and run successful simulations. The male student was able to add missing starting values of the newly added quantities after inspection of the simulation results.

For both students the use of P`s and I`s in one specific situation (causal link between the *'Quantities'* 'Water temperature' and 'Negative effect on aquatic organisms') was not clear, but as the simulation results were identical (which was proved), there was no obvious reason for them to go deeper into detail with this issue.

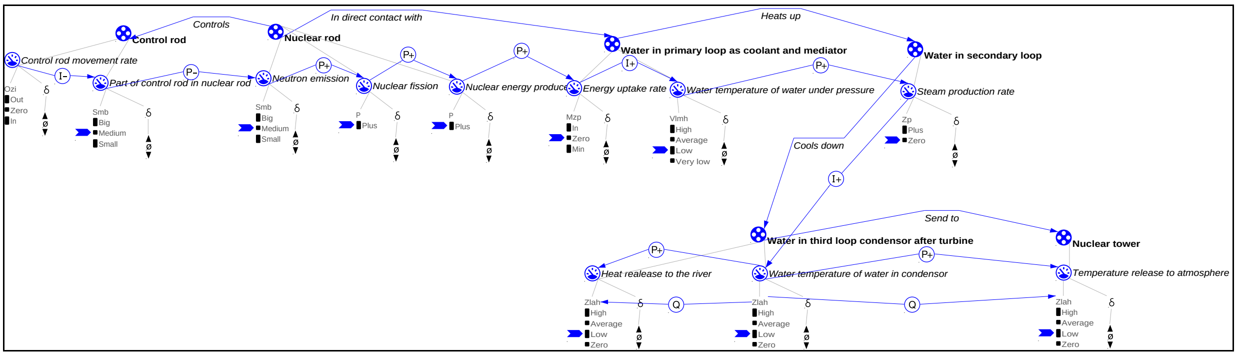


Figure 3.11: The structure of the model 'LS 4 nuclear power plant functioning incomplete'; the model had to be completed by information provided mainly via web-pages.

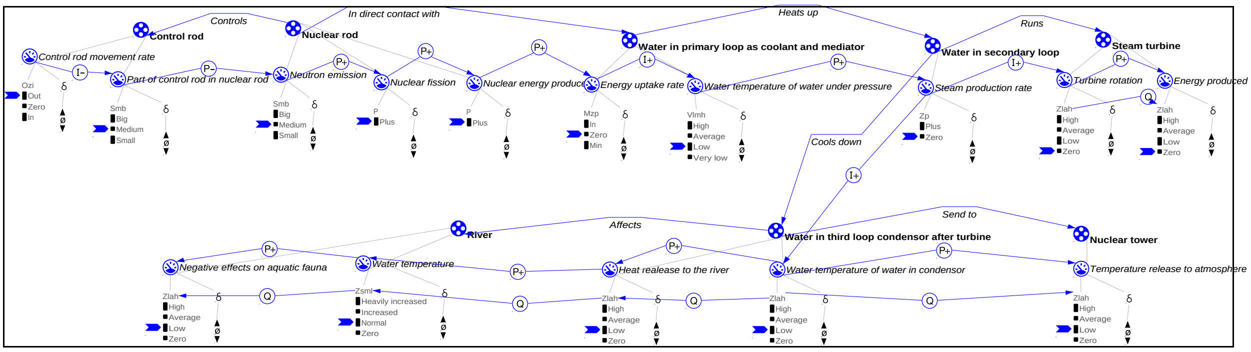


Figure 3.12: The structure of the model 'LS 4 nuclear power plant functioning feedback'; this model was used to provide recommendations from the repository.

3.3.3. Video analysis

In total analyses of 15 hours video material gathered during the iHTL evaluation from two cameras monitoring the screen of the two students was conducted. The analyses focused on modelling behaviour, problems students encountered during the use of the different features, additional help needed from teachers and social behaviour.

3.3.3.1. Modelling and social behaviour

The following section contains the results related to the following main questions:

- How was the behaviour and social interaction during the modelling work?
- Did students modelling and social behaviour differ per LS and action?

The following categories were treated:

- Acting: modelling activity on screen.
- Picking up (domain specific and modelling related) information: from the web, asking (=questions to) teacher, asking student; interactions with hamsters are not included, but are analysed in an extra section.
- Thinking: no obvious activity on screen, no speaking, obvious mental activity.

- Talking to student, talking to teacher: generic conversation, not for picking up specific information; also teachers might have started communication.
- Listening: time spent to listen to explanations and guidance provided by the teacher.
- Criticizing about buggy and not insightful features.
- Reading assignment.
- Writing: mainly related to the assignment.
- Taking a break.

Students' behaviour differed significantly between LSs and actions (Fig. 3.13). As students were not familiar with the topic, they spent about 50 % of time in LS1 picking up information (=asking teacher/student, looking in the internet/in additional material). In LS2 students worked very independently on their models (80 % of the time). Acting hereby means modelling activity.

During the first *'Recommendation'* session (LS2_FB1) student mainly worked with the *'Recommendation'* window, listened to explanations and thought about expert model`s parameters. During the LS2 grounding session students needed some time to pick up additional information, mainly from the web, for specifying the new anchor terms. Furthermore the conversation between the students as increased.

The recommendations provided from the other student`s LS2 model (LS2_FB2) induced intensive discussions among students and yielded a significant increase in communication between students, also involving the teachers.

In LS4 (Assignment 3, interpretation of simulation results) students worked more than 60% of the total session time independently.

According to the two more difficult assignments 4 & 5 (completion of ready-made, but incomplete LS5 and LS4 models) students' independent acting (=modelling) time is reduced in both situations.

Criticism about not insightful or buggy features was communicated practically during all assignments, especially during *'Grounding'*, *'Recommendation'* and the LS5 incomplete model.

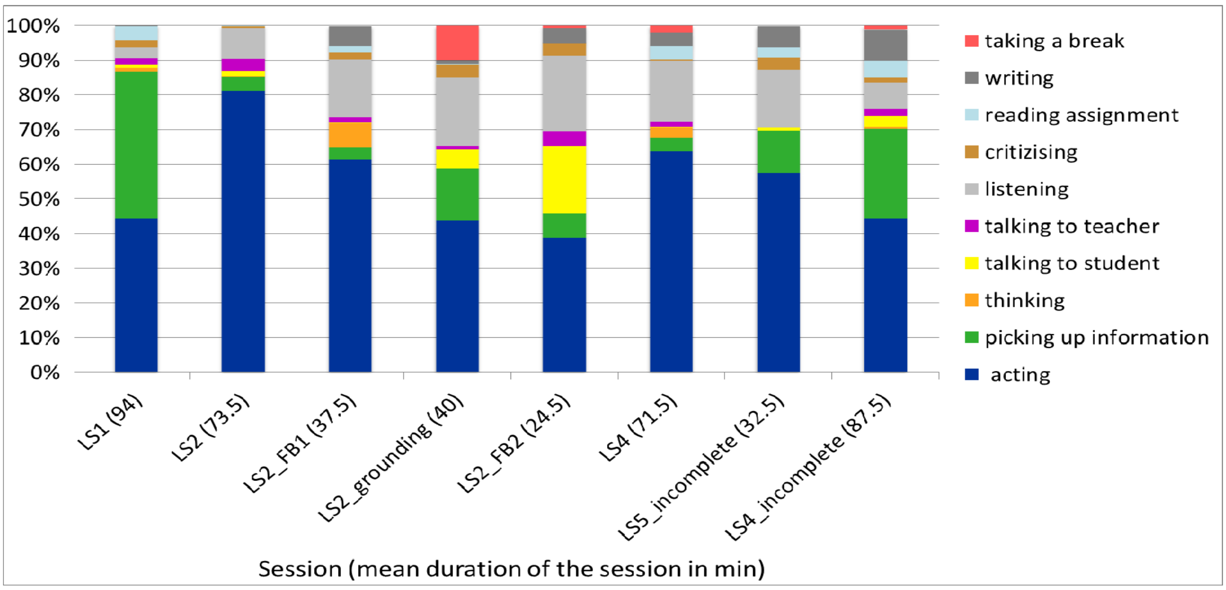


Figure 3.13: Students' behaviour at each learning session expressed as per cent of time spent for a specific activity, with total time of each learning session in minutes.

3.3.3.2. Sources of information used

Fig. 3.14 shows the sources of information during *'picking up information'* that students used at each activity. This information complements Fig. 3.13, where the extent of time spent for *'picking up information'* during different activities is described.

In LS1, during the LS2 grounding session and in LS5_incomplete and LS4_incomplete, students improved their knowledge mainly by using the internet for picking up information regarding the topic nuclear power plant and radioactive radiation.

Students interacted in all LSs with the teacher, but in LS2_FB1 and in LS4 the interaction with the teacher is dominating because of requested explanations concerning the recommendations provided by the expert model (LS2_FB1) and simulation paths in LS4.

During the session LS5_incomplete students needed information related to insert a conditional statement and finally required help from the teacher. They were not able to implement the conditional statement without any additional help from the teacher.

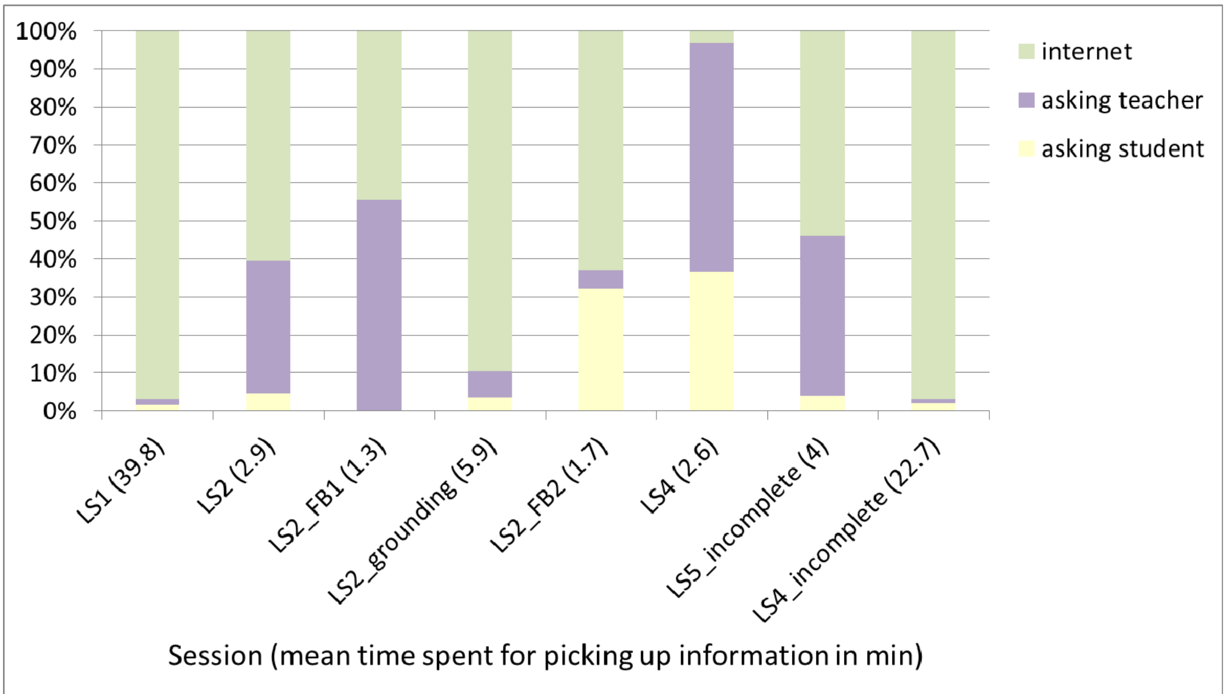


Figure 3.14: Sources of information used by students when *'picking up information'* at each LS and action expressed as percent of time spent; total mean time spent for *'picking up information'* during each learning session is given in brackets.

3.3.3.3. Types of questions asked

In Fig. 3.15 content of conversations (*'talking to teacher/student'*) and *'picking up information'* is summarized. Additionally the relative time spent for the interaction with hamsters is shown.

In LS1 time spent for *'topic'*-related questions was highest, when students developed their first understanding of the system using a semantic concept map, and decreased significantly from LS2 to LS4 during the modelling activities (Fig. 3.15). A further peak in *'topic'*-related questions and discussions occurred in LS2_grounding where students had to understand the meaning of ecological terms and especially in LS4_incomplete where they had to complete a complex LS4 model.

'Modelling' questions were mainly treated in the modelling sessions LS2 and LS4 and additionally in LS5_incomplete regarding setting a conditional statement. Generally relative time spent for *'modelling'* questions related to the conceptual understanding of the available features that can be used to express certain system structures and functions, directly arising from the interaction with the software significantly increased from LS2 to LS5. This documents the increasing possibilities of DL to reflect system structures in a more complex and realistic way.

In all LSs help was needed for explaining modelling terms (e.g., entity, configuration, quantity space, etc.). As the basic help only explains *'How to..'* and not *'What is..'*, students had to ask the teacher for help.

However, questions concerning *'Software handling'* (*'How to'* questions) also arose at all higher LSs (LS2, LS4 and LS5), although the students were motivated to use the *'Basic help'* function.

In the beginning, at LS1 and LS2 exercises it had to be explained, how the *'Virtual Characters'* could be activated (communication about *'hamsters'*). Mainly at LS4 and LS5_incomplete communication about the possibilities to use the *'Virtual Characters'* (*'hamsters'*) for help with regard to software handling was conducted.

However, the total number of activations of the basic help function was highest at LS 2 and LS 4 (see Fig. 3.16), but in most cases the virtual characters were not providing the help needed.

Questions concerning *'Recommendation'* and *'Grounding'* were dominating in the corresponding sessions.

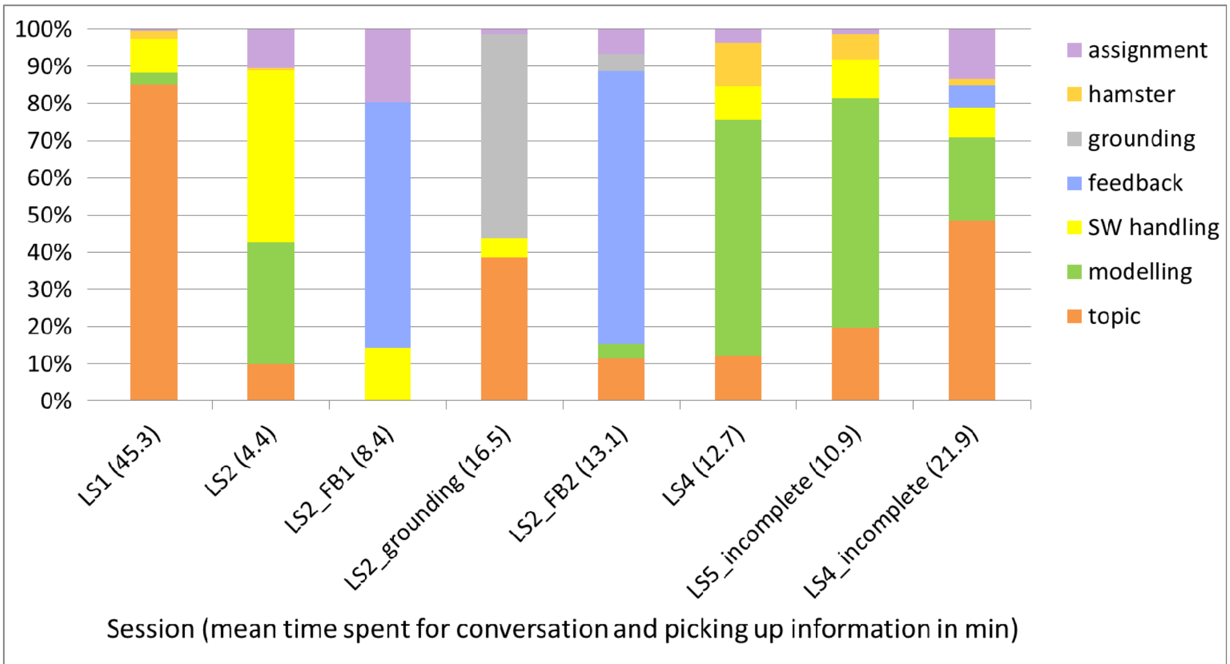


Figure 3.15: Content of conversations and questions (*'talking to teacher/student'* and *'picking up information'*) during each learning session expressed as percent of time spent; total mean time spent for *'talking to teacher/student'* and *'picking up information'* during each learning session is given in brackets.

3.3.3.4. Detailed description of 'Basic help' activations

Number of activations of *'Basic help'* was higher for the female student (Fig.3.16). The male student finally was choosing a trial and error technique to solve modelling problems (LS5_incomplete; LS4_incomplete).

LS1: activations were guided by teacher to introduce the function of the *'Basic help'* provided by the hamsters (*'How to' 'Add entity'*). Both students had problems to create a concept map – it was not clear that you have to select the '*Concept map'* option from the drop-down menu when creating a new model. Probably the hamster should be proactive in explaining how to create a new model in the beginning when the software is started for the first time. Probably with a question: *'Do you need support for creating a new model?'* Currently a description of '*How to' start a LS1-LS6 model'* is lacking.

LS2: Mainly the *'What is'* question was used – the answer was: *'Something went wrong'*, and the software crashed several times. Java processes had to be terminated manually before the Hamster-lab could be started again. Students mainly tested the *'Basic help'*-function, and expected an answer from Wikipedia provided by hamsters when asking *'What is'*.

LS4: The students tried to explore the model using the hamster, by clicking on elements in the model asking *'What is'*. Furthermore, they used the *'Basic help'* for getting information on the simulation results. As the hamsters just repeated the logical sequences of the modelling primitives this was not very useful for the students to understand the model – they skipped the answers during they were given. Students asked for more insightful explanations from hamsters, e.g. also examples for *'What is a proportionality'* etc. *'Basic help'* was used to learn about *'How to'* set an *'Influence' or 'Proportionality'* between two quantities, or to change the direction of the influence. At LS4 the male student skipped the further use of the *'Basic help'* as it obviously did not provide the answers needed for the student to understand the model better.

LS5: *'What is'* a nuclear accident was asked by the female student, obviously waiting for an explanation of the general circumstances of the model. *'How to'* function was not available, because an element was marked in the model, which makes only the *'What is'* function' available. It was criticised, that the *'Basic help'* does not support setting a conditional statement.

LS4: During the final assignment, first the hamster appeared without clothes, and did not provide any answer. The software had to be started again. As the DL software automatically offers a LS6 model at the beginning, the student asked '*How to add a scenario*', obviously expecting the answers '*How to start a new model*', *How to open an existing model*', and in this case: *'How to download a model from the repository'*. As this assignment required the implementation of new quantities to an incomplete model, the starting values (blue arrows) for the new quantities also had to be determined. As these elements were available at the existing quantities, the female student asked *'What is'* related to a marked value assignment. After the answer, she was setting successfully the value assignments at the new quantities, indicating the *'Basic help'* provided the answer needed to proceed. Finally the hamster was activated to provide an answer for a simulation producing no results. *'Basic help'* was not able to provide supportive information about the reason for the simulation not providing any states. This points out the relevance of the *'Diagnose'* function, that will be probably available later.

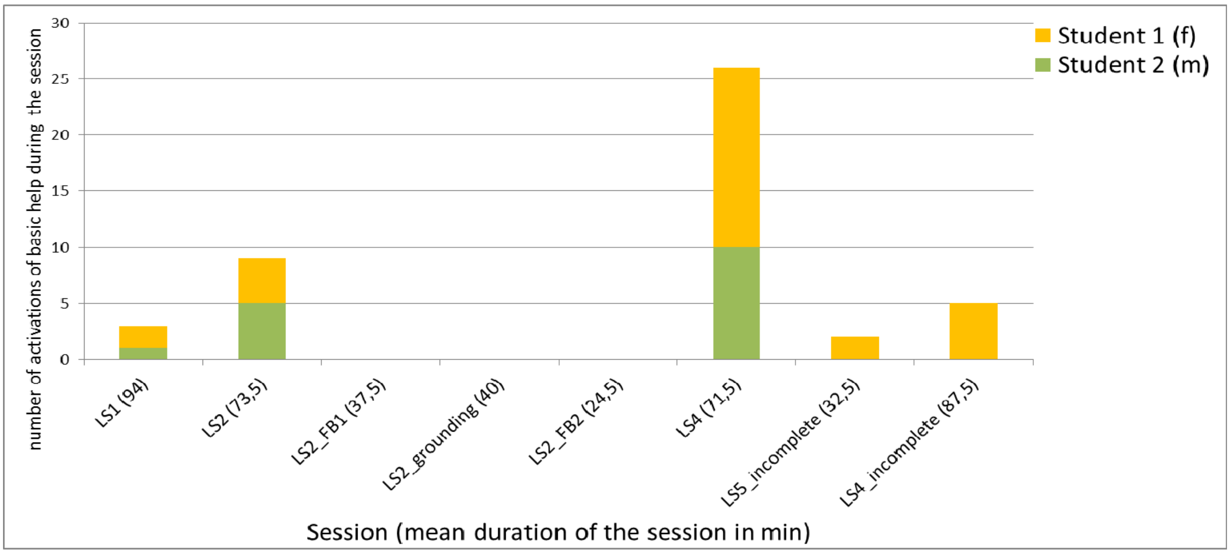


Figure 3.16: Number of activating the basic help functions per assignment related to different learning sessions per student together with the mean duration of each learning activity.

3.3.4. Results of pre- and post-tests i:HTL

Comparing pre- and post-tests (see Tab. 3.2) a slight increase of uniquely mentioned individual concepts *('single mention')* could be documented. But here it became obvious, that the parameter of uniquely mentioned individual concepts has only limited quantitative explanatory power and needs careful analysis, as students used a different, sometimes a more aggregated and focused way of answering the questions. In the pre-test they mentioned everything they knew, during the post-test their answer were more focused to the questions, and became more aggregated. For example: in the pre-test they were mentioning the *'atom'*, in the post-test only *'core fission'* and *'core fusion'* were mentioned, as the concept of the *'atom'* itself was assumed to be known already and to be of no more of relevance given the assignments. The use of *'nuclear element'* and *'nuclear material'* in pre-tests changed to a more general use of *'radioactive material'* in post-tests.

Also some different word choices for the same concept were used, for example *'steam-turbine'* (powered by steam) vs. *'turbine'* (powered by steam produced in the secondary loop of a pressurized water reactor).

On the other hand some generic descriptions like *'radioactive emissions are dangerous and are deforming humans'* became much more detailed and descriptive with regard to different organs and types of radiation.

One students mentioned *'light water reactors'* and *'heavy water reactors'* using different types of water in the pre-test, together with a description of a *'boiling water reactor'*, but with no causal explanation for the use of different types of water (which is quite complex). However, *'heavy water reactors'* are usually *'pressurized water reactors'*, where the ability of heavy water is used as coolant and neutron moderator for the fission process, whereas boiling water reactors use light water as coolant and neutron moderator. As the assignments were focusing on the differences between *'boiling water reactors'* and *'pressurized water reactors'* characterized by different loops containing the radioactive water and the steam that powers the turbine, the differentiation between *'light water reactors'* and *'heavy water reactors'* disappeared, while the difference between *'pressurized water reactors'* and *'boiling water reactors'* became well understood.

In general the use of a more unified and scientific vocabulary for domain knowledge could be documented (e.g. the wording *'core-splitting process'* or *'you split the core'* was changed to *'core fission'*, which is the scientific term typically used).

Finally, although many new concepts and a better scientific and unified wording occurred during post-tests, some important concepts were only mentioned during the pre-tests (e.g. *'storage of nuclear elements'* as potential source of problems for humans and the environment*)*, and some concepts became more generic *(*one students changed '*radioactive iodine'* in pre-test to just *'iodine'* in post-test*)*.

These results underpin the strong effect of this kind of learning on the use of vocabulary, and points out the high relevance of an intended introduction of the appropriate terminology to students. Furthermore it became obvious that the type of assignments and learning activities together changed the concepts that were memorized and repeated. This result points towards a relevance of careful design of learning units and the corresponding assignments. However, a more detailed understanding and knowledge appeared during post-tests.

The use of direct (verbal) causal relations slightly increased, whereas graphic causal relations increased significantly, and it was only the female student (student 1) that used graphical causal relations in pre- and post-tests (2 during the pre-test and 8 during the post-test situation). One wrong causal relation was documented during the pre-test (related to *'heavy water reactors'* described in relation to *'boiling water reactors'*) which disappeared during the post-test.

Also a significant decrease of the number of words used during post-tests could be documented, but can be explained by the reasons described above.

The qualitatively rated parameter *'degree of causal understanding'* of the effects of radiation and the principle understanding of radiation processes as judged by a comparison to an expert model increased by 66.7 %. The qualitatively rated parameter *'degree of abstraction'* shows an increase of 50 %.

The final analysis of the gathered data by creating networks in *Atlas.ti* displays the change of students' thinking after the learning activity with DL. In the Appendix, Fig. 8.26 and Fig. 8.28 show the cognitive maps of both students in the pre-test, Fig. 8.27 and Fig. 8.29 show the post-test maps, documenting clearly the increase of causal understanding of how things are related and influence each other.

Table 3.2: Chart with comparison of pre- and post-tests results of i:HTL evaluation (values are mean values, n=2 students).

Comparison of pre- and post-tests								
single mentioning of concepts								
parameter	**unit**	**Pre**			**Post**			***change*** *(in %)*
		Student 1	Student 2	mean	Student 1	Student 2	mean	
concepts, total	[n]	54	45	49.5	65	46	55.5	*12.1*
causal relations, direct/verbal	[n]	8	10	9	9	12	10.5	*16.7*
causal relations, graphic	[n]	2	0	1	8	0	4	*300.0*
causal relations, wrong	[n]	0	1	0.5	0	0	0	*-100.0*
number of words	[n]	251	158	204.5	192	127	159.5	*-22.0*
degree of abstraction	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	2	2	2	3	3	3	*50.0*
effects of radiation	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	3	3	3	5	5	5	*66.7*
principle understanding	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	3	3	3	5	5	5	*66.7*

3.3.5. Results of motivation questionnaires

The analysis of the motivation questionnaires (see Fig. 8.23 to Fig. 8.25 in the Appendix) of the two i:HTL students yielded a diverse picture related to the different sections of the questionnaire (see Fig. 3.17).

General appreciation: In general they liked the lesson and learning activity we had together. In contrast to last year they already knew a lot of the treated topic (nuclear radiation, its effects and its usability and nuclear power plants). However, the exploration of the subject-matter with DL by modelling enabled them strongly to better understand the topic.

Recommendation functionality: The female student (student 1) rated the questions with regard to the recommendation functionality very negative, whereas the male student had a more positive opinion. This can be explained by the long time the recommendation needed to be delivered, and the missing clarity in the *'Recommendation'* window to which model the missing terms and extra terms belonged.

Grounding: The grounding functionality was liked, although student 2 had concerns about the clarity of the grounding window.

Virtual characters: Although the virtual characters were liked by both students, they were not rated as useful providing sufficient help to learn how to use the software, and were not sufficient to support model building activity.

Ease of using the software: It was not very easy for the student 1 (female student) to use the features of software and run simulations. Defining processes and rates was rated as being more challenging as defining quantities and entities.

Simulations: The possibility to run simulations was rated positive.

Learning by modelling: Both students agreed that the process of modelling motivated them to learn more about the topic, although both students were neutral with regard to the potential of the software to enable them to learn by themselves.

3.3.5.1. *Criticism and proposed improvements by students (individual statements)*

Software handling and modelling:

- create a new configuration → only press 'Enter' would be more user-friendly
- a new configuration is ordered alphabetically; when you need a configuration more often, you must always search the word in the alphabetical order because the selection always goes to the top of the order
- the LS1 model should appear transparently behind the LS2 model
- when you work in LS1 and then you want to continue with LS2, you must type all entities again; there should be an import function (from LS1 to LS2)
- create a new entity → at first you must delete the name 'new entity' and then you can type a new word
- when you write a definition → the words are separated in the middle
- it isn`t possible to show two different models side by side
- there was no information provided about setting conditions at LS 5
- the computer shows the passwords when logging into the repository (not wanted)

Recommendation:

- no alphabetical order of the expert models, no possibility for ordering
- the window with the extra terms and missing terms should be bigger
- better overview; it was difficult to see to which model the information belonged
- it would be good when you can select a quantity in the expert model and import it into your own model

Grounding:

- there should be a search function for the terms provided
- the ordering of the terms was not insightful
- the words in the model contained numbers but the grounding didn`t work with numbers
- the grounding window should have graphics and colours like Wikipedia

Basic help:

- when the hamster explains something → the further steps should be already shown in the window
- hamster just said obvious things, but not why something went wrong or what you can do instead
- hamster just gave little information, no detailed information or examples for better understanding
- maybe there could be playing hamsters when the computer is loading.

3.3.6. Personal impressions as evaluator

Recommendation:

- recommendation window not insightful enough
- not clear: meaning of missing and extra term
- both students got partly wrong recommendation results
- students enjoyed getting recommendation from other student`s model

Grounding:

- Grounding terms not in alphabetical order

- Grounding window not self-explaining
- Function of anchor terms did not work
- Not possible to ground terms with figures (Iodine 131, Caesium 137)

Teachable agents:

- Not helpful enough
- Should appear during waiting time (e.g., *'Recommendation'* response)

Modelling:

- Not possible for both students to set a condition in LS5 by their own

Figure 3.17: Mean rating value per question of the evaluation questionnaire at the i:HTL evaluation (1=very negative, 3=neutral, 5=very positive).

4. Second evaluation study: BOKU

At BOKU University we had the possibility to implement DL during two lessons within the course "Selected Topics of aquatic ecology and river management" as 2 of 6 sessions in total. The lesson plans for the whole course as well as for the two afternoons with DL can be found in the Appendix (section 8.2.2). The rest of the course was held as PowerPoint presentations. This course provides comprehensive information about river management, river landscapes and large river systems as well as benthic invertebrate ecology, water quality assessment, EU Water Framework Directive or classification and modelling of river systems.

4.1. Setup

Date:	11.05. and 12.05.2011; 17.5.2011 (alternate date)
Place:	BOKU, Vienna, AT
Responsible person:	Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar
Participating students:	31 students (15 female, 16 male) in total; 26 (13 female, 12 male) finished the whole evaluation by delivering all assignments and questionnaires (see Figs. 4.18 and 4.19)
Age of students:	20-38 years old
Educational level of students:	mainly master students
Topic:	River channelization: background; physical and biological effects
Activity:	two afternoons introducing DL and modelling with LS1, LS2 incl. recommendation, grounding, debugging
Evaluation instruments:	Videotaping of the modelling activity and social interactions, questions and answers; pre- and post-test, motivation questionnaire, final exam

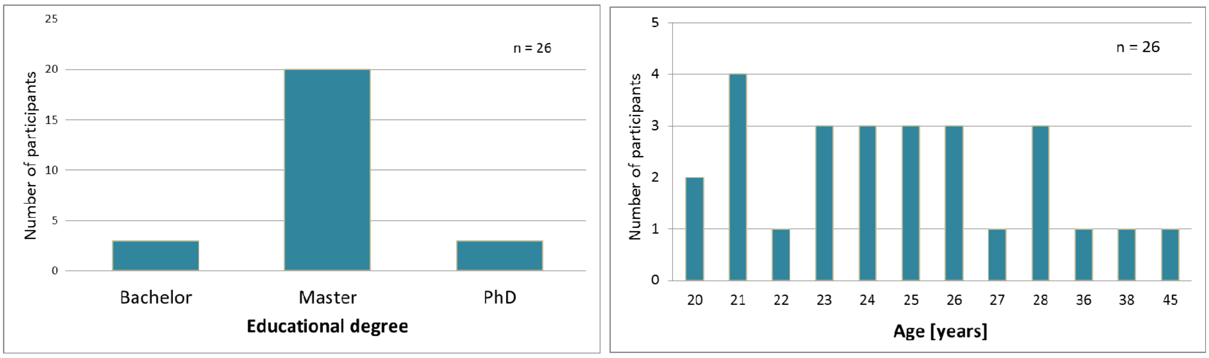


Figure 4.18 and Figure 4.19: Educational degrees and age distribution of the 26 students that finished the DynaLearn course.

4.1.1. Expectations from this setting

- Feedback on usability and problems that learners encounter with the software. This will help to focus *'Basic help'*, *'Diagnostic feedback'*, *'Recommendations'*, *'Bug repair'* etc.
- Specific testing the functionality and appreciation of *'Basic help'*, *'Recommendation'* and '*Grounding'*.
- Assessment of different pedagogical strategies

- to support self-organized learning, e.g. provision of assignments via the moodle platform

- The pre- and post-test will help us in knowing if they learned something, and if the structure of their knowledge is influenced by the activities with DL.
- The final exam will show, how students perform with regard to content delivered within the modelling session in comparison to content delivered by the other lessons (held as PowerPoint presentations with discussion)
- A motivation questionnaire will help us knowing if they liked what they did and collect impressions and ideas.

4.1.2. To be considered

The group of participants consisted mainly of 31 experienced students that were already well informed in the treated topics. As the DynaLearn session took place within a regular lecture at the BOKU, students were free to attend or not. This factor is pictured by differing attendance / collaboration / output figures in our results.

4.2. Data analysis BOKU

For the analysis of the BOKU evaluation sessions, the following components were available:

- pre- and post-tests,
- motivation questionnaires,
- final exams of the course (with written answers),
- video analyses,
- comparison of LS2 students models made before and after using the recommendation,
- personal observations during the assignments.

The analytical process of the **pre- and post-tests** was similar to the one used for the i:HTL evaluation described above: scanning the tests, importing them into *Atlas.ti*, marking quotations, linking them with codes and memos, categorization of causal relations and determination of the degree of abstraction. For the analysis we got 26 completed pre- and post-tests from the students.

To identify the improvements students made by using the *'**Recommendation**'* we compared students LS2 models made before and after using the *'Recommendation'*. The number of corresponding entities and quantities of students' models to the expert model were counted. The amount of correct and/or wrong causal relationships is crucial for the quality of the LS2 model and was considered additionally.

The **motivation questionnaire** (see Fig. 8.23 to Fig. 8.25 in the Appendix) was completed by 26 students after the evaluation lessons. The questionnaire is similar to the one used at i:HTL. 33 of the 39 questions allowed ticking applicable answers (in a 5-tiered scheme) and the remaining six had to be answered qualitatively by writing textual answers. The data were processed with Excel by calculating arithmetic means and medians of the single ratings. The analysis of the answers and remarks in the motivation questionnaires highlighted students` attitude to different Software feature.

The third component of the BOKU evaluation was the assessment of the performance with regard to two questions within the final **exam** of the course, which offered us the possibility to verify how much the students learned about the topic explored with the help of DL in comparison to the content delivered as PowerPoint presentations in the rest of the lessons. In total 34 students delivered a test, at which 9 of those did not participate in the DL lessons. Therefore, all students, participating the DL lessons or not, had the same condition of acquiring knowledge by at least having the possibility of downloading the presentations and documents of all course lessons digitally from the courses homepage. Every single question was graded separately by the lectors of the course (1 = very good, 2 = good, 3 = average, 4 = adequate, 5 = unsatisfactory), allowing the calculation of mean values per question in an Excel matrix.

The lessons were **videotaped** by two cameras. We analysed the frequency and duration of interactions between students and teachers by using Transana software (see chapter 3.2.1 and chapter 10.2.2 in the 7.2.5 deliverable for a detailed software description). These interactions are distinguished into three categories: (1) student asked for help by using a direct signal (e.g., by hand) (2) student gave indirect signal for needing help (e.g., long break, no work, no discussion between students) (3) teachers asked student.

4.3. Results BOKU

4.3.1. Video analysis and LS2 model comparison

30 BOKU students worked through five assignments during two afternoon sessions (for further details see lesson plans in the Appendix, section 8.2.2) in groups of 2-3 students per Laptop (LP). For those students, who could not attend the first or second course an alternate date was offered. Three teachers were attendant in the classroom during all sessions.

Assignments:

11/5/2011: LS1 and LS2 model

12/5/2011: *'Recommendation'* from Expert model, debugging in LS2, *'Grounding'*

17/5/2011 (for those students who could not attend the first or second course):

LS2 model, *'Recommendation'*, *'Grounding'*

4.3.1.1. Assignment 1: Concept Map (LS1)

The aim of this lesson was to create a concept map (LS1) representing students` knowledge of the phenomenon of river channelization. 26 students worked with DynaLearn for approx. 55 min. (see lesson plans in the appendix, section 8.2.2). Students worked in groups of 2-3 at 14 Laptops (LP).

The guiding questions of this session were:

- Are students able to picture their knowledge semantically in DynaLearn?
- Could students create a concept map independently?
- Is the Software self-explaining or can the 'Basic help' functions provide sufficient support to the students?

Video analyses showed 46 interactions between students and teachers within the LS1 session of 55 minutes (Fig. 4.20). The total duration of the interactions was 82 minutes, which clearly shows the need for more than one teaching person to provide sufficient support. It was indicated in the assignment that if students need help, they should try to take as much advantage of the basic help of the software. Nevertheless some students groups demanded a lot of explanations and help from the teachers. One group (LP6) had interactions with the teacher almost over half of the lesson (Fig. 4.21). Other students groups could build their concept map mainly independently. But all students were able to create a concept map and fulfilled the assignment within time permitted.

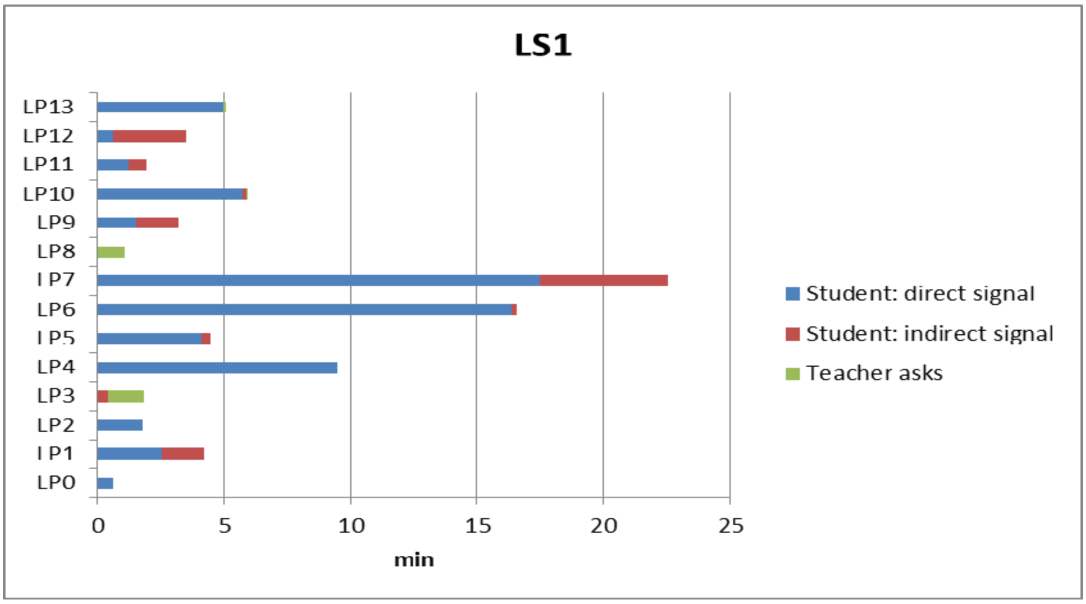


Figure 4.20: Interactions between students and teachers during the LS1 session in minutes..

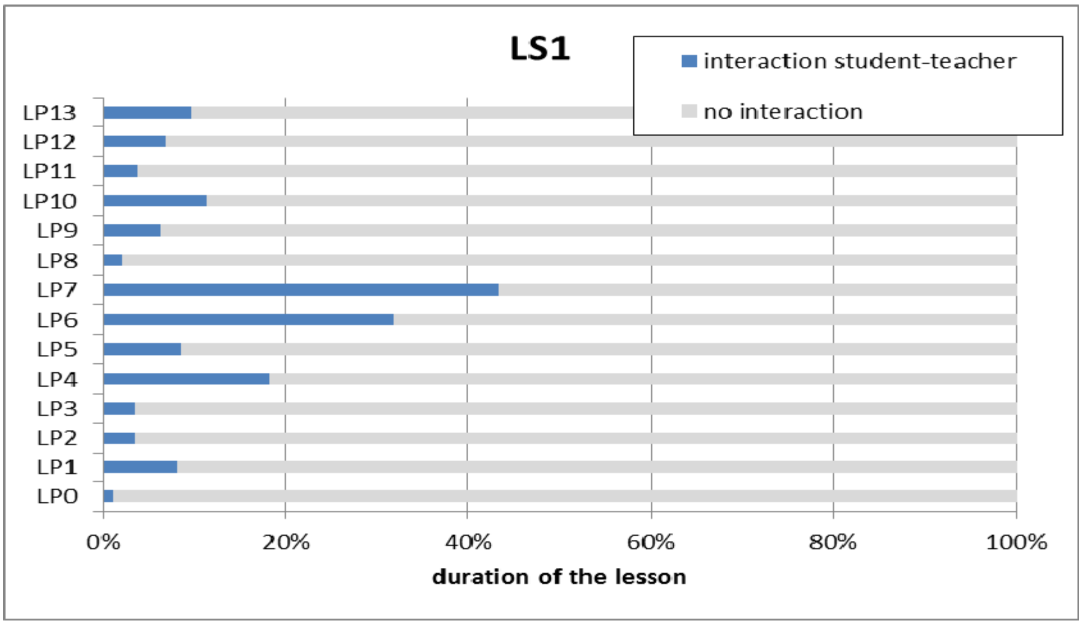


Figure 4.21: Interactions between students and teachers during the LS1 session in % of the total duration of the lesson.

4.3.1.2. Assignment 2: Basic Causal Model (LS2)

The aim of this lesson was to create a basic causal model at LS 2 that captures students` explanation of the phenomenon of river channelization and its abiotic and biotic effects. 26 students worked with DynaLearn for approx. 45 min. (see lesson plans in the appendix, section 8.2.2). Students worked in groups of 2-3 at 14 Laptops (LP).

The guiding questions of the session were:

- Could students create a basic causal model independently?
- Is the Software self-explaining or can the *'Basic help'* functions provide sufficient support to the students?

In total 117 minutes support by teachers was given during the LS2 session (duration = 45 min.). Three student groups (LP3, 11 and 12) needed no help and created their LS2 models without having any questions (Fig. 4.22 and Fig. 4.23).

Students at LP14, 15 and 16 started with Assignment 2 (LS2) without having done a LS1 model before. Students at LP2 left the course after Assignment 1, others decided to work together (LP4+LP5, LP6+LP7).

Students that started with LS1 needed significantly less support for LS2, than those students that started with LS2 without having conducted LS1 work before (Fig. 4.24). Vice versa, three student groups that started with DynaLearn with assignment 2 (LP14, 15 and 16, contact only with LS2, n=3) needed significantly more help from teachers as the 11 other groups that worked on LS1 and LS2 (contact with LS1 and LS2; n=11; see Fig. 4.24).

One of the 'first contact with LS2' student groups (LP15) demanded help during more than 60 % of the whole session (26 min.) (Fig. 4.22 and Fig. 4.23). Two students also needed significant help for LS1 (Fig. 4.24).

These results show the difficulty students might have to start with the DL software, especially for modelling at LS2. In this phase additional help, in many cases intensive assistance, was needed.

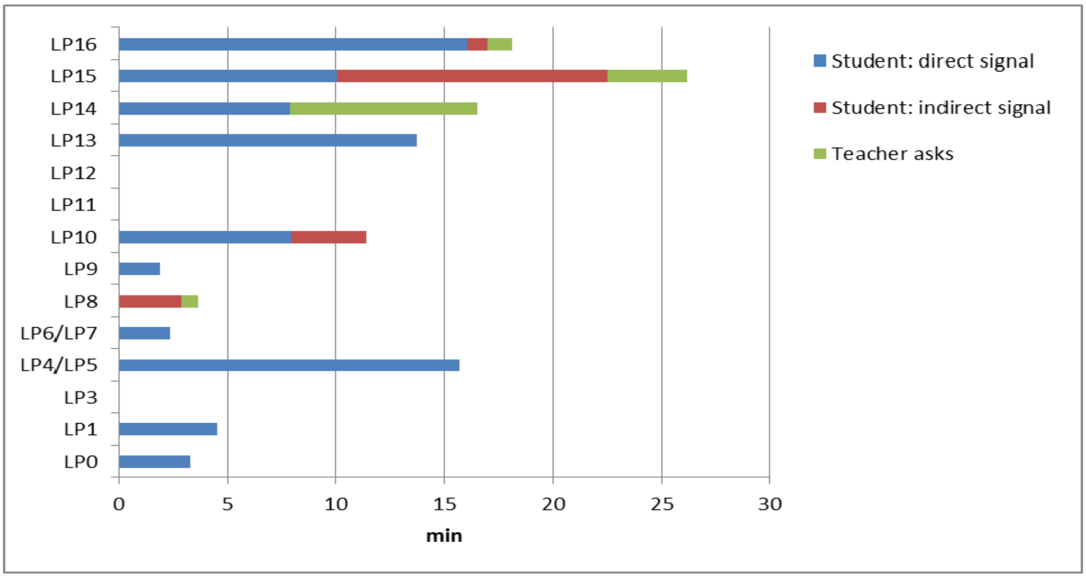


Figure 4.22: Interaction between students and teachers during the LS2 session in minutes.

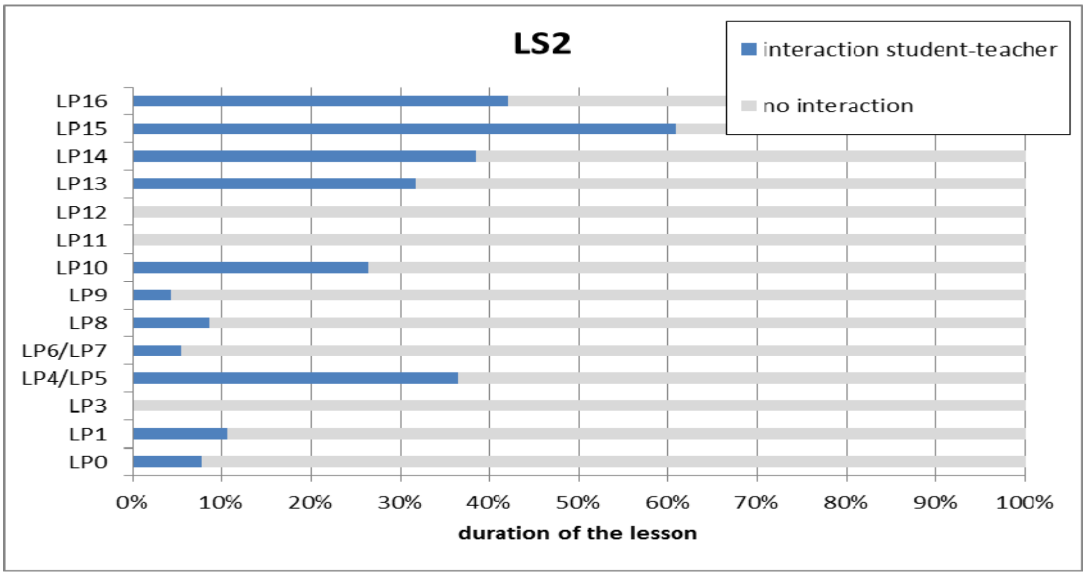


Figure 4.23: Interaction between students and teachers during the LS2 session in % of the total duration of the lesson.

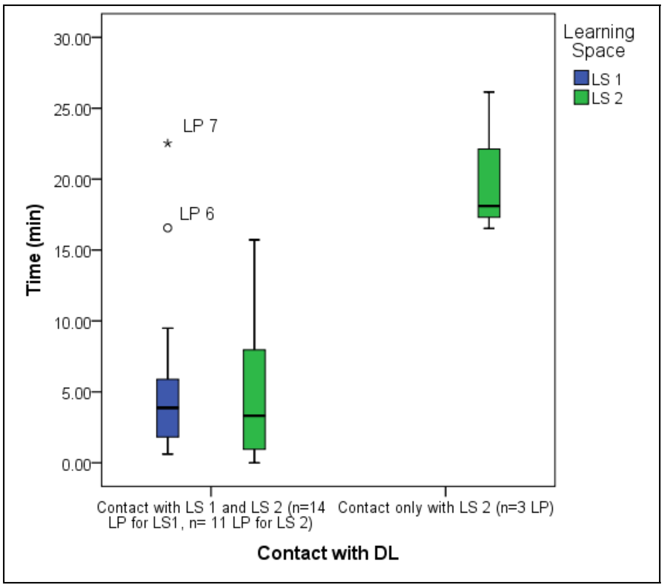


Figure 4.24: Interaction between students and teachers according to the first contact of students with DL.

4.3.1.3. Assignment 3: Basic Causal Model (LS2) - Recommendation

The DynaLearn project includes a *'Semantic Repository'* to store models made by users (students, teachers, or experts) (Gracia et al., 2010). These expert models can be used by the ontology matching technology to provide learners with recommendations and relevant information concerning their own knowledge construction process.

During Assignment 3, the students were asked to gather recommendations on their LS2 models built one day before by using the *'Recommendation'* tool of DL. 26 students worked on 12 LP with the *'Recommendation'* for approx. 40 min. and improved their LS2 model afterwards for approx. 20 min (see lesson plans in the Appendix, section 8.2.2). Because of login problems to the repository only 9 Laptops (LP) out of 12 got recommendations. Students worked in groups of 2-3.

Eight paired LS2 models (before and after using *'Recommendation'*) were available for comparative analysis of the effect of the *'Recommendation'* function on student models; one student group (LP6/LP7) did not save their models on the moodle platform.

The guiding questions of the session were:

- Could students follow the *'Recommendation'* procedure in the software independently?
- Is the *'Recommendation'* window in the software clearly arranged?
- Are the given results by the *'Recommendation'* usable for the students?
- Could the students improve their models by the *'Recommendation'* functionality?

Students needed help between 0 and 7.5 min. during the *'Recommendation'* lesson (40 min.) (Fig. 4.25 and Fig. 4.26). The main questions were related to the design of the *'Recommendation'* window. The terms *'extra xx'* and *'missing xx'* were not understood as self-explaining. Students found the window confusing and not clearly arranged. However, only one student group needed help for more than 20 % of the whole lesson.

During the following model adaptation process, no help was provided by the teachers, to only test the efficiency of the *'Recommendation'* provided by the technology to improve the models.

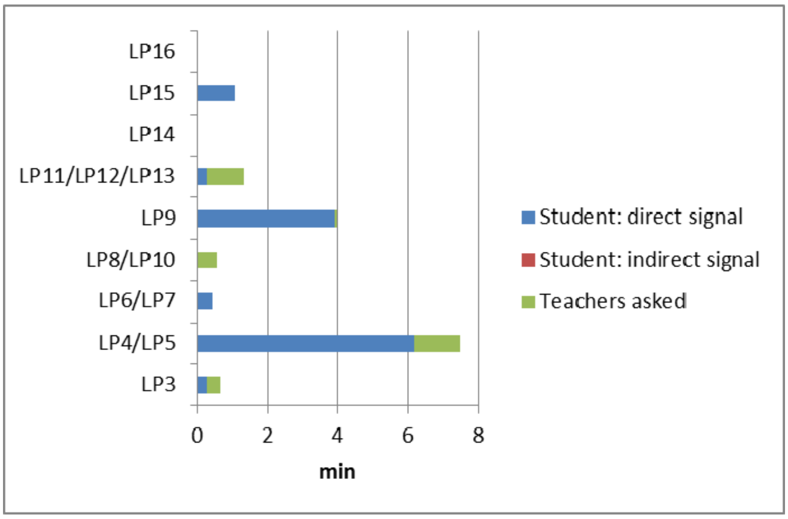


Figure 4.25: Interaction between students and teachers during the *'Recommendation'* session in minutes.

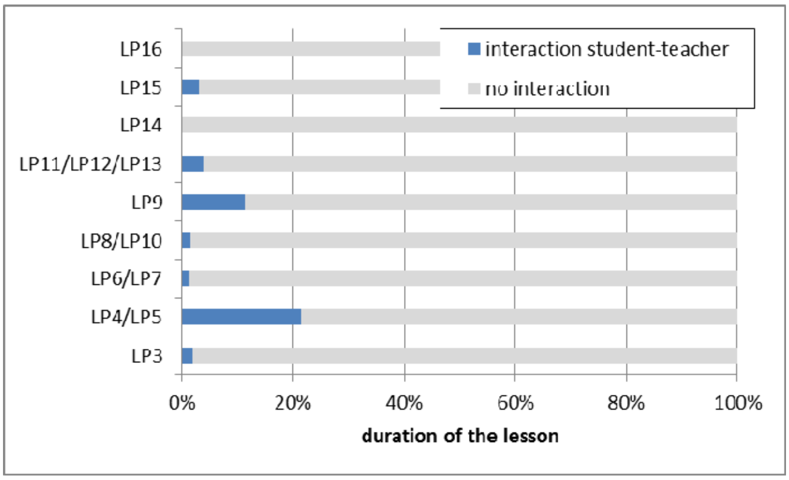


Figure 4.26: Interaction between students and teachers during the *'Recommendation'* session in % of the total duration of the lesson.

The evaluation of the *'Recommendation'* showed that the quality of students models compared to an expert model increased in a very short time period.

The comparison of the eight LS2 models before and after recommendation from the expert model showed a significant progress and improvement of the students' models (see Fig. 4.27 and 4.28). The number of entities and especially of quantities and correct causal relationships increased significantly.

One student group (LP14) defined more correct causal relationships than the expert model through a huge amount of extra quantities.

Summarizing, in general students liked the *'Recommendation'* function, but indicated a lack of clarity in the structure of the *'Recommendation'* window. However, based on the *'Recommendations'* provided, students were able to significantly improve their models in a very short time.

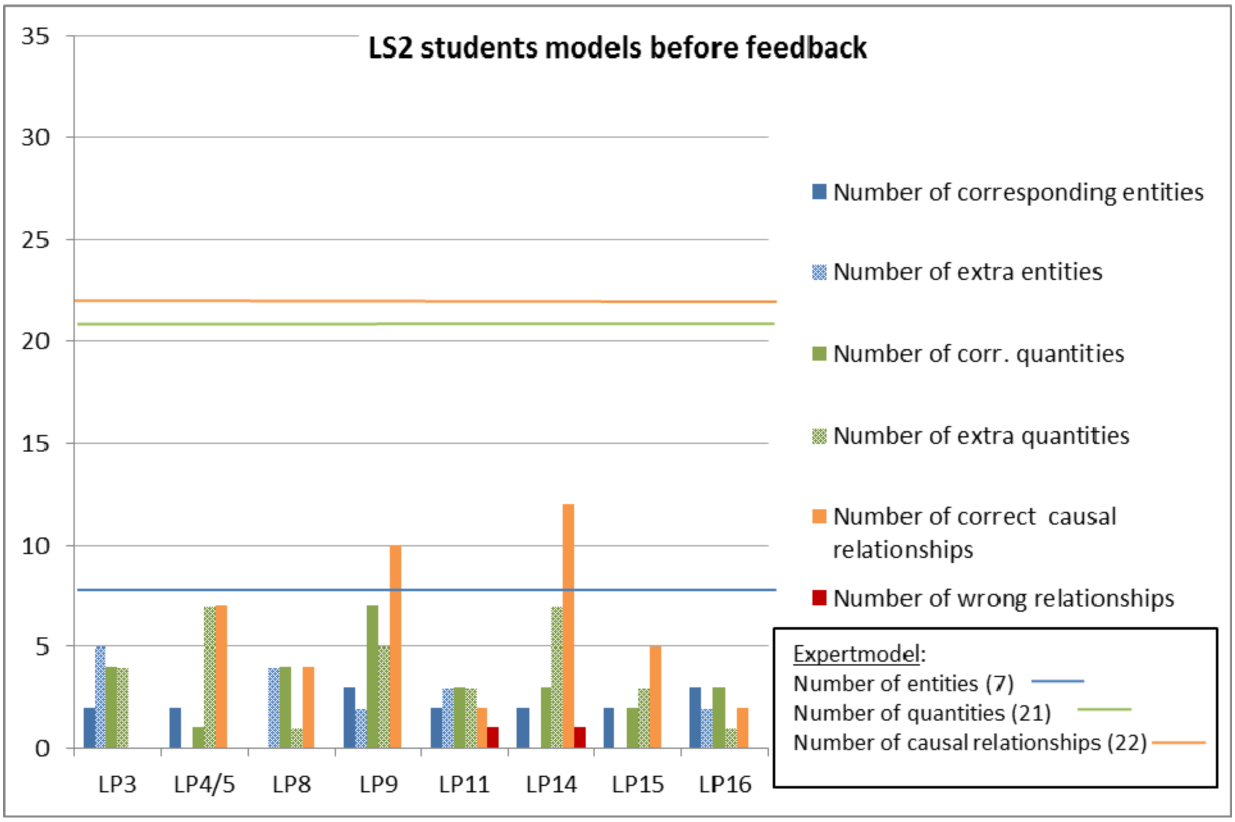


Figure 4.27:Comparison of the elements of the student models with the expert model BEFORE *'Recommendation'* via the repository.

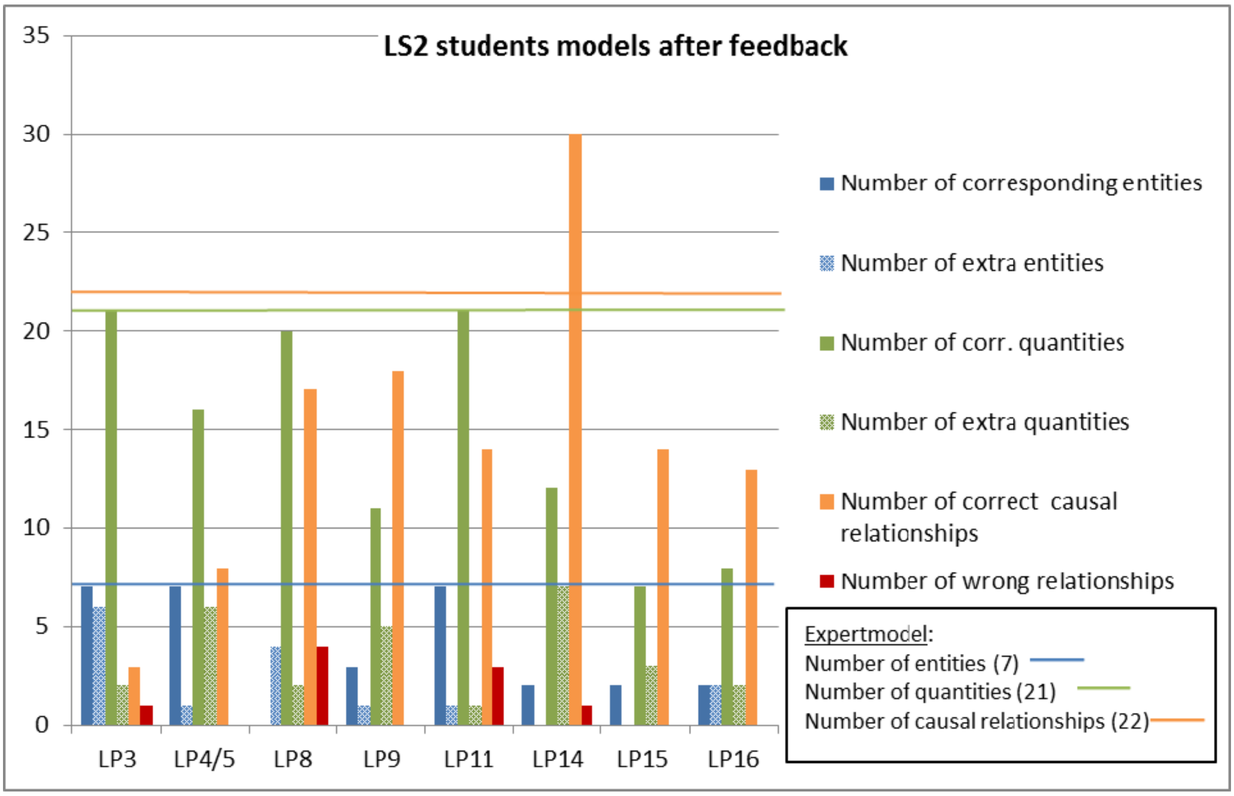


Figure 4.28: Comparison of the elements of the student models with the expert model AFTER *'Recommendation'* via the repository.

Statistical analyses of the elements contained by the student models before and after *'Recommendations'* from the expert model proved a significant increase of correct causal relations and quantities after

'Recommendations' (Fig. 4.30 and Fig. 4.31). The increase of entities and wrong causal relations was not significant (Fig. 4.29 and Fig. 4.32).

It was observed, that students had significant problems in developing and restructuring the entity structure and hierarchy. They initially also had significant problems differentiating between entities and quantities.

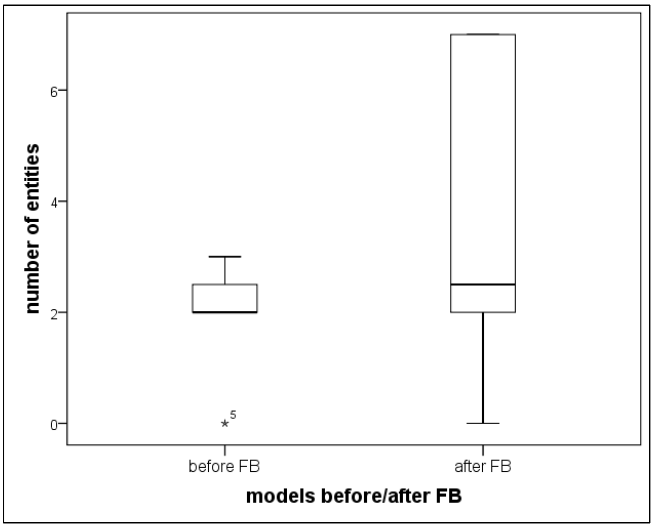


Figure 4.29: Comparison of the number of entities in 8 student models before and after *'Recommendation'* (Mann-Whitney U, P=0.328).

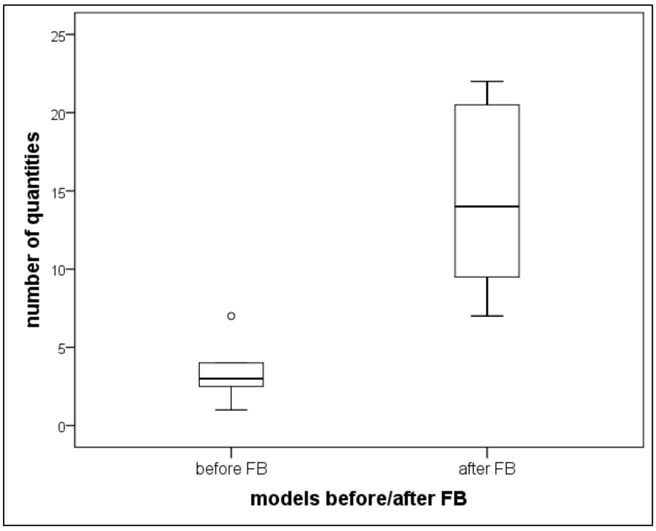


Figure 4.30: Comparison of the number of quantities in 8 student models before and after *'Recommendation'* (Mann-Whitney U, P=0.000).

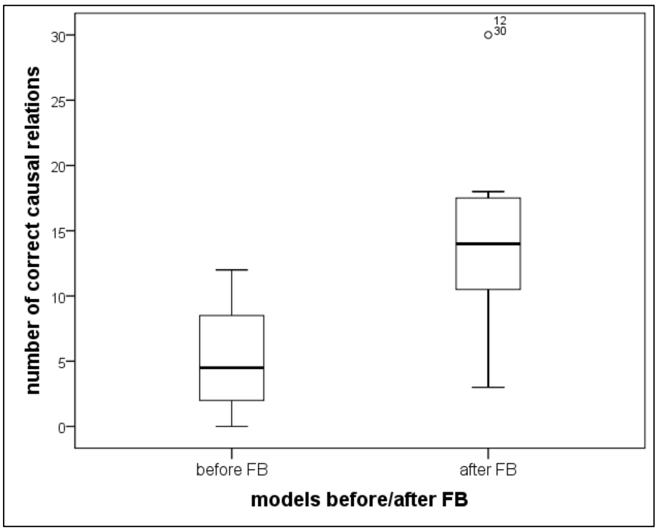


Figure 4.31: Comparison of the number of correct causal relations in 8 student models before and after *'Recommendation'* (Mann-Whitney U, P=0.007).

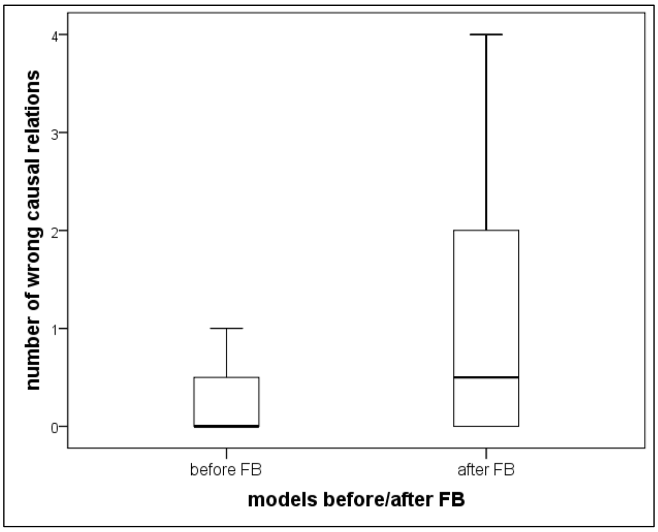


Figure 4.32: Comparison of the number of wrong causal relations in 8 student models before and after *'Recommendation'* (Mann-Whitney U, *P*=0.328).

4.3.1.4. Assignment 4: Basic Causal Model (LS2) - Debugging

The students` task in assignment 4 was to identify two model bugs in a LS2 model. 20 students worked on 9 Laptops (LP) in groups of 2-3 persons for approx. 20 min. (see lesson plans in the Appendix, section 8.2.2).

The guiding questions of the session were:

- Could students apply their previously obtained model knowledge in an advanced LS2 model?
- Could students find the bugs in the model independently?

Students worked very self-consistently and needed little help (Fig. 4.33). In total about 7 minutes of help was required, mainly requested by students.

Seven student groups detected both mistakes within 20 minutes. Two student groups (LP4 and LP10) found the mistakes only after group discussion and further explanations. 78% of all students managed to understand the pictured complex processes in an advanced LS2 model quickly.

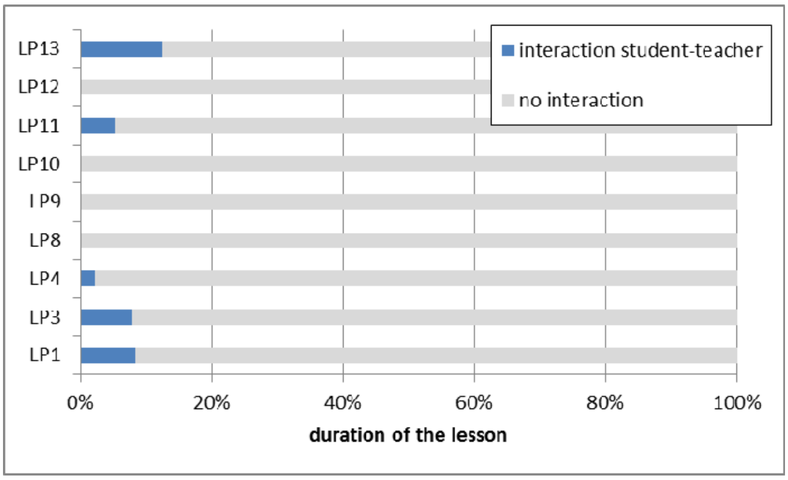


Figure 4.33: Interaction between students and teachers during the model debugging session in % of the total duration of the lesson.

One student group had problems with the understanding of positive and negative causal relationship whilst working with DynaLearn. During Assignment 4 they used the '+' and '–' symbols wrongly, although they used the causal relationships correctly in the previous lessons. The remark in a student`s motivation questionnaire ('*In LS2 the positive-negative symbols are sometimes confused with maths symbols*') points out that these students had problems to understand the meaning of a positive and a negative causal relationship.

4.3.1.5. Assignment 5: Basic Causal Model (LS2) - Grounding

The students` task in assignment 5 was to ground several terms of a ready-made LS2 model. 24 students worked on 9 Laptops in groups of 2-3 persons for approx. 20 min. (see lesson plans in the appendix, section 8.2.2). One teacher gave a short introduction in grounding and demonstrated different groundings in DynaLearn. Two additional teachers were present in the classroom during the whole session.

As this short session was rather a strongly guided learning activity than a self-regulated learning unit, it is not comparable to the other sessions.

4.3.2. Results of pre-and post-tests BOKU

During the BOKU evaluation both, the direct/verbal and graphic causal relations increased significantly in post-tests (Tab. 4.3). This can be interpreted as an increase of causal understanding of the topic after the learning activities with DL. The increase of wrong causal relations expresses a de facto increase from 1 to 7 wrong relations. Obviously the students were not able to digest all new information, mainly provided via the recommendations from the expert model, adequately.

In the post-tests the students also use a higher number of words and they mention a higher number of concepts (keywords). The degree of abstraction increased by about 10 % as well as the clear identification 'human as driver' (by about 22 %) and the 'pressure' (by about 36 %).

The structuring of the pre- and post-test data by creating networks of the codes in *Atlas.ti* expresses graphically the numbers in the table below: difference between pre- and post-test networks of some of the students is remarkable. Examples illustrating the changes in the mental models from pre- to post-test situation of two students are displayed in Figs. 8.31-8.34 in the Appendix.

Table 4.3: Chart with comparison of pre- and post-tests results at BOKU evaluation (means of all tests, n=26).

Comparison of pre- and post-tests				
single mentions of concepts				
parameter	**unit**	**pre-tests**	**post-tests**	***change* *(in %)***
concepts, total	[n]	28,52	36,19	*26,9*
causal relation, direct/verbal	[n]	2,63	5,07	*93,0*
causal relation, graphic	[n]	1,00	2,78	*177,8*
causal relation, wrong	[n]	0,04	0,26	*600,0*
number of words	[n]	152,26	188,07	*23,5*
degree of abstraction	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	2,26	2,48	*9,8*
human as driver	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	2,44	3,00	*22,7*
pressure	rated from 1 (very low), 2 (low), 3 (medium), 4 (high) to 5 (very high)	2,59	3,52	*35,7*

4.3.3. Results of motivation questionnaires BOKU

The analysis of the 26 motivation questionnaires (see Fig. 8.23 to Fig. 8.25 in the Appendix) collected at the BOKU evaluation, involving more experienced students, shows a rather homogeneous result compared to the i:HTL (see Fig.4.34).

General appreciation: Students liked the lessons and learning activity supported by DL and they found it quite interesting to work with DL. Although the students were already well informed about the issue that was explored by DL, the activity was able to contribute to a new understanding of the system. The importance of building models in different LSs was also rated as high.

Concerning the *'**Grounding'*** and ***'Recommendation'*** functions of DL there were quite positive reactions, although the functions didn't work very properly on the evaluation day due to server problems.

Recommendation functionality: The results of the motivation questionnaires concerning **recommendation** showed students` positivity to this DynaLearn feature. Students proved with a mean of 3,96 (n=26) a positive attitude to the *'Recommendation'* functionality. They strongly agreed (mean= 3,96) that the recommendations could improve their models. The question *"I clearly understood the information provided by the feedback (recommendation)"* was answered with a mean of 3,0 that highlights that some information of the recommendation was not clear.

Grounding: Two questions in the motivation questionnaire are related to the **grounding** functionality. Students liked the grounding feature (mean=4,0; n=26) and proved the structure of the grounding window as insightful (mean= 3,61).

Virtual characters: The lowest agreement was documented regarding the **Virtual Characters**: the students didn't find them very useful for building models although they liked the fact, that there is a helping component in the form of hamsters (this was rated at least neutral or slightly positive).

Ease of using the software: Interacting with the interface of the software was not experienced as being easy, which might be also related to the lack of appropriate support by the hamsters. Although it was rated as being not so easy defining processes and rates, this result is of limited interest, as the focus of the BOKU evaluations was mainly on LS2 where no differentiation between processes, rates and proportionalities is needed. Interestingly the students rated the identification of entities and quantities as easy, although they had significant problems in building up the appropriate entity structure of the model with their associated quantities.

Simulations: The possibility to run simulations was highly liked, and the possibility to run simulations provided the students with a better understanding of system behaviour.

Learning by modelling: DL was positively experienced as a new and interesting way of learning. As it was the case at the iHTL evaluation, DL software was judged as neutral in supporting students to learn by themselves. The process of modelling itself was not seen very positively related to the motivation to learn more about the phenomenon.

4.3.3.1. Criticism and proposed improvements by students (individual statements)

Students gave the following remarks / proposed improvements in the motivation questionnaires:

What did they like?

Software handling and simulation

- Simulations show how things are connected, they help to understand changes in the system and show the effects of an action and the changes in other parameters immediately.
- Easy way to think how a system works and to understand complex situations and those small changes can affect a change of a whole system.
- To see how the factors influence each other.
- Individual and cooperative working possible, better understanding of system parameters.
- Better understanding of relationships in a system.
- Structure/composition of lesson.
- SW forces to think about the relationships of a system.
- You can use your own knowledge for modelling and creation of one's own knowledge model.
- Visualisation of interactions, easy use, overview of a system.

Virtual characters

- They are perfect for school kids.
- The stupid and funny look of the hamster and the voice.
- They help to understand the software.
- Combination of voice and text.
- Later I know what to do and then I understand the VC better.
- Generally, some of the students liked the VC, and that they could read and listen to them, but the VC were sometimes a bit slow or didn`t work properly.
- Short and good answers to the most important basic questions.
- It`s important for advanced users that it doesn`t appear all the time. But it is important to make it easier that it appears! Just a click on a button.

What did they dislike / find complicating and are there suggestions for improving the features?

Software using and simulation

- Many students reported that they didn't understand the difference between entity and quantity and how to connect them. The *'Basic help'* provided only information how to create an entity and doesn`t say what it is.
- Simulations should be more colourful, the differences should be pointed out more clearly and in a more obvious way.
- In order to run the simulation you have to link the entities and quantities, already understanding and knowing them, so the effects in the simulation were not a surprise.
- In LS2 the positive/negative symbols seemed to be confusing with mathematic symbols.
- It's difficult to get started – in the software and in modelling process.
- The different handling and user interface compared with Microsoft software (e.g. left-click on mouse, etc.)
- Installation process was quite complex and challenging.
- Finding mistakes in models.

- When you add a new entity/configuration/quantity it should immediately say "new…", because now sometimes replaced the names of other elements by adding a new one.
- Model can get very messy, it should be shown how to collapse and expand parts of your model.
- How to start a model is lacking; first steps should be provided in the new software.
- Buttons are not really clear, clearly arranged and self-explaining.

Virtual characters

- The help from the VC isn`t always self-explanatory and I think circuitous.
- Some video tutorials maybe helpful.
- A general description, how to use program, would be good.
- I didn`t need the hamster. Best way of learning is learning by mistakes/doing.
- They should explain more graphically.
- It would be better, when you can select a symbol and then I click on the VC → the character should explain the symbol. I often don`t know where I should look to find the correct explanation.
- The sense or the goals of certain functions are not really well/clearly explained.
- It didn`t show you the first steps which should be normally easy, but it took often more than 5 minutes to get through an easy task to delete a wrong placed arrow.
- They don`t allow for an explanation of what a part of the software is: what is a quantity? Why should I link it like this? What function for the buttons would be good? etc.
- Sometimes it is difficult to understand the answers (if you don’t know the system).
- Maybe a classic help-box would be more sufficient.
- They should explain in a more detailed way.
- It would be nice to have a possibility to point at something to get it explained.

Grounding

- It takes time to understand the system behind.
- It should be possible to use pictures.
- The box where you can read the stuff should be bigger or at least you should be able to close the size of it by "dragging".
- You should be able to correct the definitions you put in yourself, instead of only adding.
- It should be more clearly visible if grounding information was written by you or it is from a server/”official or professional source”. And it should be possible to edit the information.

Recommendation

- Maybe it could also show how things are connected. But this might lower the learning effect?
- I`m not sure if it is necessary to provide configurations at the "missing words" part; maybe only entities and quantities?
- There should be more explanation on what the proposed new term means. When you should learn by this program means that you encounter terms you don`t know.
- More precise recommendations instead of general list; that would be more effective.

- Opportunity to add missing entities/quantities automatically → add all
- The recommendation does not understand or consider that everybody builds another system/model.
- Misinterpretation of own model elements by the recommendation; and the software suggested responses in that context suggesting changes that are not insightful.
- Variables should be described differently to make them and their connection easier to understand.

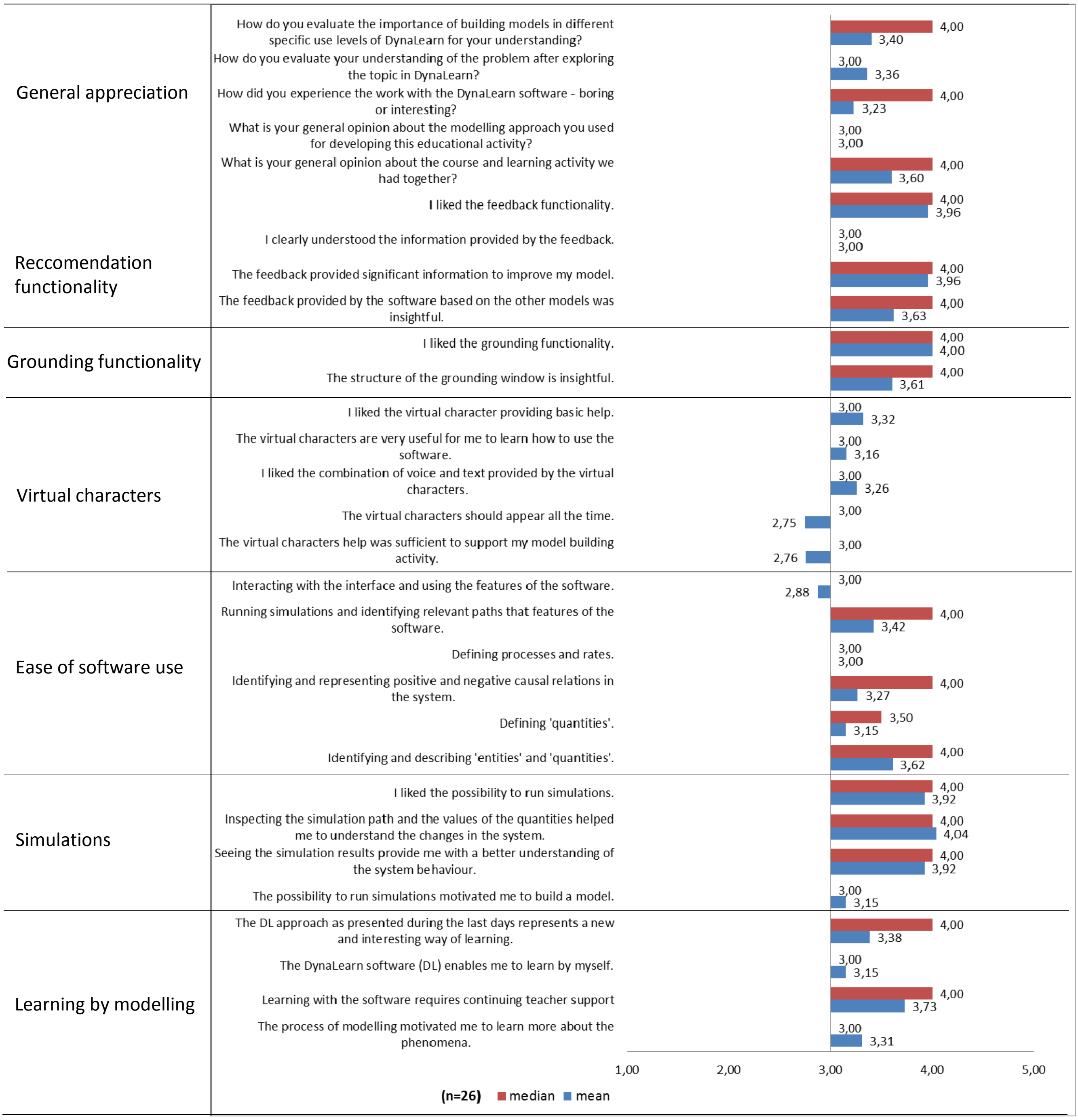


Figure 4.34: Mean and median rating values of the 30 questions (of altogether 39) of the evaluation questionnaire at the BOKU evaluation (1=very negative, 3=neutral, 5=very positive).

4.3.4. Impressions as evaluator

General impressions

- In principle they liked the modelling process.
- They liked the presentation and the way things were introduced.
- Generally high interest of students to learn something new, to look at a topic in a different way, to highlight causal relationships.
- The engagement of the students was quite heterogeneous (some only did what was shown, others started to extend the models by their own) → partly maybe because of the group size, otherwise they were put off by the whole 'technical process' of installation, getting into a new software, etc.
- Some were hard to motivate to develop models by themselves; they simply rebuilt what was shown on the screen and stopped then doing other things.
- It was good to have two afternoons for evaluation to really work through different LSs and cope with different software features.
- The modelling process initiated profound discussions with professor/evaluator.
- Most interested in the approach seemed people that already had modelling experience and/or a profound knowledge on the topic (PhD students); they really had fun with finding ways to express their knowledge.
- Compared to last year's evaluation, it seemed that the students had fewer problems handling the software and were much more discussing on thematic topics and content (maybe also because of the limited time in last year's evaluation).

Installation process

- The installation worked quite fine with most of the students → the installer is a helpful tool anyway. There were some questions about info of the version of the operating systems. Nevertheless, the installation process took more the 1 hour and some of the students were not able to do it by themselves.
- There were many questions about the step (in the installer) where to download and copy the jSmile files seems not really self-explaining → they did not realise, what they should do with the downloaded files and didn't click to the next step: maybe downloading and copying should be one step or it should be explained explicitly.
- On some laptops with MS Windows 64bit versions there were problems/conflicts with starting the MaryTTS server.
- There were several problems with changing the installation path in the installer → error message, that the directory cannot be written; in some cases the workaround with creating a folder manually and refer to this folder in the installer was successful, in some cases that procedure was not possible either and you could only choose the folder proposed by the installer. Maybe this is also a MS Windows 64bit problem?

Using the software

- Generally, the use of the software does not seem to be as self-explaining as it should be. In many cases also the hamsters didn't really help; especially in situations where the students wanted to know more about meaning and duty of software elements and not just where they can be found or how they can be added.

- For many students the difference between entity and quantity was not self-explaining.
- In contrast causal relations and state values seemed to be quite self-explaining.
- Students had big troubles to proceed from LS1 to LS2
- The + and – notation in causal diagrams and at P`s and I`s were sometimes not intuitively understood. Here further clear support should be provided by the software.
- Maybe it would be quite useful and helpful to have a help-button in the software to get some basic help "how to start a LS", etc. or just to link to the tutorial videos on the homepage (but these should be presented more prominently on the project homepage - not under 'publications' but under software).
- Probably due to the use of a developing and not final version of the software *'Recommendation'* server in Madrid crashed; only 5 out of 10 recommendations worked.
- *'Recommendation'* window was not insightful for many of the students.
- Some recommendation results were wrong.
- The grounding worked correctly.

Typical modelling mistakes and questions by students

- Why different entities or quantities cannot be linked?
    - Answer: In most cases only one, or more than one was selected
- There were many questions about why there is no "return"-button.
- Many students also asked why it is not possible to copy certain elements, e.g. from one model to the other.
- Accidental re-naming of the quantity or configuration definition because they didn't click the „add new"-button.
- Some did not find the button for creating a new model.
- Some liked to change colours or sizes of the representation for a better overview.

4.3.5. Results of final BOKU exam

The analysis of the test results of the final exam of the 25 participating DL evaluation students showed, that the topic explored with DL (questions 5 and 7; vertically striped bars in blue, Fig. 4.35) were amongst the best graded questions. That indicates the highly satisfying and 'very good' understanding of the topic explored with DL in comparison to other comparable questions of the remaining course (filled blue bars).

As for some questions (indicated by the diagonally striped bars in black) only some single facts had to be memorized, they are considered as not being directly comparable to the other questions, requiring a deeper and broader understanding of the involved entities and processes.

The direct comparison of the exam results according to participating and non-participating students of the DL evaluations at the BOKU (green vs. blue bars in Fig. 4.35) showed that in the two DL related questions the participating students reached around half a point better grading compared to those who did not follow the DL evaluation, yielding the biggest differences between the two groups for these questions. In most of the remaining questions there were no significant differences between these two groups. In principle, both student groups had access to the same learning material provided on the institute's web page.

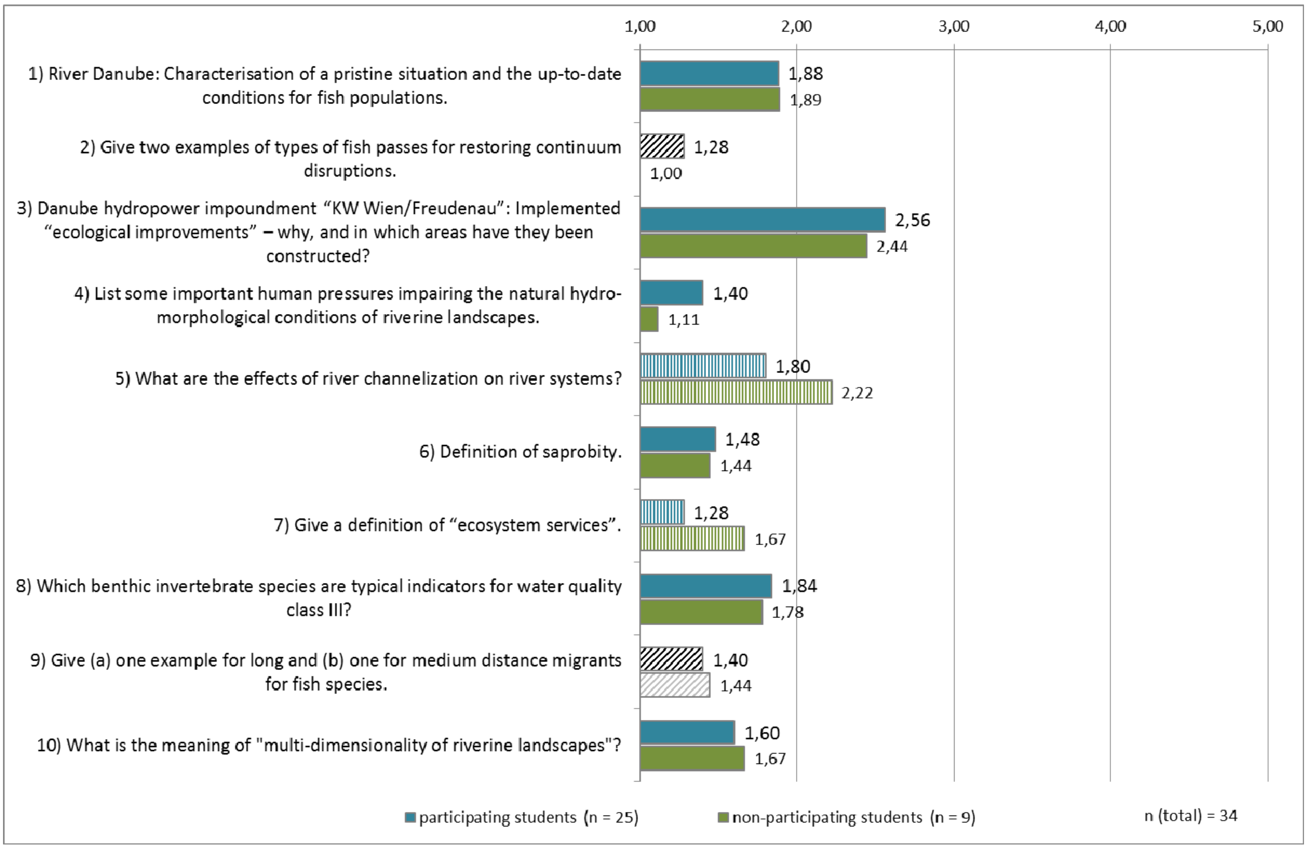


Figure 4.35: Mean grades (1 = very good, 2 = good, 3 = average, 4 = adequate, 5 = unsatisfactory) achieved per question at the final exam of participating and non-participating students (vertically striped bars represent the topics explored by DL, filled bars represent comparable questions of similar complexity, and the diagonally striped bars in black represent questions that are not comparable because they were asking for some single facts.

5. Stakeholder evaluations

In addition to the evaluation sessions at the school and the university we had the possibility to present the DL project as well as the software to stakeholders at the Environmental Education Forum Austria, and the V/3 section of the Austrian Federal Ministry for Education, Arts and Culture, IT-Systems for in Education, and at a workshop of the "Education Group", an initiative of and a platform for teachers in Upper Austria concerning pedagogical and technical support for IT in education.

5.1. Forum Umweltbildung

The BOKU team presented the DL software at the Environmental Education Forum on February 22nd 2011 from 15:00-17:00 (with discussion until 17:45).

Participating persons: Andreas Zitek und Michaela Poppe (BOKU, Vienna); Markus Langer (Business Manager of E.E.F.), Wolfgang Sorgo, Anita Zrounek, Karin Schneeweiss, plus one practicant (all working at Environmental Education Forum).

This afternoon yielded the following results:

- There was scepticism that DynaLearn could be applied in normal classroom settings.
    - Special settings for the use of DL in school were discussed as only opportunity, e.g. project weeks etc.
    - How could a non-expert use the software without training? So training and experts on applying DL seem to be required for any use in classrooms.
    - Furthermore they were not able to imagine how to organize the software installation on school PC`s practically (it would take a significant amount of time for one person to install the software on 25 PC's in a computing room).
- They asked for the accompanying didactic material, to support and guide interested teachers with their activities with DL, for giving the whole approach a chance.
    - The material should give a clear picture, how learning activities with DL look like, giving clear ideas on settings needed etc.
    - The didactic material should be based on profound expert knowledge and linked to the existing educational frameworks.
- This also links to issues of the target population, pointing out the consideration of different age classes from a pedagogical view. How to deliver content for different age classes? Are there "rules" out there?
- We were asked several times, which age classes we want to address. Our answer was 10-14, 15-18 and 19-24, as in principle DL is scalable with the accompanying didactic material (and the use/not use of hamsters).
- The hamsters were not very well accepted, the voices were not liked. It was suggested that they could be only useful for learners from 10-14, for which they considered the software being too complicated.

- They were afraid, that other existing educational knowledge of successful (environmental) education is not considered in the DL approach (the role of personal contact, communication, emotions for the environment and contact with the environment).

- Furthermore they were a bit afraid of the potential manipulative power of 'expert' models, and the whole approach. They mentioned IBM and other people who might want to establish certain programs in education for specific reasons

    - here DL clearly needs objective judgement and critical discussion with people, institutions and partners already involved in designing school education and performing/developing quality standards.

- Provision of material via the moodle platform was discussed as a means to provided didactic material for integration in classroom activities for interested teachers.

- Although they run many projects by themselves (games in physics teaching, etc.) and our approach seemed too complicated to them, which could be in principle overcome by training of teachers, special settings and accompanying didactic material. But they were not very enthusiastic about that.

- It seems to be of crucial importance to link new ideas like DL to local educational institutions/partners already involved in designing school education and performing/developing quality standards.

From a technical perspective the following aspects seem to be noticeable:

- The grounding and the OBF worked fine (although some additional quantities appeared in the uploaded expert model of the presenter when asking for *'Recommendation'* from it).

- Some questions were asked about:

    - How is DBpedia created from / linked to Wikipedia? Which content is abstracted from there?

    - Where are the anchor terms saved? The anchor terms are not added to DBpedia, but stored at a different place - which means that the OBF searches DBpedia and this other source.

    - How does the OBF (missing entities, quantities) deal with spelling issues of terms (mistyping)?

- The hamsters still sometimes did what they want - appear, not appear, voice, no voice,...

Summarizing it can be concluded that for a successful implementation of DL in classrooms we need:

- A clear picture of how DL activities can be linked to existing educational activity of science education in class rooms; science education is much more than using DL.

- Didactic material embedding DL in an overall strategy of science education with a clear description of the setting in which it can be used. The material has to be clearly designed for different age classes to be addressed.

- Training material/courses for teachers how to work with DL - teacher involvement is the key.

- Involvement of existing educational initiatives planning and managing school education and setting quality standards in different countries for official acceptance and visibility - for this we need point 1 and 2 (didactic material and teachers willing to use this approach).

- Easy installation of the complete software package without annoying bugs on different computer systems.

5.2. Federal Ministry for Education

DL was presented at the Austrian Federal Ministry for Education, Arts and Culture (http://www.bmukk.gv.at/schulen/index.xml) at 22.3.2011 from10:00-12:00. Aim of the meeting was the discussion of the possibilities to establish DL in schools.

Participating persons: Dr. Reinhold Hawle, Leader of Dep. V/3, IT-Systems for Education, Schaller Michaela, Bock Andrea (Ministry); Andreas Zitek, Michaela Poppe, Michael Stelzhammer (BOKU, Vienna).

Dr. Hawle was very enthusiastic about the potential of DL, especially with regard to the possibilities of individualized and science oriented learning, and invited us to present DL at the 'Gegenstandsportal'-meeting of the Education Group Austria[7] in Wels on May, 3 2011. The aim of this presentation should be the discussion of the development of learning materials for different teaching domains with educational people in Austria, and to get access to teachers interested to apply IT in education.

5.3. Education Group

The BOKU Team presented DL in form of a Power Point presentation followed by a short demonstration of model building in LS 2 and LS4 including simulations at the meeting 'Gegenstandsportal' of the Education Group Austria[8] in Wels on May, 3 2011. The meeting was participated by representatives of the Ministry of Education and teachers, all dealing with IT at school (e-learning). In total about 30 persons were present.

The 'Gegenstandsportal'[9] represents an online platform that provides IT based learning units for different subject-matters.

The idea was to discuss potential ways, to disseminate DL among the teacher community interested in the application of IT in education. About 15 % of the teachers in Austria are known to actively use the "Gegenstandsportal" providing IT based learning activities.

The main results of the discussions were:

- There was great interest for using techniques like DL for the systems based exploration of different topics.
- DynaLearn activities must be provided as ready-made learning blocks, as teachers do not want to do additional preparations for these activities.
- Reliable background information for different subject matters needs to be linked to defined learning activities with DL according the competence matrix for environmental education in Austria.
- The software should be web-based, as the need for on-site installations and maintenance are known to be one of the biggest problems limiting software applications in schools.
- If we are able to provide these ready-made learning activities with DL, and a software that is approved, they could be easily put online on the 'Gegenstandsportal' linked to the corresponding subject-matters.

[7] http://edugroup.at/
[8] http://edugroup.at/
[9] http://www.eduhi.at/gegenstand

6. Summary and conclusions

The evaluations of the prototype of the DL software primarily aimed at providing information on

- usability and problems learners encounter with the software. This will help to focus *'Basic help', 'Diagnostic feedback', 'Recommendations', 'bug repair'* etc.
- functionality and appreciation of *'Basic help'*, *'Recommendation'* and '*Grounding'*.
- efficiency of different pedagogical strategies and design strategies for learning units
    - to support self-organized learning, e.g. provision of assignments via the moodle platform
- appreciation of the software by students and their impressions and potential ideas for increasing usability,
- changes in knowledge and knowledge structure influenced by the activities with DL,
- possibilities for the application of DL in Austrian schools.

In the following section the main results and conclusions of the evaluation of the versions 0.8.2 and 0.8.8 of the DL software are summarized.

6.1. Modelling

6.1.1. Results

Problems in defining *'Entities'* and *'Quantities'*.

Problems in realizing the differences between *'Direct influences'* (I`s) and *'Proportionalities'* (P`s).

The meaning of *'Agents'* and *'Conditions'* was mixed up.

Model building strategies at different LSs not clear for students.

Students were able to identify a LS2 model from a textual description via the elements needed to implement the text in a model.

Students reported that the software requires continuing teacher support.

6.1.2. Conclusion

Software is not self-explanatory with regard to model building. Meaning and function of different modelling elements need to be introduced carefully. Once students have understood the opportunities the different LSs provide, they should be able to decide which LS is most adequate for their model based on textual assignments.

6.1.3. Action

Careful introduction of the different modelling elements, especially the nature of *'Entities'* and *'Quantities'*, the use of I`s and P`s and different model building strategies on different LSs by the teacher.

Advancement of *'Basic help'*, providing generic information (an introduction) which elements are available, and which kinds of models can be built at each LS (probably some videos). Furthermore typical modelling patterns should be described by the *'Basic help'*.

6.2. Basic help

6.2.1. Results

'Basic help' rarely supported the flow of modelling of students.

It was not sufficient to support self-oriented model building of students, no *'What is…'* entity etc. question available, no question *'How to build a model at LSx'* available, no information on the different model building strategies on different LSs.

Using the *'What is'* question, students were expecting feedback from Wikipedia, not only a repetition of the name of the element together with its obvious relationships.

Students were not able to set a conditional statement at LS5 based on the support provided by the software because there was no '*How to add a conditional statement'* help available.

Students criticized, that only obvious things were provided by the *'Basic help'*.

One teacher, especially at the BOKU evaluation with about 25-30 students, proved not be enough for providing the support needed, which was evaluated by the total time needed to give support during different assignments.

Diagnosis of simulation bugs was tried to be conducted using *'Basic help'.*

6.2.2. Conclusions

'Basic help' insufficient in the current form to successfully support model building of students.

'What is' related to the basic model ingredients is lacking, and also wrongly understood by students, who expected an explanation from Wikipedia.

Teachers need to be well prepared for giving feedback and supporting modelling, and represent an indispensable source of guidance and support.

However, *'Basic help'* needs to be improved significantly to reduce the support need from teachers; in normal class situations only one teacher will be available, which proved not to be enough for giving the support needed by 25-30 students in the current situation.

Need for *'Diagnosis'* was pointed out.

6.2.3. Actions

Basic help should provide generic information (an introduction) which elements are available, and which kinds of models can be built at each LS. Furthermore typical modelling patterns should be described.

Basic help should also provide information on *'What is an entity'* etc. and more interactive help is needed to guide the modelling process.

The '*What is*' question should provide more knowledge about the selected element in the model, and its relevance (from Wikipedia, etc.), not only a repartition of its name and type of element with its obvious relations.

'How to' add a conditional statement is one example of an important help feature that needs to be added. *'How to build a model at LSx'* should be added.

Teachers need to be trained in the support and scaffolding that is still needed from their side.

Implementation of *'Diagnosis'*, especially to find the reason for simulations producing not the desired behaviour. This might contribute to significant learning.

6.3. Virtual characters

6.3.1. Results

BOKU students and expert evaluators had concerns about the hamsters, especially with regard to the older target communities.

6.3.2. Conclusions

Hamsters not adequate for university students, and probably for students older than 16/17 years.

6.3.3. Actions

Hamsters should be only used at appropriate, especially younger age classes, and not at university level.

6.4. Recommendation

6.4.1. Results

In general the *'Recommendation'* function was liked by the students, and especially the recommendations with regard to missing entities and quantities based on ontology matching using a single model for *'Recommendation'* had a significant effect on the quality of the student models.

Students were able to add missing *'Entities'* and '*Quantities*' relatively quick to their models.

On the other hand the *'Recommendation'* window was experienced as not insightful enough.

'Recommendation' was also very slow.

Useful recommendations on the entity structure and causal relations were lacking.

6.4.2. Conclusions

'Recommendation' works for missing *'Entities'* and *'Quantities'* when ontology matching is used, but was insufficient to provide more useful information (e.g. on causal relations and the entity structure).

'Recommendation' window not insightful enough, *'Recommendation'* too slow.

6.4.3. Actions

'Recommendation' functionality should provide clear information on the model structure (*'Entities'*, causal relations etc.), and the clarity of *'Recommendation'* window should be improved. Speed of *'Recommendation'* process needs to be improved.

6.5. Grounding

6.5.1. Results

The *'Grounding'* function was liked, but students requested lots of possible improvements. The ranking of the terms was not insightful and practical. Still some information provided by the *'Grounding'* window was unclear (anchor terms, other models that also used that term etc.)

6.5.2. Conclusions

Structure and information provided in *'Grounding'* window still insufficient

6.5.3. Actions

Improvement of *'Grounding'* window, search function for terms, clear description of anchor terms, and models using this terminology.

6.6. Learning by modelling

6.6.1. Results

Causal understanding increased significantly.

Use of terminology and vocabulary changed towards more scientific vocabulary.

'Recommendations' from expert model significantly improved learner models.

Wrong causal relations increased from pre- to post-tests at BOKU.

Using the *'What is'* question, students were expecting feedback from Wikipedia, not only a repetition of the name of the element together with its obvious relationships.

The software did not strongly support students to learn by themselves and did not motivate them much to learn more about the topic (which was reported by the motivation questionnaire).

Self-organized model building proved to be complicated for students.

6.6.2. Conclusions

Different DL functions support causal understanding and learning well.

Misconceptions might occur, when the time for digestion of new knowledge is too short (BOKU evaluation).

'Basic help' still not sufficient, software still not motivating enough. *'What is'* question not supportive.

6.6.3. Actions

A generic model building strategy will help students to re-apply their modelling competences, and support their self-learning capabilities.

Significant improvement of the *'Basic help'* function to better guide and scaffold the modelling activities.

Some more motivating, knowledge based features should be implemented. This could be a link of the '*What is'* question to more knowledge about the selected element in the model, and its relevance.

It makes sense to introduce the benefit of such kind of modelling activities for the students, and the need for conceptual understanding in science.

Careful design of learning units, to achieve the targeted development of modelling competences, the use of domain vocabulary and knowledge.

6.7. Design of learning units

6.7.1. Results

Students had severe problems to distinguish between *'Entities'* and '*Quantities'*, and using I`s and P`s.

Modelling patterns on different LSs were not easy to understand.

'Recommendations' from each other's models was very motivating.

Learning between different LSs occurred

Moodle provided a good platform for providing assignments.

Significant improvements of knowledge could be achieved by a combination of diversified learning activities and assignments involving the internet as information source.

The different functionalities of DL (*'Conceptual Modelling'*, *'Recommendations'*, *'Grounding'*, simulations, etc.) should be applied wisely for specific learning targets.

Types of learning (individual, groups) and social interactions should be also considered in advance.

Temporal needs for specific learning activities need to be considered carefully.

The teacher represented an important source of information and was strongly needed to give modelling support.

Time was sometimes too short to complete the model building activity at LS1 and LS2 with *'Recommendations'* and *'Grounding'*, especially at the BOKU session (two afternoons).

Three days of modelling were insufficient to introduce generic modelling patterns and all possibilities from LS1 to LS5. LS 6 was not considered during the evaluations so far.

6.7.2. Conclusions

Need for a clear introduction in the modelling primitives available in DL.

Model building in LS1 (probably because of its semantic structure) was found to provide an important possibility for students to familiarize with the software. Students lacking the LS1 experience needed significantly more time to use LS2, even at a university level.

Especially a good modelling practice with regard to the definition of entities (hierarchy theory) and quantities and the use of I`s and P´s is needed.

The design of the learning activity affects the social interaction.

Design of learning activities should be diverse, to keep the engagement of students high.

The internet as information source should be included.

The teacher is indispensable, and always needs to have a clear picture of what should be achieved by the different activities.

Time needed to develop modelling skills with DL is significant and usually not available during normal school settings.

6.7.3. Actions

LS1 activities should be always used at the beginning of lessons to familiarize modelling novices with the software.

It makes sense to introduce a good modelling practice with regard to entity and quantity definition very early, even before LS2 modelling activities.

The use of generic modelling patterns at different LSs should be presented, as this might significantly improve the potential of students to become independent modellers.

Modelling activities should be designed in a way, to lead the students from strongly guided model exploration/building mode to a more independent mode.

At higher LSs (LS4-LS6) a strongly guided modelling activity should be provided first, before students should re-apply this competence by their own in an increasingly independent mode.

Opportunities for student interactions, e.g. by exchanging model information via *'Recommendation'*, and discussing the differences, should be provided.

Specific learning targets (with regard to modelling and with regard to domain knowledge) need to be defined and modelling activities designed accordingly.

Temporal aspects of individual learning units, the desired learning and modelling mode, the desired learning outcome need to be carefully considered.

Clear material with regard to the development and use of learning units for teachers needs to be developed.

Teachers need to be trained with regard to scaffolding and support that should be provided by them.

Temporal needs to develop simple independent modelling skills from LS1 to LS5 are significant. A minimum of about 10 school days of modelling at different LSs is probably needed to introduce and practice modelling at different LSs (LS1 to LS5). A good modelling practice and adequate learning activities (from strongly guided exploration and replication mode to a more self-organized modelling mode) will help students to become independent modellers. After about ten days students should be able to work more or less independently on simple modelling tasks from LS1 to LS5.

6.8. Application in classrooms in Austria

6.8.1. Results

In general there is the possibility to introduce new learning environments in Austrian schools via an existing e-learning platform relatively easy.

Ready-made learning units with minimal effort for the teacher are required.

There were concerns about the quality and potential manipulative power of expert models

However, the modelling activities especially at BOKU with about 30 students required significant support from 2-3 teachers.

Teacher workshops are seen as the basis for any successful application.

Software installation is still challenging, and the web based semantic technology still too slow and buggy.

6.8.2. Conclusions

DL in its current form cannot be broadly implemented in schools. However, there is a chance for implementation in specific settings. Workshops for interested teachers need to be conducted and ready-made learning activities need to be provided.

DL and its features, as well as the models need to be transparent in their quality and functionality.

'Basic Help' provided by the software needs to be much more supportive and pro-active guiding students through their learning activities.

6.8.3. Actions

Development of ready-made learning units addressing specific target community, and linked to subject matters and local teaching plans. Clear description of learning/modelling goals along with description of temporal needs for each learning activity.

Quality of models and links to scientific literature needs to be clearly documented.

A background document needs to be produced, that contains all the important information of how DL and its functions can be used in learning activities, together with a short description of the different functionalities (User Management, User Rights, Course development, Use of Repository, *'Basic help'*, '*Virtual character'* functions, *'Recommendation'*, *'Grounding'*, Anchor term definition etc.). This document should provide the transparency needed for an educational software for its official application in schools.

It makes sense to develop learning activities according to the Austrian competence matrix for environmental education.

Development of a web based version of DL.

Significant improvement of the *'Basic help'* function to better guide and scaffold the modelling activities.

Improvement of the speed, stability and insightfulness of the web-based features (*'Recommendation'*, *'Grounding'*) of DL.

7. References

ABERNETHY, M. A., HORNE, M., LILLIS, A. M., MALINA, M. A. & SELTO, F. H. 2005. A multi-method approach to building causal performance maps from expert knowledge. Management Accounting Research, 16, 135-155.

DRESNER, M. & ELSER, M. 2009. Enhancing science teachers' understanding of ecosystem interactions with qualitative conceptual models. Teaching Issues and Experiments in Ecology, Vol. 6: Research (online source).

FELLOWS, N. J. 1994. A window into thinking: Using student writing to understand conceptual change in science learning. Journal of Research in Science Teaching, 31, 985-1001.

GLASER, B. G. & STRAUSS, A. L. 1999. The Discovery of Grounded Theory: Strategies for Qualitative Research, Aldine Pub.

GRACIA, J., TRNA, M., LOZANO, E., NGUYEN, T. T., GÓMEZ-PÉREZ, A., MONTAÑA, C. & LIEM, J. 2010. Semantic repository and ontology mapping. DynaLearn, EC FP7 STREP project 231526, Deliverable D4.1.

KINCHIN, I. M., HAY, D. B. & ADAMS, A. 2001. How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development. Educational Research, 42, 43 - 57.

LEWIS, R. B. 2004. NVivo 2.0 and ATLAS.ti 5.0: A Comparative Review of Two Popular Qualitative Data-Analysis Programs. Field Methods, 16, 439-464.

LOZANO, E., GRACIA, J., GÓMEZ-PÉREZ, A., LIEM, J., VAN WEELDEN, C. & BREDEWEG, B. 2010. Ontology-based feedback on model quality. DynaLearn, EC FP7 STREP project 231526, Deliverable D4.2.

MAVROU, K., DOUGLAS, G. & LEWIS, A. 2007. The use of Transana as a video analysis tool in researching computer-based collaborative learning in inclusive classrooms in Cyprus. International Journal of Research & Method in Education, 30, 163-178.

RICH, P. J. & HANNAFIN, M. 2009. Video Annotation Tools. Journal of Teacher Education, 60, 52-67.

ROBERTS, C. W. 2000. A Conceptual Framework for Quantitative Text Analysis. Quality &Quantity, 34, 259-274.

RUIZ-MALLEN, I., BARRAZA, L., BODENHORN, B. & REYES-GARCIA, V. 2009. Evaluating the impact of an environmental education programme: an empirical study in Mexico. Environmental Education Research, 15, 371-387.

STRAUSS, A. L. & CORBIN, J. M. 1998. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, Sage Publications.

WANG, S.-K. & REEVES, T. 2006. The Effects of a Web-Based Learning Environment on Student Motivation in a High School Earth Science Course. Educational Technology Research and Development, 54, 597-621.

WIßNER, M., HÄRING, M., BÜHLING, R., BEEK, E., LINNEBANK, F., LIEM, J., BREDEWEG, B. & ANDRÉ, E. 2010. Basic Help and Teachable Agent. DynaLearn, EC FP7 STREP project 231526, Deliverable D5.3.

ZEYER, A. 2010. Motivation to Learn Science and Cognitive Style Eurasia Journal of Mathematics, Science & Technology Education 6, 123-130.

Online sources

http://edugroup.at (Education Group GmbH)

http://elsa20.schule.at (eLSA – eLearning im Schulalltag)

http://umweltbildung.at (FORUM Umweltbildung)

http://www.atlasti.com (Atlas.ti – qualitative data analysis software)

http://www.ihtl.at (International HTL Bad Radkersburg, Austria)

http://www.transana.org (Transana - Qualitative analysis software for video and audio data)

8. Appendix

8.1. Questionnaires, assignments and other support material

8.1.1. i:HTL Pre- and post-test questionnaire

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Test questionnaire

Please describe all questions in as much detail as possible!

1.	Please explain the principle of nuclear radiation?

2.	How is energy produced in nuclear power stations?

Figure 8.1: First page of the pre- and post-test used at i:HTL.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

3.	Describe the principle of two types of nuclear power plants.
4.	What emissions of nuclear power stations might cause problems for the environment and humans? Where are they created in the power plant?

Figure 8.2: Second page of the pre- and post-test used at i:HTL.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

5.	Why are the emissions of a nuclear power station, especially in case of an accident, so problematic for humans?
6.	Do you know strategies to avoid the negative effects of nuclear emissions in case of an accident? Please, describe the principle behind that strategy.

Figure 8.3: Third page of the pre- and post-test used at i:HTL.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

7.	What is the unit in which the biological effect of nuclear radiation to humans, animals and plants is measured? Is there natural nuclear radiation occurring? Are there benchmarks describing the amount of radiation causing negative effects on humans?

THANK YOU!!!

Figure 8.4: Fourth and last page of the pre- and post-test used at i:HTL.

8.1.2. BOKU Pre- and post-test questionnaire

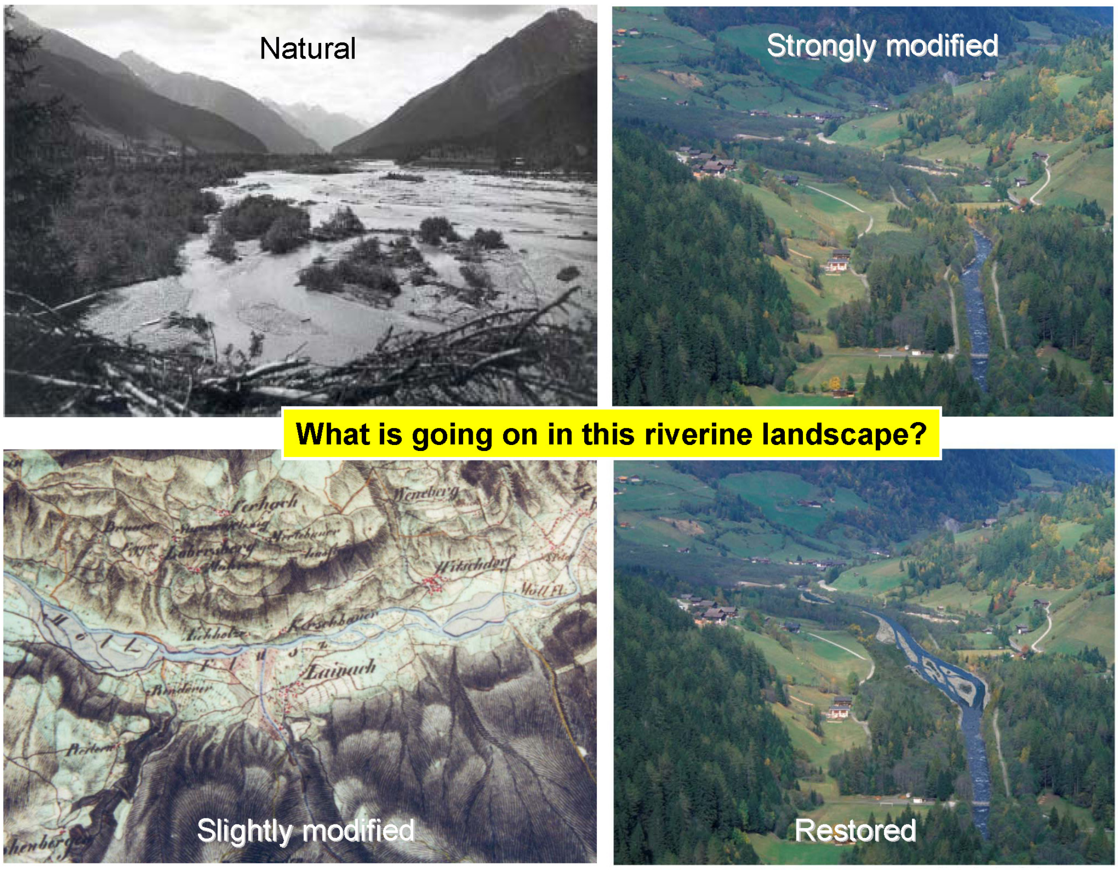


Figure 8.5: Pre- and post-test of the BOKU evaluation lessons.

8.1.3. i:HTL evaluation introduction

LS 1

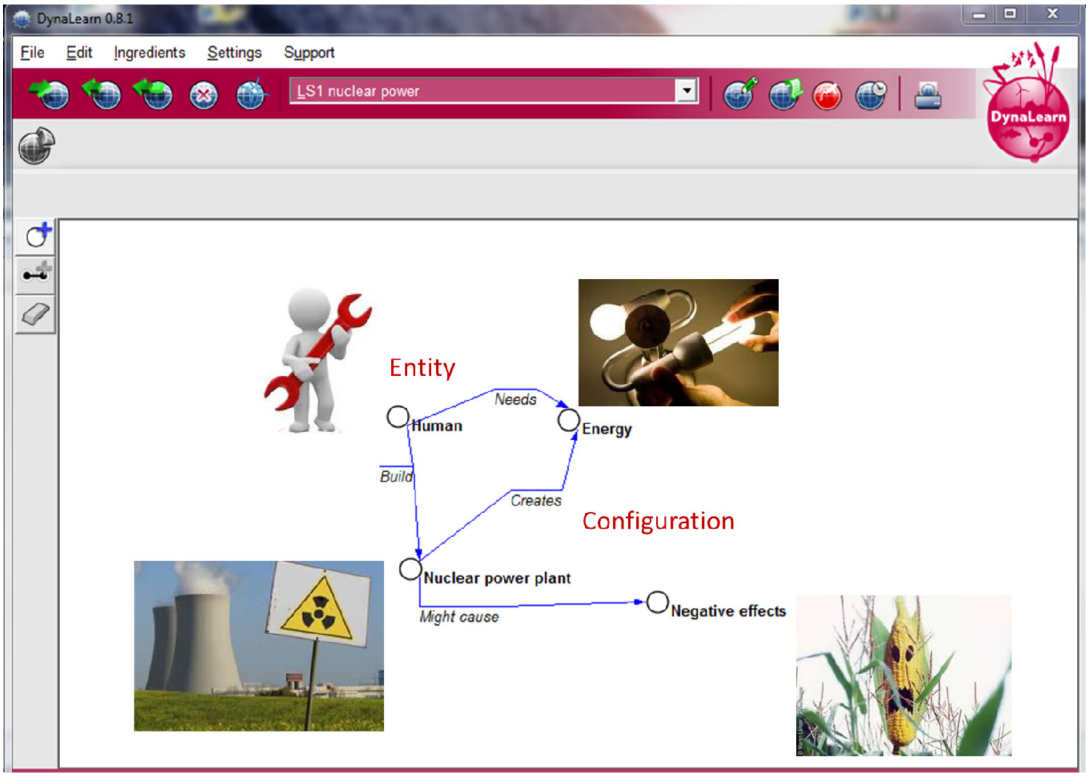


Figure 8.6: The world in DynaLearn, Learning Space 1.

LS 2

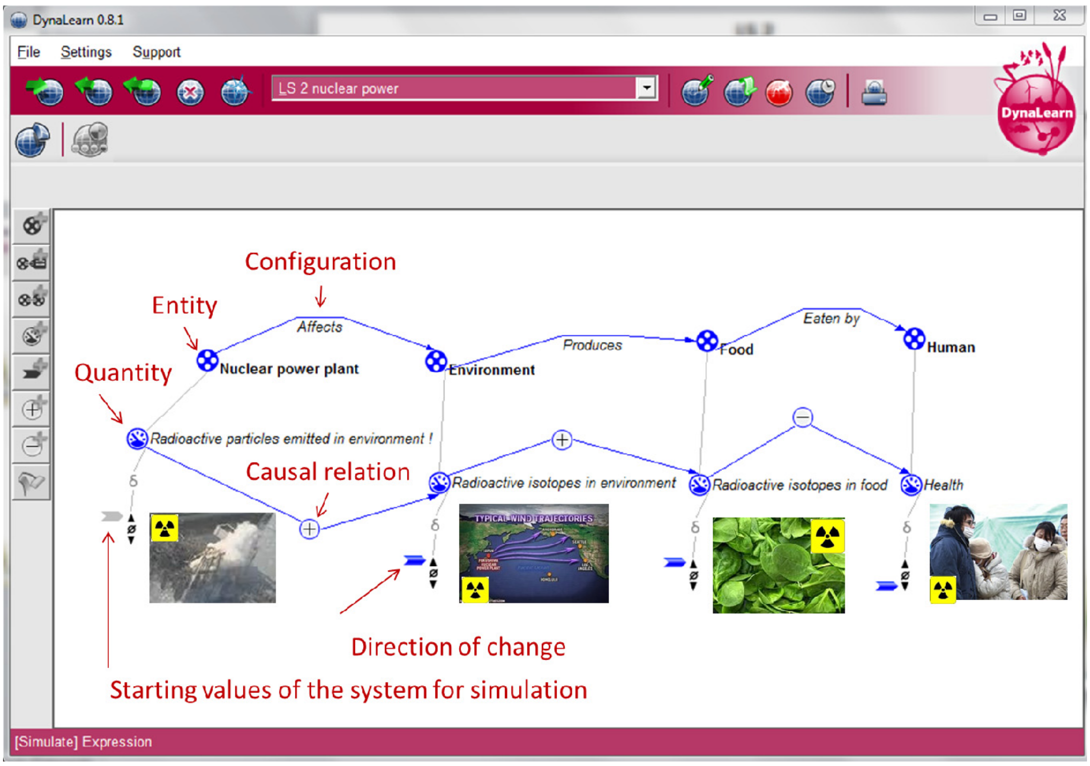


Figure 8.7: The world in DynaLearn, Learning Space 2.

LS 3

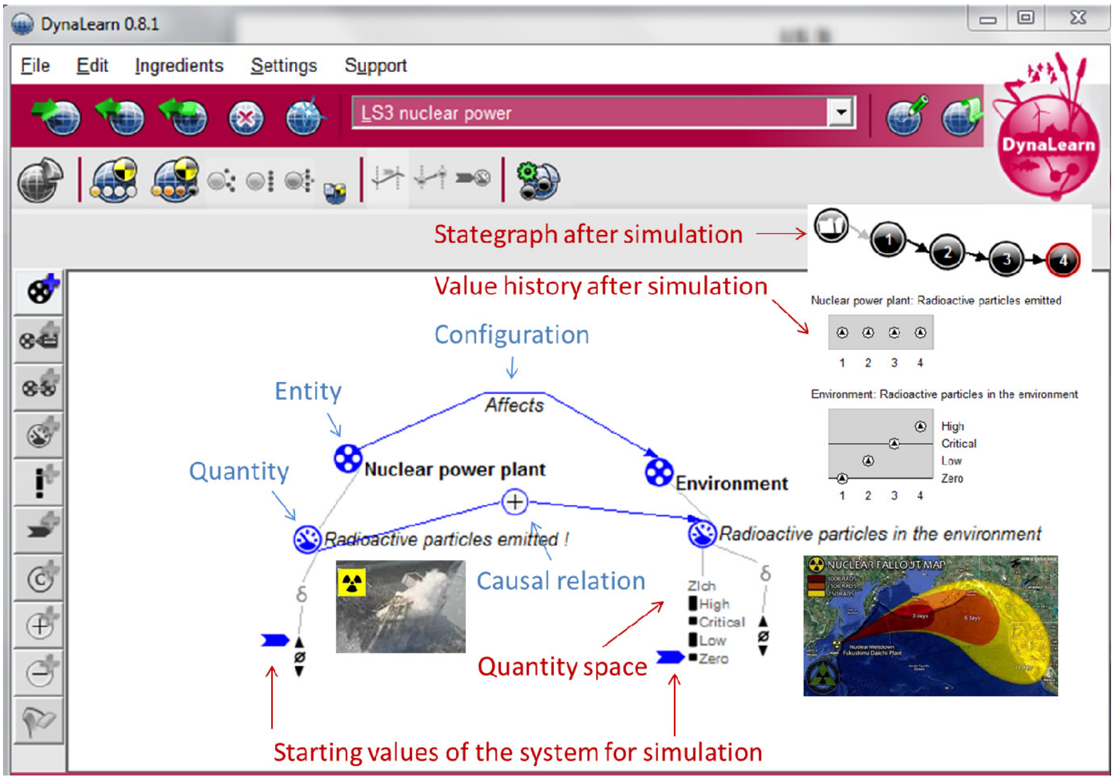


Figure 8.8: The world in DynaLearn, Learning Space 3.

LS 4

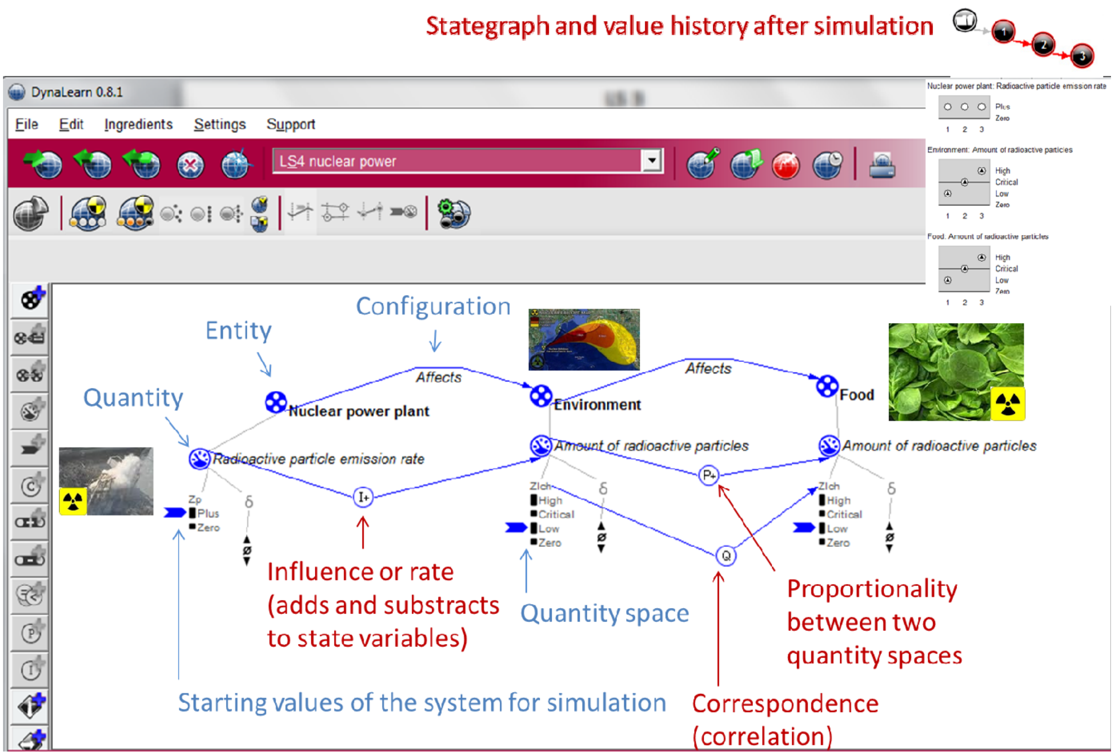


Figure 8.9: The world in DynaLearn, Learning Space 4.

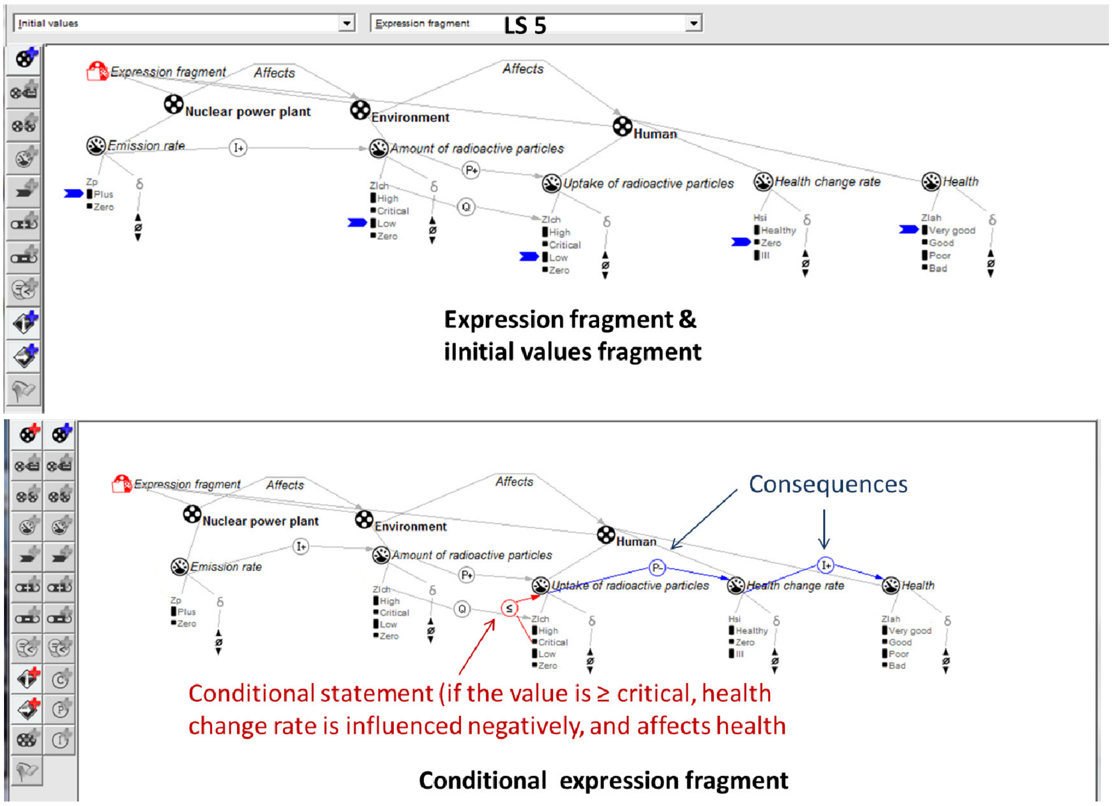


Figure 8.10: The world in DynaLearn, Learning Space 5.

8.1.4. i:HTL evaluation assignments

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Assignment 1:

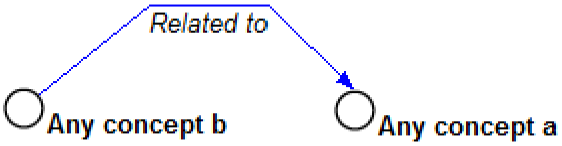
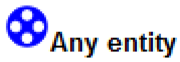
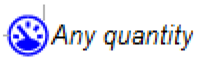
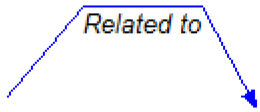
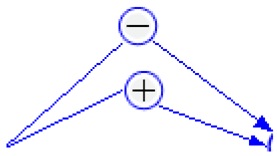
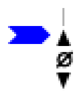
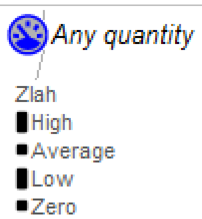
In the case of an accident at a nuclear power station, radioactive isotopes are emitted to the environment, where the amount of nuclear particles and level of nuclear radiation increases. For humans either direct contact with radiation, e.g. at the power plant itself or via uptake with food increases the probability of getting ill. The amount of different isotopes is increasing within different regions of the human body, increasing the risk of different types of illness.

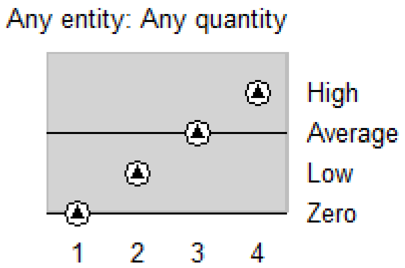
Guiding Questions:

- Which radioactive isotopes might be emitted in case of a nuclear accident?
- Where does the amount of radioactive particles increase in nature after a nuclear accident?
- Which are the main transport routes of radioactive particles in nature until they reach the human?
- Which types of food are mainly poisoned?
- In which regions of the human body do different radioactive isotopes increase and why?
- What types of diseases can be caused by nuclear radiation, considering the different nature of radioactive isotopes and their increase in different body regions?

Figure 8.11: First assignment of the i:HTL evaluation.

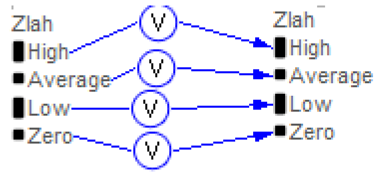
Table 8.1: Elements available in DynaLearn.

 Concepts linked by relations *Idea: capture and structure relevant information.*	 Entity *Entities are the physical objects or abstract concepts that constitute the system. Their relevant properties are represented as quantities.*
 Quantity *Quantities assigned to entities are the dynamic features of a system holding information on magnitude and direction of change.*	 Configuration *Configurations are links between entities that are used to hierarchically or causally structure the system from a conceptual point of view.*
 Causal relation *Causal relations describe positive or negative causal relationship between two quantities.*	 Derivative of change *The derivative of change holds information on direction of change (e.g. increase, decrease, steady).*
 Quantity space *Quantity spaces represent changeable features of entities and contain an ordered set of system states and allow for simulations creating a state-graph with value history of system behaviour.*	 Simulation state graph *A state graph visualizes the succession of system states during a simulation.*



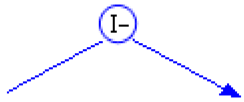
Simulation value history

Derived from a state graph, the value history shows the values quantities go through in a simulation.



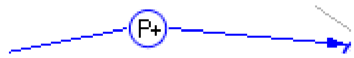
V-correspondences

V-correspondence between two magnitudes / quantity values providing simultaneity: if values of two quantities correspond, then when one occurs, the other one also occurs.



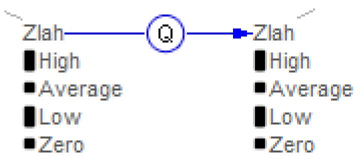
Direct influence

Direct influences are directed relations between two quantities, and are either positive or negative. Direct influences are the cause of change within a model, and are therefore said to model processes. They are used to add or substract continuously from state variables.



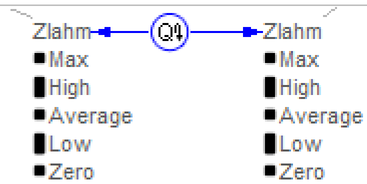
Proportionalities

Qualitative proportionalities are directed relations between two quantities and can also either be positive or negative.. They propagate the effects of a process from one quantity to another (like a correlation). For this reason, they are also referred to as indirect influences.



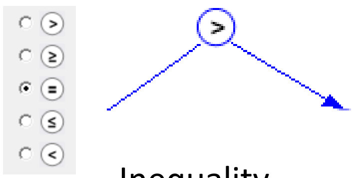
Directed Q-correspondence

Directed Q-correspondence is a correspondence between two quantity spaces providing simultaneity: if two quantity spaces correspond directed, their values change simultaneously during a simulation (if one value is high, the other one is also high). It`s used to reduce the complexity of the simulation.



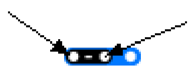
Inverse Q-correspondence

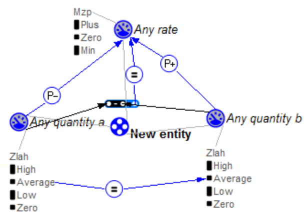
Inverse Q-correspondence is a correspondence between two quantity spaces providing simultaneity: if two quantity spaces correspond inversely, their values change inversely during a simulation (one goes from zero to high, the other one from high to zero). It`s used to reduce the complexity of the simulation.



Inequality

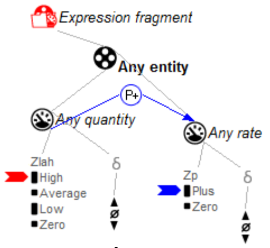
Inequalities (<, ≤, =, ≥, >) specify an ordinal relation between two quantities i.e. that one item is different from (or equal to) the other item; e.g. allows to say when which rate is bigger/smaller to reduce when two rates are active on one state variable, ambiguity.





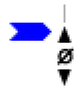
Calculus

The- calculus can be used to substract two quantity spaces to create a positive or negative rate.



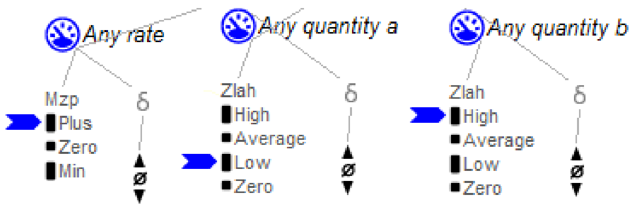
Condition

A process becomes only active, when a certain limit in the system is reached (red=condition, blue is consequence). This knowledge is specified in conditional expression fragments.



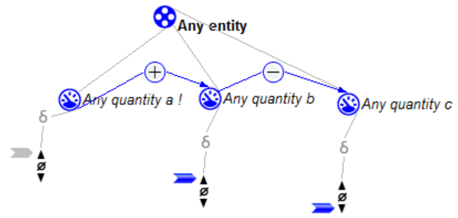
Value assignments

The value assignment describing the direction of change starts the simulation (e.g. increase, decrease, steady).



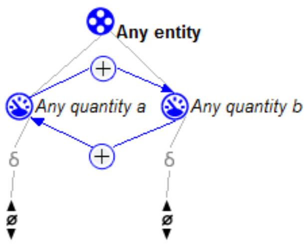
Value assignments

The value assignments to quantity spaces describe the starting values of a system before change takes place.



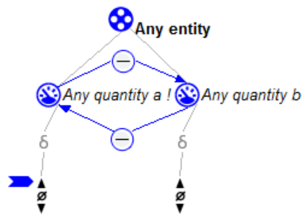
Simulated directions of change

After a starting value has been assigned to describe the direction of change, based on the causal relations, the directions of change of the other quantities are calculated.



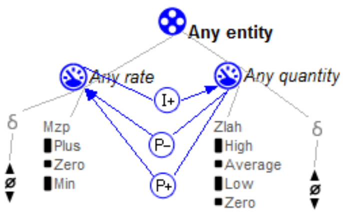
Positive feedback loop

If one quantity has a positive influence on another quantity, there could be only a positive feedback on the original quantity increasing this positive influence.



Negative feedback loop

If one quantity has a negative influence on another quantity, there could be only a negative feedback on the original quantity increasing this negativee influence.



Positive & negative feedback loop

If a rate has a positive influence on another quantity, there could be a negative and positive feedback on the rate increasing or decreasing its influence.

Table 8.2: Look-up table of the elements available in DynaLearn per Learning Space.

Nr	Learning Space	Introduced ingredients
1	Concept map	• Entities • Configurations
2	Causal model	• Entities • Configurations • Quantities ○ Value assignments -> direction of change (Derivatives) • Causal relationships (+ and –) • Simulation of directions of change, only shows increase/decrease/steady
3	Causal model with state graph	• Entities • Configurations • Quantities • Quantity spaces ○ Value assignments -> direction of change (Derivatives) ○ Value assignments -> start value within quantity space • Causal relationships (+ and –) • Correspondences • Simulation has a state graph and value history
4	Causal differentiation	• Entities • Configurations • Quantities • Quantity spaces ○ Value assignments -> direction of change (Derivatives) ○ Value assignments -> start value within quantity space • Causal relationships ○ Influences (=rates which add and substract) ○ Proportionalities (=correlations between state variables) • Correspondences • Inequalities (<, ≤, =, ≥, >) • Calculus (+ and –) • *Agents (no influence on simulations)* • *Assumptions (no influence on simulations)* • Simulation has a state graph and value history
5	Conditional knowledge	• Entities • Configurations • Quantities • Quantity spaces • Value assignments -> direction of change (Derivatives) • Value assignments -> start value within quantity space • Causal relationships ○ Influences (=rates which add and substract) ○ Proportionalities (=correlations between state variables) • Correspondences • Inequalities (<, ≤, =, ≥, >) • Calculus (+ and –) • Conditional expressions • Simulation has a state graph and value history
6	Generic and reusable	• All elements of above available • Different modelling approach – compositional modelling • Entity hierarchy • Model fragments • Scenarios that recall model fragments • Assumptions, that activate specific model fragments to be active within a scenario • Only needed to show that a certain behaviour is only true under certain circumstances, in a specific environment -> this can be implemented using assumptions in model fragments • Only build process model fragments • Simulation needs a scenario • Simulation has a state graph and value history

Below, a summary of the characteristics of each use level is presented:

A *concept map* (sometimes also referred to as an entity-relation graph) is a graphical representation that consists of two primitives: nodes and arcs. Nodes reflect important concepts, while arcs show the relationships between those concepts. From a qualitative reasoning point of view, concept maps are less interesting because they do not capture dynamics.
However, having this use level is useful from a learning point of view, as it is the root from which more complex knowledge representations emerge.

The use level *basic causal model* focuses on quantities, how they change and how this change influences other quantities to change. Quantities represent behaviour. They are connected to entities, the structural units in the model. Simulation at this use level means to calculate for each quantity one of the following options (for its derivative): decrease, steady, increase, ambiguous (because of opposing influences), or unknown (because of missing information).

The use level *basic causal model with state-graph* augments the basic causal model level with the notion of a quantity space, which can be assigned to one or more quantities. This feature introduces concepts such as state-graph, behaviour path, and value history.

The use level *causal differentiation* takes all details defined for the basic causal model with state-graph and refines certain notions, particularly those related to causality. Different from the preceding use level is that the notion of exogenous quantity behaviour is included in the default setting. Also included in the default setting is the idea of an agent. Positive and negative feedback loops are possible!

The use level *conditional knowledge* is a refinement of the causal differentiation level. All representation details apply as they do for this preceding level. The main difference is the possibility to specify conditions under which specific set of details are true. In the preceding use levels all the expressions created by a learner are always true. However, some facts (e.g. the process of evaporation) only occur when certain conditions are satisfied. The conditional knowledge use level addresses situations like these.

The use level *generic and reusable knowledge* reflects the highest and most complex level of modelling. The main difference with the other use levels is the focus on 're-usable' knowledge. That is, to capture essential details in a context-independent manor as much as possible, or otherwise to explicate the conditions under which the knowledge is applicable. At this level the notion of types and hierarchy become important. Also the idea of learners creating their own models by re-using (partial) solutions stored in a repository now viable.

Table 8.3: Modelling elements identification table.

<table>
<tr><td colspan="2">Evaluation:</td><td>Evaluators:</td></tr>
<tr><td colspan="2">Name of student:</td><td>Date:</td></tr>
<tr><td colspan="2">Which Learning Space you are going to use, to build the model? (LS 1-6)</td><td></td></tr>
<tr><td colspan="2">Entities – what are the main entities of the system you are looking at?</td><td></td></tr>
<tr><td colspan="2">Configurations – how are the entities linked?</td><td></td></tr>
<tr><td colspan="2">Quantities – what are the most important quantitative features in your system?</td><td></td></tr>
<tr><td rowspan="2">Quantities with their quantity spaces needed – decide on your quantity spaces, are there important landmarks/ relevant/critical values</td><td>State variables (linked by P`s or positive/negative causal relations), describe the state of a quantity</td><td></td></tr>
<tr><td>Rates – add or substract constantly from a state variable – what is the most relevant rate in your system?</td><td></td></tr>
<tr><td colspan="2">Is there a feedback loop to be implemented? How are you going to do that?</td><td></td></tr>
<tr><td colspan="2">Conditional knowledge – a specific process only takes place if a certain value is reached</td><td></td></tr>
</table>

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Assignment 2:

Go to http://dynalearn.dia.fi.upm.es/dynalearn and create a new user. Check email, and finalize registration.

Use the model developed in LS2 yesterday, and

1) **Get Feedback and** analyse feedback and add relevant entities to your model
    a. **Sophie LS2_uptake of radiogenic emissions by humans_2S.hgp**
    b. **Oliver LS2_uptake of radiogenic emissions by humans_1O.hgp**
2) **What was missing (please write) - and was it relevant?**

and 3) Grounding - check all groundings and ground at minimum 3 terms , and create at minimum 3 groundings of some terms by your own.

Which did you ground by dbpedia?

A)

B)

C)

Which did you define by your own?

A)

B)

C)

4.) Upload your model and try to get feedback from each other's model. What could you learn from each other? Are there any relevant entities/quantities that you have missed?

Figure 8.12: Second assignment of the i:HTL evaluation.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Assignment 3:

LS4 model – Iod uptake: download model ***LS4 Iod uptake.hgp*** from repository, run simulation and

1) detect the state which should be reached after an iod pill has been eaten.

2) Why is this state desirable? Describe in your own words.

3) Describe what's happening along this simulation path, and under which circumstances this desirable end situation is achieved.

Figure 8.13: Third assignment of the i:HTL evaluation.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Assignment 4 :

Nuclear radiation uptake and human health – LS5 model

1) Download model ***LS5_nuclear emissions and health_incomplete.hgp*** from repository and

2) run the simulation. What happens to health? Why?

3) Determine the benchmark value for the maximum yearly uptake of nuclear radiation by humans and set the conditional statement, what happens when the value nuclear radiation is equal or higher the critical value.

Figure 8.14: Fourth assignment of the i:HTL evaluation.

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Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Assignment 5:

Nuclear power plant – pressured water reactor

General information:

There are mainly two types of nuclear power plants: the **boiling water reactor** and the **pressured water reactor**. In your model you will have to deal with the pressured water reactor.

Generally in both reactors in nuclear rods heat is produced constantly by fission by a controlled chain reaction which is used to heat up the water.

In a **pressured water reactor** the water which passes over the reactor core (primary loop, water serving as moderator and coolant) to act as moderator and coolant does not flow to the turbine does not flow to the turbine is contained in a pressurized primary loop. The primary loop water produces steam in the secondary loop which drives the turbine. The steam then is cooled down by a condenser, which represents the third loop – the cooling water cycle. Here usually water is taken by a river to cool down the steam which is then re-used within the secondary loop for steam production. The cooling water usually releases part of the temperature via the cooling towers (the big tower-like elements of the nuclear power stations), and is then released to the river. Here unnatural high water temperatures might negatively influence river type specific aquatic organisms adopted to lower temperatures. Residual heat is usually not used for energy production in nuclear power plants.

The obvious advantage to this is that a fuel leak in the core would not pass any radioactive contaminants to the turbine and condenser.

Just for your info: *In the boiling water reactor the same water loop serves as moderator, coolant for the core, and steam source for the turbine.*

For more details have a look at

- *nuclear chain reaction at Wikipedia,*
- http://www.temelin.com/akw/AKW.html and
- http://hyperphysics.phy-astr.gsu.edu/hbase/nucene/control.html.

Guiding Questions:

- What are the main elements of a nuclear power plant?
- What are the three loop systems in a pressured water reactor and how are they linked?
- How is the energy produced by which main element?
- How does a nuclear chain reaction work?
- How is the heat produced by a nuclear rod?
- How are the neutrons and hence the level of energy produced in a nuclear rod controlled?
- What could be possible effects on the aquatic fauna living in rivers and why?

Figure 8.15: First page of the fifth assignment of the i:HTL evaluation.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

Model building activity:

Have a look on the model ***LS4 nuclear power plant functioning incomplete*** (download from repository) and try the following

- Find out, what is missing with regard to energy production?
- What else is missing with regard to the text above?
- Add the missing information!

- Now get feedback from the repository using the model ***LS4 nuclear power plant functioning feedback,*** and see if there are differences between your model and the model in the repository.
- Are there still differences? Are they relevant? Please describe below in a few words!

- Run a simulation, inspect the value history and the causal chain**. What happens to the energy produced and why**? (Please describe in your own words below)
    - when you move the control rod into the nuclear rod

    - when you move the control rod out of the nuclear rod

Figure 8.16: Second page of the fifth assignment of the i:HTL evaluation.

8.1.5. BOKU evaluation assignments

Evaluation of DynaLearn 0.8.8 Software
Date: 11.05.-12.05.2011 (alternate date: 17.05.2011)
Place: BOKU Vienna, AT
Course: Selected Topics of aquatic ecology and river management, LV 812330
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar

Modelling supported learning

Assignment 1: Concept map (LS1)

Date: Wednesday 11.05.2011

Practical: Create a concept map capturing the concepts related to river channelization.

Duration: 30-45 min., then submit your '.hgp' file at the end of this session.
Software: DynaLearn – Learning Space 1

1. Context
River channelization has caused severely impacted rivers all over the world, and represents a major issue related to the degradation of the ecological integrity of river systems. A comprehensive, inter-disciplinary understanding is needed for successful management of river systems measures.

2. Create a Learning Space 1 concept map
Create a concept map model at **Learning Space 1** that captures all concepts and information relevant to characterise the effects of river channelization. If you need any help please try to take as much advantage of the basic help of the software situated at the *Support Menu.*

Step 1: Create a new Dynalearn Model by

- File menu
- Start new model
- selecting the Use Level Concept Map
- Name the model LS1_.familyname.hpg
- File menu
- Save current model to file
- Choose your favourite working directory

3. Submit first version of the model via Moodle

- Kurs 812.330\students`models\LS1 modelsOriginal programme file (LS1_familyname.HGP)

Figure 8.17: First assignment of the BOKU evaluation.

Evaluation of DynaLearn 0.8.8 Software
Date: 11.05.-12.05.2011 (alternate date: 17.05.2011)
Place: BOKU Vienna, AT
Course: Selected Topics of aquatic ecology and river management, LV 812330
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar

Modelling supported learning

Assignment 2: Basic Causal Model (LS2)

Date: Wednesday 11.05.2011, Tuesday 17.05.2011

Practical: Create a basic causal model describing the causal network of effects of river channelization.

Duration: 30-45 min., then submit your '.hgp' file at the end of this session.
Software: DynaLearn – Learning Space 2

1. Context
River channelization has caused severely impacted rivers all over the world, and represents a major issue related to the degradation of the ecological integrity of river systems. A causal understanding has been proved to be essential for planning and implementing effective river rehabilitation measures.

2. Create a Learning Space 2 expression
Create a basic causal model at **Learning Space 2** that captures your explanation of the phenomenon of river channelization and its effects. If you need any help please try to take as much advantage of the basic help of the software situated at the *Support Menu.*

Step 1: Create a new Dynalearn Model by

- File menu
- Start new model
- selecting the Use Level Basic Causal Model
- Name the model LS2_familyname.hpg
- File menu
- Save current model to file
- Choose your favourite working directory

3. Submit first version of the model via Moodle
- Kurs 812.330\students`models\LS2 models
- Original programme file (LS2_familyname.HGP)

Figure 8.18: Second assignment of the BOKU evaluation.

Evaluation of DynaLearn 0.8.8 Software
Date: 11.05.-12.05.2011 (alternate date: 17.05.2011)
Place: BOKU Vienna, AT
Course: Selected Topics of aquatic ecology and river management, LV 812330
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar

Modelling supported learning

Assignment 3: Basic Causal Model (LS2) - Feedback

Date: Thursday 12.05.2011, Tuesday 17.05.2011

Practical: Use of the Feedback feature in LS2.

Duration: 60 min then submit your '.hgp' file to moodle
Software: DynaLearn – Learning Space 2

1. Get feedback on your LS2 model

- Open your model built yesterday
- Go to the *Support* menu
- Login into the repository with
    - **Username:** demo-student@dynalearn.eu
    - **Password:** student
- Select *None*
- Press button *Select course*
- Select *Get Feedback on Current Model*
- Depending on **your own model preferences** select either the model
    - **LS 2 channelization_discharge efficiency_feedback.hgp** -> *focused on changes of width/depth relationship*

    or
    - **LS 2 channelization_slope_feedback.hgp** -> *focused on reduction of river length*
- Find out the differences of your model that you submitted, and adopt your model accordingly to the expert model. Implement as much information as possible from the feedback given.

2. Submit final version of the model via Moodle

- Kurs 812.330\students`models\LS2 models feedback
- Original programme file (LS2_FB_familyname.HGP)

Figure 8.19: Third assignment of the BOKU evaluation.

Evaluation of DynaLearn 0.8.8 Software
Date: 11.05.-12.05.2011 (alternate date: 17.05.2011)
Place: BOKU Vienna, AT
Course: Selected Topics of aquatic ecology and river management, LV 812330
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar

Modelling supported learning

Assignment 4: Basic Causal Model (LS2) – model debugging

Date: Thursday 12.05.2011

Practical: Model debugging of a ready-made model.

Duration: 20-30 min, then write in your own words the mistakes you have detected and its consequences, submit the updated .doc assignment file to moodle.

Software: DynaLearn – Learning Space 2

1. Model debugging

- Open LS 2 channelization_slope_mistake.hgp
- There are **TWO mistakes** in the model
- **Find them, and debug** the model
- Describe in own words below,
    - how you did the debugging
    - which mistakes you detected
    - and which consequences these mistake had on the following quantities

2. Submit THIS updated word.doc via Moodle

- Kurs 812.330\assigment 4 students solutions
- This doc file (Assignment 4_LS2_model debugging familyname.doc)

YOUR ANSWERS:
How was debugging performed?

Which mistakes did you detect?

What were the consequences of these mistakes on the modelled system?

Figure 8.20: Fourth assignment of the BOKU evaluation.

Evaluation of DynaLearn 0.8.8 Software
Date: 11.05.-12.05.2011 (alternate date: 17.05.2011)
Place: BOKU Vienna, AT
Course: Selected Topics of aquatic ecology and river management, LV 812330
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer, Susanne Muhar

Modelling supported learning

Assignment 5: Basic Causal Model (LS2) – grounding

Date: Thursday 12.05.2011, Tuesday 17.05.2011

Practical: Grounding of selected terms in ready-made model.

Duration: 15-20 min.

Software: DynaLearn – Learning Space 2

1. Grounding

- Open LS2 ecosystem services.hgp
- Select *Support*
- *Login to repository*
  - User Name: demo-student@dynalearn.eu
  - Password: student
- Select *None*
- Press button *Select course*
- Select *Support*, *Ground model*
- See if the grounding provided for the term ecosystem service is adequate
- If yes, ground the term to this description
- If not, create an anchor term defining ecosystem service (button right up) – based on the definitions in the presentation of S. Muhar (see Moodle),
- and save the grounding (button left down)
- Ground as many terms as you find adequate

2. Submit grounded version of the model via Moodle

- Kurs 812.330\students`models\LS2 models grounding
- Original programme file (LS2 ecosystem services_GR_familyname.HGP)

Figure 8.21: Fifth assignment of the BOKU evaluation.

8.1.6. BOKU exam questionnaire

EXAM

812.330 Selected Topics of aquatic ecology and river management

Name:

Study programme No.: Matric. No.:

1) Give (a) one example for long and (b) one for medium distance migrants for fish species.
2) Give two examples of types of fish passes for restoring continuum disruptions.
3) What is the meaning of "multi-dimensionality of riverine landscapes"?
4) List some important human pressures impairing the natural hydro-morphological conditions of riverine landscapes.
5) Definition of saprobity.
6) Which benthic invertebrate species are typical indicators for water quality class III?
7) River Danube: Characterisation of a pristine situation and the up-to-date conditions for fish populations.
8) Danube hydropower impoundment “KW Wien/Freudenau”: Implemented “ecological improvements” – why, and in which areas have they been constructed?
9) Give a definition of “ecosystem services”.
10) What are the effects of river channelization on river systems?

Figure 8.22: Final exam questionnaire of the BOKU course in which the evaluation took place.

8.1.7. Motivation questionnaire of i:HTL and BOKU

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

1. Learning by Modeling

To what extent do you agree:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The process of modeling motivated me to learn more about the phenomena.					
2. Learning with software requires continuing teacher support.					
3. The software enables me to learn by myself.					
4. The DL approach as presented during the last days represents a new and interesting way of learning					

2. Learning Spaces in DynaLearn

Which of the learning spaces contribute mostly to achieve the following aims:

Mark with a "x" all relevant Learning Spaces	LS1	LS2	LS3	LS4	LS5	LS6
1. Learning about the structure and components of an environmental system.						
2. Representing the relationships between active factors in the system.						
3. Understanding the behavior of the system.						

3. Simulations in DynaLearn

Which of the learning possibilities of simulations contribute mostly to your understanding?

To what extent do you agree:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The possibility to run simulations motivated me to build a model.					
2. Seeing the simulation results provide me with a better understanding of the system behaviour					
3. Inspecting the simulation path and the values of the quantities helped me to understand the changes in the system.					
4. I liked the possibility run simulations.					
5. Why did you like the simulations? Please, explain your answer to item 4.					

Figure 8.23: First page of the motivation questionnaire used at i:HTL and BOKU.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

4. Ease in Using the Software

I found easy to use DL	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Identifying and describing "entities" in the system.					
2. Defining quantities.					
3. Identifying and representing positive and negative causal relations in the system.					
4. Defining processes and rates.					
5. Running simulations and identifying relevant paths that appear in the simulation.					
6. Interacting with the interface and using the features of the software.					
7. What were the most complicated things when you used DynaLearn? Please describe					

5. Virtual characters

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The virtual characters help was sufficient to support my model building activity					
2. If you don't agree that the virtual characters are sufficient to support your modeling activity, please, explain what you feel that was missing.					
3. The VC should appear all the time					
4. I liked the combination of voice and text provided by the virtual character.					
5. The VC are very useful for me to learn how to use the software.					
6. I liked the virtual character providing basic help.					
7. Please describe what you liked at the VC.					

Figure 8.24: Second page of the motivation questionnaire used at i:HTL and BOKU.

Evaluation of DynaLearn 8.2 Software
Date: 27.03.-30.03.2011
Place: i:HTL Bad Radkersburg, AT
Dynalearn partner: BOKU
Responsible persons: Andreas Zitek, Michaela Poppe, Michael Stelzhammer

DynaLearn

6. Grounding

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The structure of the grounding window is insightful.					
2. What additional feature/information should be available at the grounding window?					
3. I liked the grounding functionality.					

7. Feedback

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The feedback provided by the software based on the other models was insightful.					
2. The feedback provided significant information to improve my model.					
3. I clearly understood the information provided by the feedback.					
4. Any ideas to improve feedback?					
5. I liked the feedback functionality.					

8. Motivation

Motivation	Very negative	Negativ e	Neutral	Positive	Very positive
1. What is your general opinion about the course and learning activity we had together?	**Very bad** 1 2 3 4 5 **Very good**				
2. What is your general opinion about the modelling approach you used to develop this educational activity?	**Very difficult** 1 2 3 4 5 **Very easy**				
3. How did you experiencing the work with the DynaLearn software – boring or interesting?	**Very boring** 1 2 3 4 5 **Very interesting**				
4. How do you evaluate your understanding of the problem after exploring the topic in DynaLearn?	**I am very much confused** 1 2 3 4 5 **I understand much better now**				
5. How do you evaluate the importance of building models in different specific use-level of DynaLearn for your understanding?	**Very little importance** 1 2 3 4 5 **Very important**				

THANK YOU VERY MUCH!

Figure 8.25: Third and last page of the motivation questionnaire used at i:HTL and BOKU

8.2. Course and lesson plans of evaluation sessions

8.2.1. Course and lesson plans of the i:HTL evaluation session

Table 8.4: Course plan with general information of the i:HTL evaluation session.

LEARNING-UNIT/COURSE PLAN ID: **E-DAY, PROJECT WEEK / OPEN DAY AT I:HTL BAD RADKERSBURG, AUSTRIA** **MARCH 2011**	
Topic:	Nuclear radiation
General Objectives:	Developing a deeper understanding of nuclear radiation and, using of nuclear power as well as its effects on the environment and on humans.
Target population:	2 students, working separately
Procedure	
Duration:	4 days, 28.03. – 31.03.2011
Implementation plan and schedule:	**Evolving model mode:** Students will be introduced to the modelling approach with DL based on examples related to their field of experience. They will get assignments to develop models for nuclear energy use based on a set of questions. Further information can be found in the lesson plan.
Teaching/Learning organization:	BOKU in cooperation with IHTL Bad Radkersburg, Styria, Austria
Assessment:	**Formative:** The whole process will be guided and the attitude of the students towards DL will be assessed continuously via interviews, questionnaires and video recordings.
Resources	
DynaLearn resources:	Short summary of the most important features of the DL software with examples (written); a short structured description/framework of how to build models within DL software from level 1 to 6 pointing out the specific features available at different use levels.
Learning materials:	Internet, literature.

Table 8.5: Lesson plan with specific information of the i:HTL evaluation session.

LESSON PLAN ID: **E-DAY, PROJECT WEEK / OPEN DAY AT I:HTL BAD RADKERSBURG, AUSTRIA** **LEARNING UNITS WITH DYNALEARN**	
Topic:	Nuclear radiation
Specific Objectives:	Developing a deeper understanding of nuclear radiation and, using of nuclear power as well as its effects on the environment and on humans.
Content knowledge and skills:	Important technical, environmental and health issues related to the use of nuclear power.
Modelling knowledge skills:	Features of the DL software, structured way of building models of increased complexity.
Prerequisite knowledge and skills:	Knowledge related to the use of nuclear radiation and of how to use the internet for searching information as well as presentation skills. An important issue is to develop an understanding of how DL modelling language links to the UML language that has been used by the students to develop their models so far.
Teaching/Learning mode/s:	**Evolving-model mode and collaborative modelling (TM)** - collaborative development of models with increasing complexity along with the student's model building abilities. The work of students is based on a set of key questions delivered to them at the beginning of the project, and is guided along the course by regular learning and feedback units. **Model building mode (LM)** - students will develop models on different use levels based on existing model fragments, other sources like Wikipedia, internet (as a whole), scientific literature and the teachable agent of the DL software. **Project based** approach supported by the DL software with **final presentation**.
Modelling level/s:	Modelling should follow a framework for model building, and will focus on levels 1, 2, 4 and 5.
Procedure	
Duration:	4 days, 28.03. – 31.03.2011
Implementation plan and schedule:	1. The session will start with a short introduction of the project and the DynaLearn software with its main features and elements and in structured model building and gaining information via internet. (PowerPoint presentation) 2. Software installation 3. Pre- and post-test; motivation questionnaire 4. Modelling at different LSs on the topic after assignments, gaining knowledge via internet. 5. Final public presentation of the modelling experiences at the school
Assessment (if planned):	**Mainly formative** by interviews, recording and questionnaires for collecting information during the whole model building process that allow to identify if the DL software • provides useful vocabulary to capture complex problems, • enables students to address more complex problems (done by comparing the first results to the final model), • supports individual learning behaviour and self-organization of knowledge (questionnaire), • is able to attract students towards environmental sciences (questionnaire).
Resources	
DynaLearn resources:	Short summary of the most important features of the DL software with examples (written) that show the relationship between the DL modelling concept and vocabulary and the UML modelling language in use not to overload students with similar vocabulary with different meanings. A short structured description/framework of how to build models within DL software from level 1 to 6 pointing out the specific features available at different use levels.
Learning materials:	Internet, literature.

Table 8.6: Lesson plan with the timetable of the i:HTL evaluation session.

LESSON PLAN ID **E-DAY, PROJECT WEEK / OPEN DAY AT I:HTL BAD RADKERSBURG, AUSTRIA** **TIMETABLE OF LEARNING UNITS WITH DYNALEARN**
First day, 28.03.2011
7:50 - 13:00 o Pre-Test o Installation of the DL software (version 0.8.2) o Introduction in the topic, in DynaLearn (PowerPoint presentation) and in internet search o LS1 (including the use of teachable agent): 'Model nuclear radiation and its effects on the environment.' *13:30 - 15:00* o Determination of LSs by cards, selected according to the text o Assignment 1: LS2, 'Accident at a nuclear power station and its effects on environment and human health.'
Second day, 29.03.2011
10:00 - 13:30 o Assignment 2: feedback and grounding of the LS2 models. Upload of the models and try to get recommendations/feedback from each other's model. o Assignment 3: LS4, 'Iod uptake' detecting questioned issues in the ready-made LS4 model *14:00 - 15:30* o Assignment 4: LS5, 'Nuclear radiation uptake and human heath' detecting questioned issues in the ready-made but incomplete LS5 model
Third day, 30.03.2011
08:00 - 12:00 o Assignment 5: 'Nuclear power plant – pressurized water reactor' o Post-test o Motivation questionnaire *12:30 - 15:00* o Preparation for the final presentation
Fourth day, 31.03.2011
09:00 - 11:00 o Final presentation (multiple repetitions of the 10 mins presentation in context of e-day/open day)

8.2.2. Course and lesson plans of the BOKU evaluation session

Table 8.7: Course plan with general information of the BOKU evaluation session.

COURSE PLAN ID: **Course: Selected Topics of aquatic ecology and river management** **2 SWS – 3 ECTS** **March - June 2011**	
Topic:	Main topics: 1. River management and applied examples. 2. Basics of river landscapes and their fluctuations. 3. Large river systems - examples from the Danube. 4. Benthic invertebrate ecology, water quality assessment, EU water framework directive 5. Classification and modelling of river systems.
General Objectives:	Developing and improving students understanding of processes in aquatic ecology and river management. The selected topics should cover the range of aquatic ecology and river management. A variety of examples will be presented.
Target population:	about 30 Bachelor and mainly Master, PhD students
Procedure	
Duration:	5 lessons with duration of about 4h
Implementation plan and schedule:	**Demonstration and investigation mode** 4 topics will be presented without DynaLearn software, each in one afternoon, lasting for about 4h using a traditional power point teaching approach. In the fifth lesson (held as a 2 afternoon's workshop with 4h each) an applied example in river management (topic 1) will be developed and discussed by means of the DynaLearn software.
Teaching/Learning organization:	BOKU, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management
Assessment:	**Summative** 1) Pre- and post-test at the DL event 2) At the end of the course there is a written assignment, with relatively open questions what allows comparing the answers related to the content delivered by the support of the DL software with answers related to content delivered in form of PowerPoint presentations. **Formative** Interviews & questionnaires, observational notes
Resources	
DynaLearn resources:	
Learning materials:	1) PowerPoint presentations 2) Textbook: *Angewandte Fischökologie an Fließgewässern*, Jungwirth et al., 2003. Facultas UTB 2113 ISBN 3-8252-2113

Table 8.8: Lesson plan with specific information of the BOKU evaluation session.

LESSON PLAN ID **COURSE: SELECTED TOPICS OF AQUATIC ECOLOGY AND RIVER MANAGEMENT** **LEARNING UNIT 5 (WITH DYNALEARN)**	
Topic:	Applied example in integrative river management
Specific Objectives:	• Catchment management • Natural processes forming riverine landscapes and habitats • Flood protection
Content knowledge and skills:	Important processes influencing riverine landscapes being relevant for an integrative catchment management
Modelling knowledge skills:	Model building based on DL modelling principles introduced by an introduction.
Prerequisite knowledge and skills:	Basic knowledge of river ecology
Teaching/Learning mode/s:	**Demonstration mode (TM)**. Models are used as a basis to explore the potential of the DL software and the modelling approach itself **Investigation mode (TM)**. The learning activity is devised around a key question (reflected in a picture of a riverine landscape) **Collaborative modelling mode (TM)**.Students will build models in small groups and finally present results **Model building mode (LM)**. Students will start with concept maps developing a model using model parts from the repository.
Modelling level/s:	Modelling follows a general framework for model building and will focus on levels 1 and 2, as well as the recommendation/feedback and grounding features of the software.
Procedure	
Duration:	11.05. – 12.05.2011: 2 afternoons (4 hours each) Alternate date, 17.05.2011: one afternoon (5 h)
Implementation plan and schedule:	6. Features of the DL software, introduction of a structured way of building models. The lesson will start with a short introduction of the project and the DynaLearn software with its main features and elements (0,5h); 7. the software is explored in a collaborative mode demonstrated on an expert model (DL software running on individual laptops) (0,5h); 8. The students should explore in small groups (2-3 students) different topics with the DL software that have been presented (3 h). 9. Discussion (1h) - possibility to contrast the students models with expert models and analysing the differences
Assessment (if planned):	**Formative**: Interviews and **questionnaires** for collecting information during the model building process; final questionnaires; At a later date: **summative assessment** - content related questions that allow to identify the effect of the DL software on model building and learning/understanding capabilities/effects (Topic 1: lecture and DynaLearn Workshop)
Resources	
DynaLearn resources:	1) User's manual/Installation guide 2) Short summary of the most important features of the DL software, incl. simple test models in each LS, presented by PowerPoint slides as kick-off for modelling, related to System Dynamics vocabulary. 3) Expert models.
Learning materials:	1) Printed PowerPoint presentation on the topic, as a basis to formulate models. 2) Pictures of the Pre- and post-test. 3) Expert models (as basis for semantic recommendations)

Table 8.9: Lesson plan with the timetable of the BOKU evaluation session.

LESSON PLAN ID **COURSE: SELECTED TOPICS OF AQUATIC ECOLOGY AND RIVER MANAGEMENT** **TIMETABLE OF LEARNING UNIT 5 (WITH DYNALEARN)**
First afternoon, 11.05.2011
13:00: Installation of the DL software by the students 13:40: Pre-test 14:00: Introduction of DynaLearn project and its implementation in selected topics 14:10: Introduction of the topic: Effects of river channelization, including Ecosystem services (as PowerPoint presentation) 14:45: Break 15:00: Assignment 1: LS1 (30-45min, including basic help) 'Create a concept map capturing the concepts related to river channelization' 15:45: Assignment 2: LS2 (45-60min, including basic help) 'Create a basic causal model describing the causal network of effects of river channelization' 16:45: Conclusion and upload to Moodle (course management system platform)
Second afternoon, 12.05.2011
13:00: Summary of the first afternoon 13:10: Assignment 3: LS2 feedback from expert model (45-60min) 'Use of the *'Recommendation/Feedback'* feature in LS2' 14:10: Break 14:20: Assignment 4: LS2 Debugging expert model (30-40 min) 'Model debugging of a ready-made model' 15:00: Break 15:10 Assignment 5: LS2 Grounding (15-20min) 'Grounding of selected terms in ready-made model' 15:30: Post-test 15:50: Break 16:00: Motivation questionnaire 16:20: Conclusion and end
Alternate afternoon, 17.05.2011
14:00: Pre-test 14:20: Presentation of the topic: introduction "Effects of river channelization (including Ecosystem services)" as printed document for self-study 14:50: Short introduction of DynaLearn project and its implementation in selected topics 14:55: Break 15:00: Assignment 2: LS2 (45-60min, including basic help) 'Create a basic causal model describing the causal network of effects of river channelization' 16:00: Break 16:10: Assignment 3, LS2 feedback from expert model (45-60min) 'Use of the *'Recommendation/Feedback'* feature in LS2' 17:00: Break 17:10: Post-test 17:30: Motivation questionnaire 17:50: Conclusion and end

8.3. Results

8.3.1. Results of i:HTL *Atlas.ti* analysis

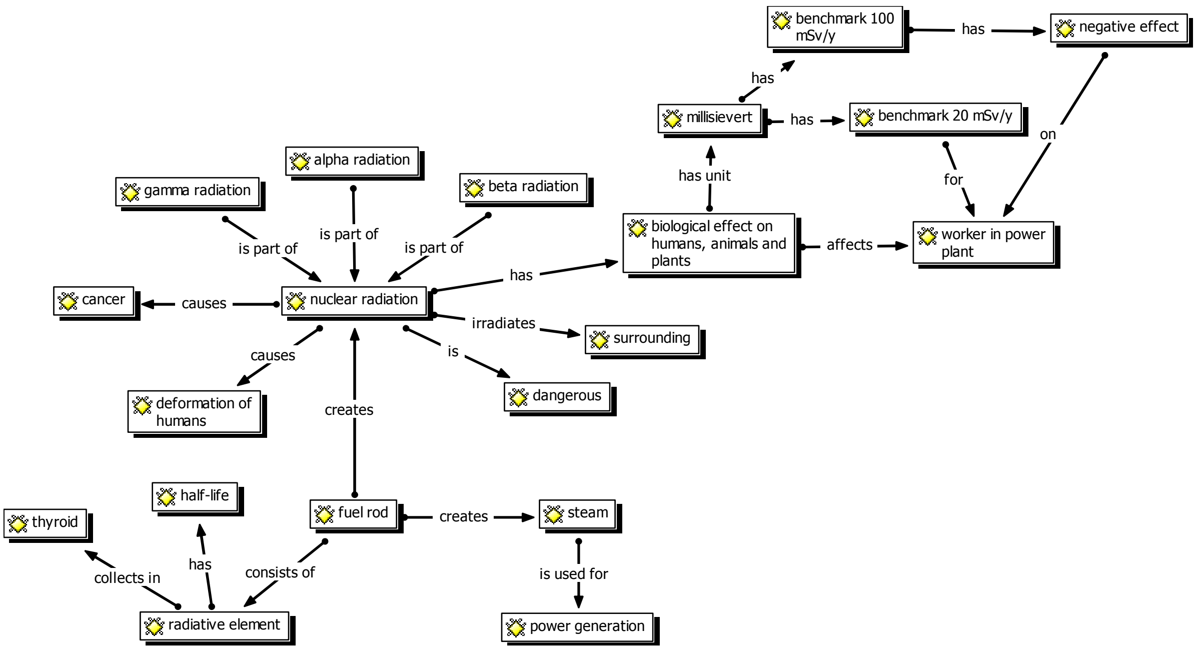

Figure 8.26: Network view of the linked keywords in the pre-test of i:HTL student 1 (f).

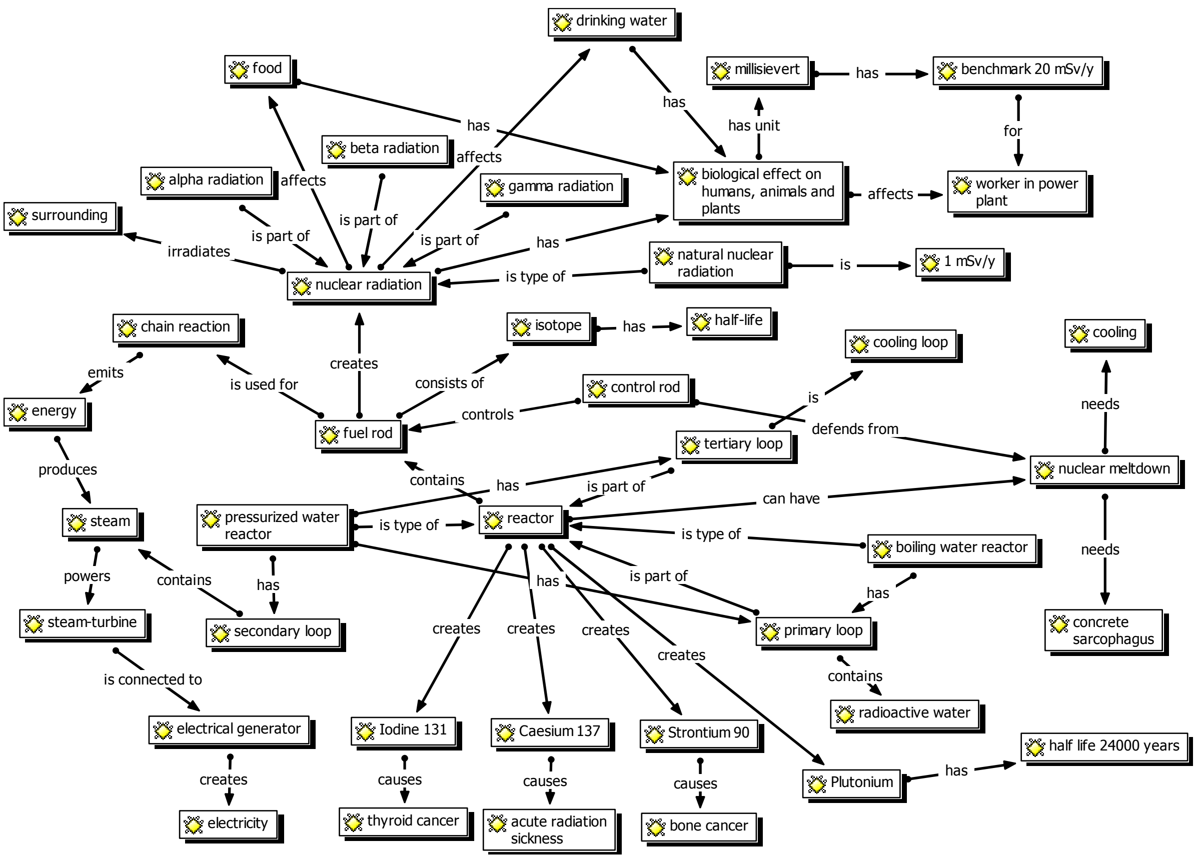

Figure 8.27: Network view of the linked keywords in the post-test of i:HTL student 1 (f).

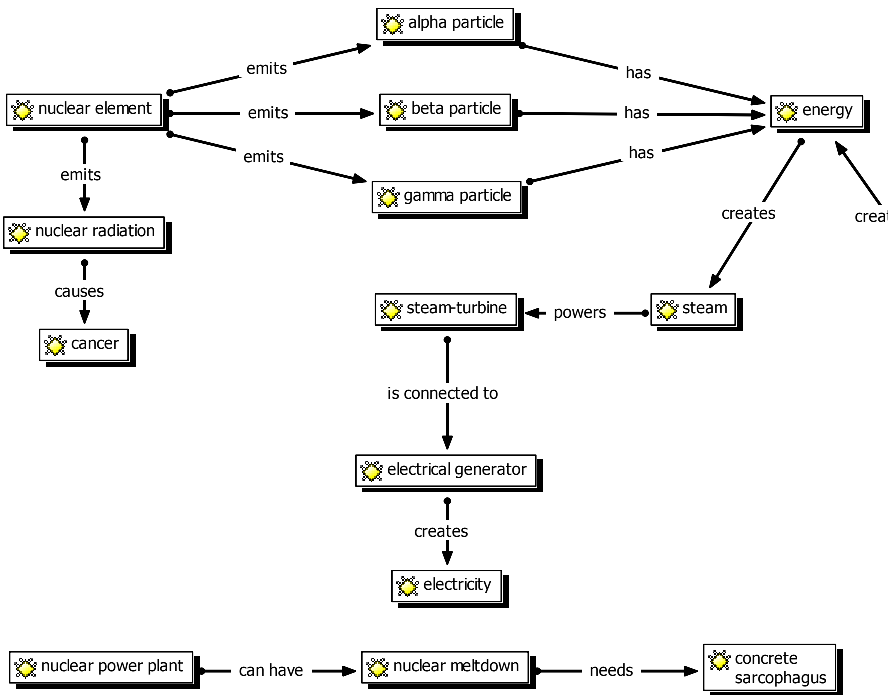

Figure 8.28: Network View of the linked keywords in the pre-test of i:HTL student 2 (m).

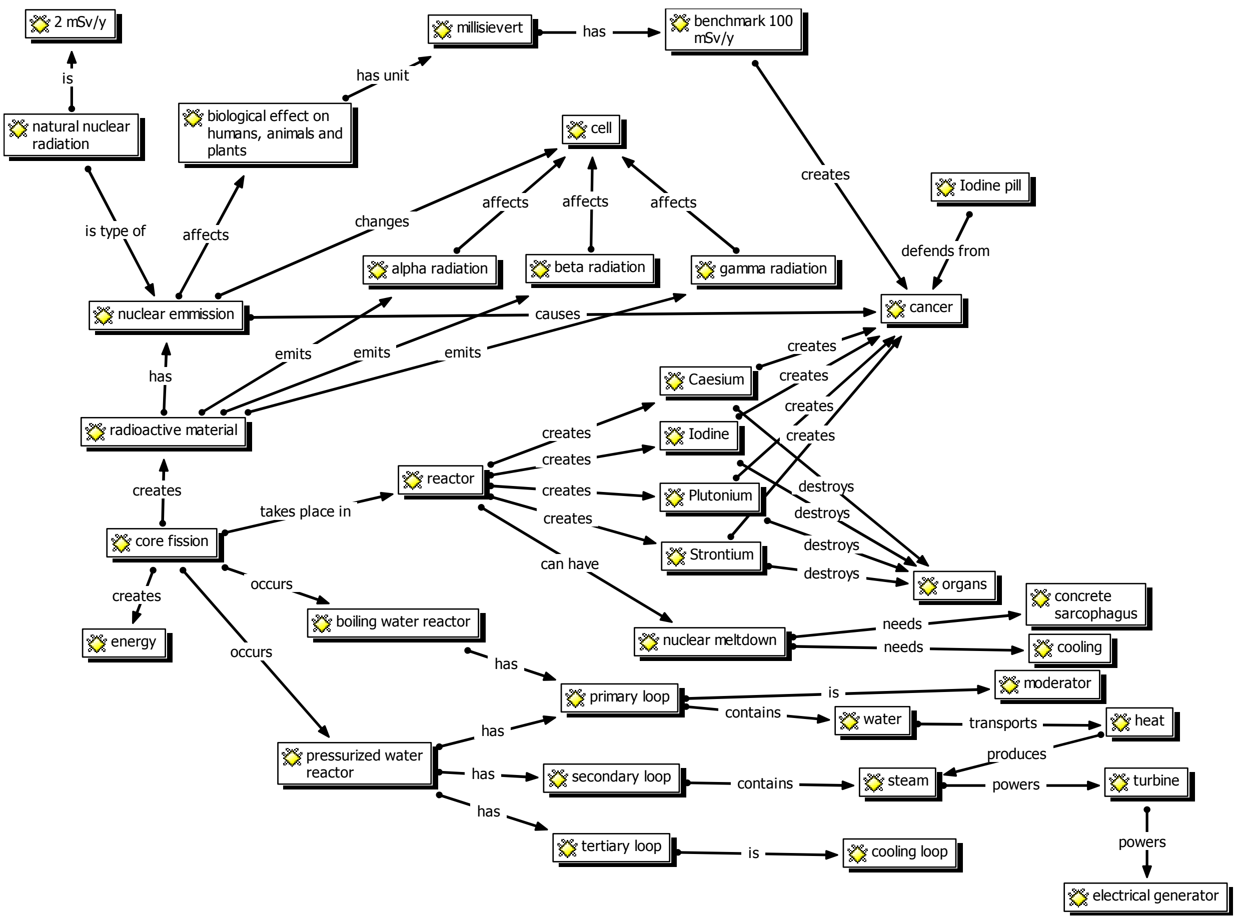

Figure 8.29: Network View of the linked keywords in the post-test of i:HTL student 2 (m).

8.3.2. Selected results of BOKU I *Atlas.ti* analysis

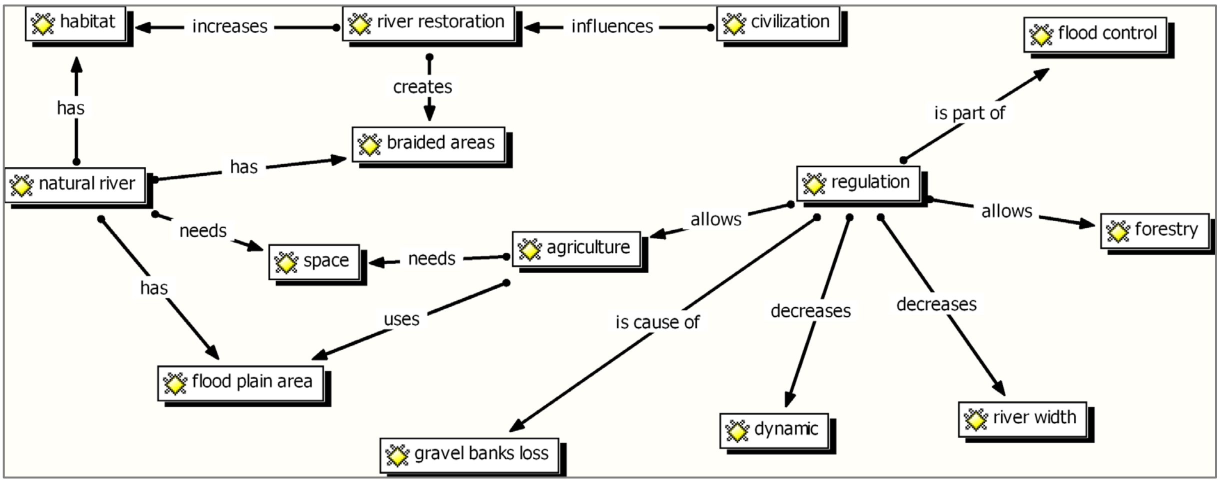

Figure 8.30: Pre-test network view of the BOKU evaluations (student 1).

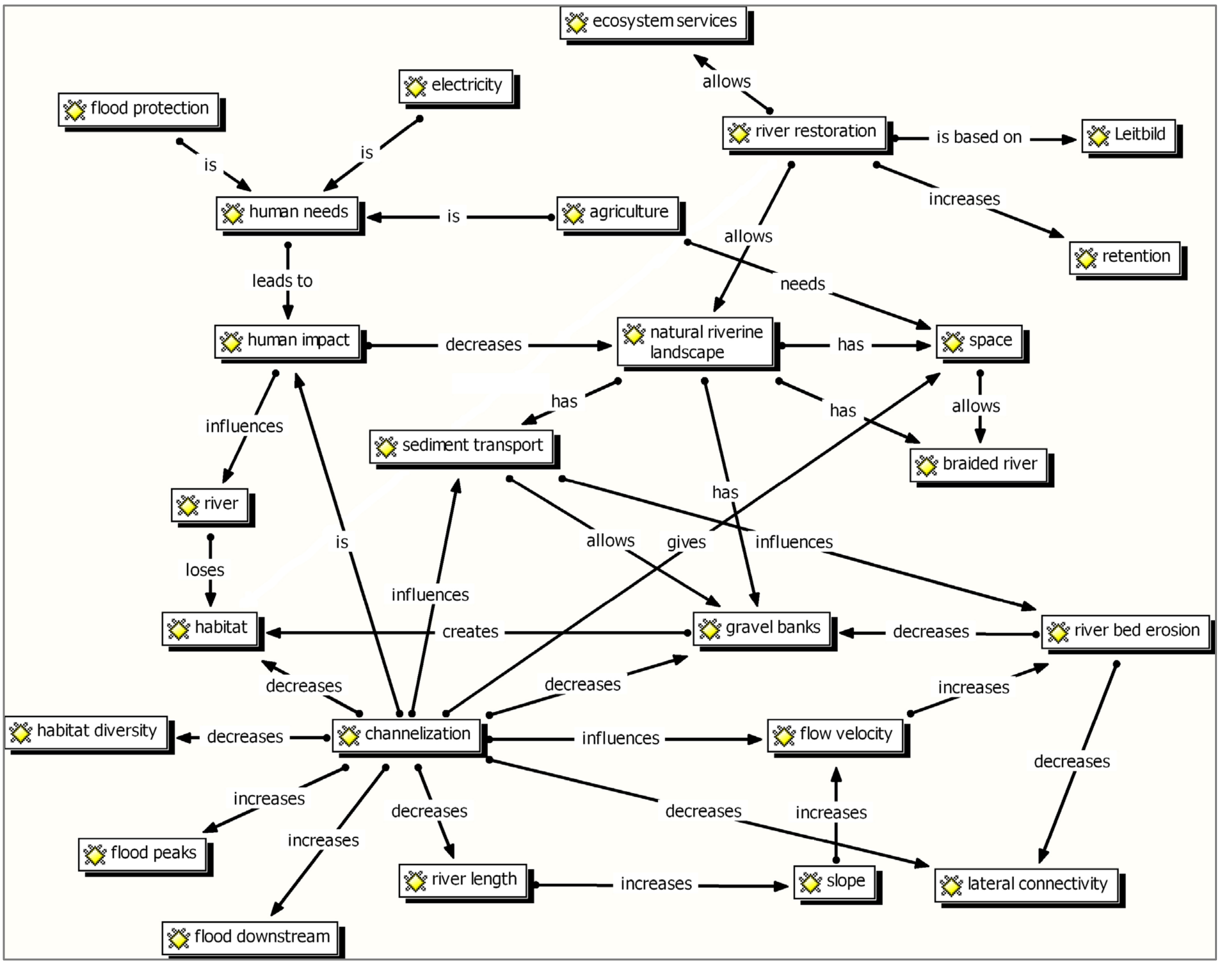

Figure 8.31: Post-test network view of the BOKU evaluations (student 1).

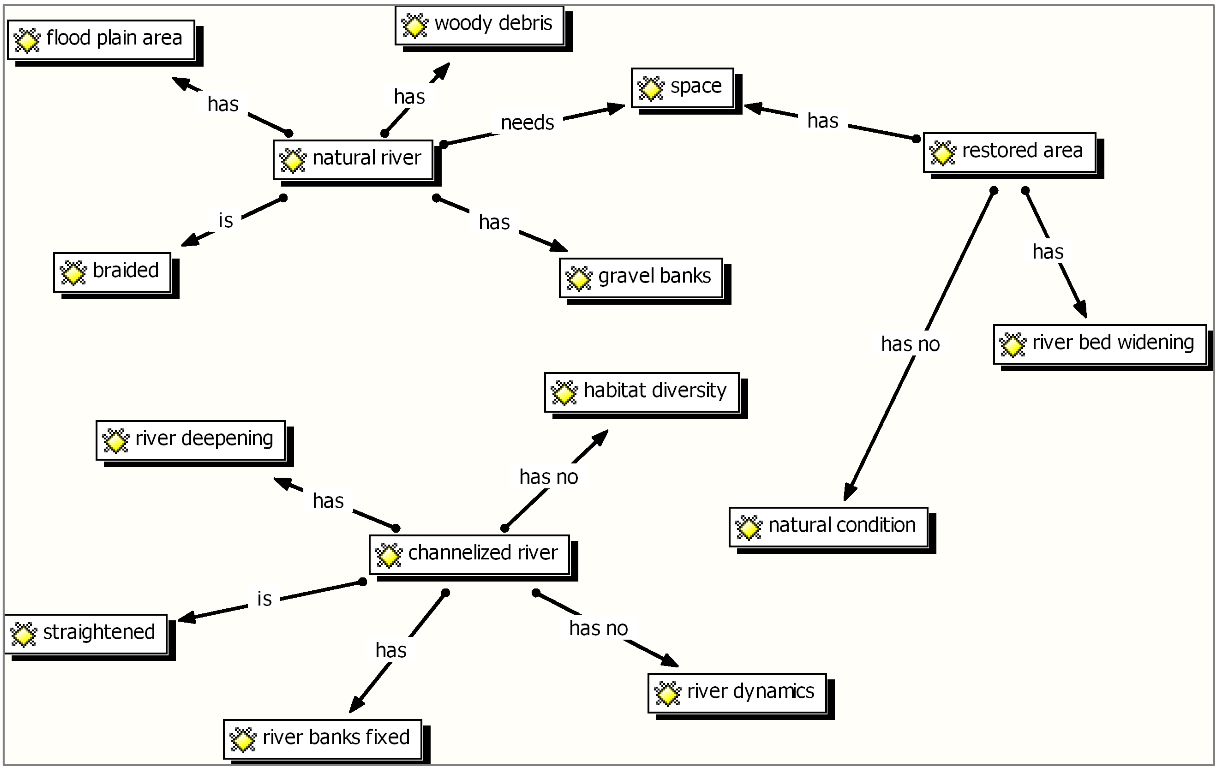

Figure 8.32: Pre-test network view of the BOKU evaluations (student 2).

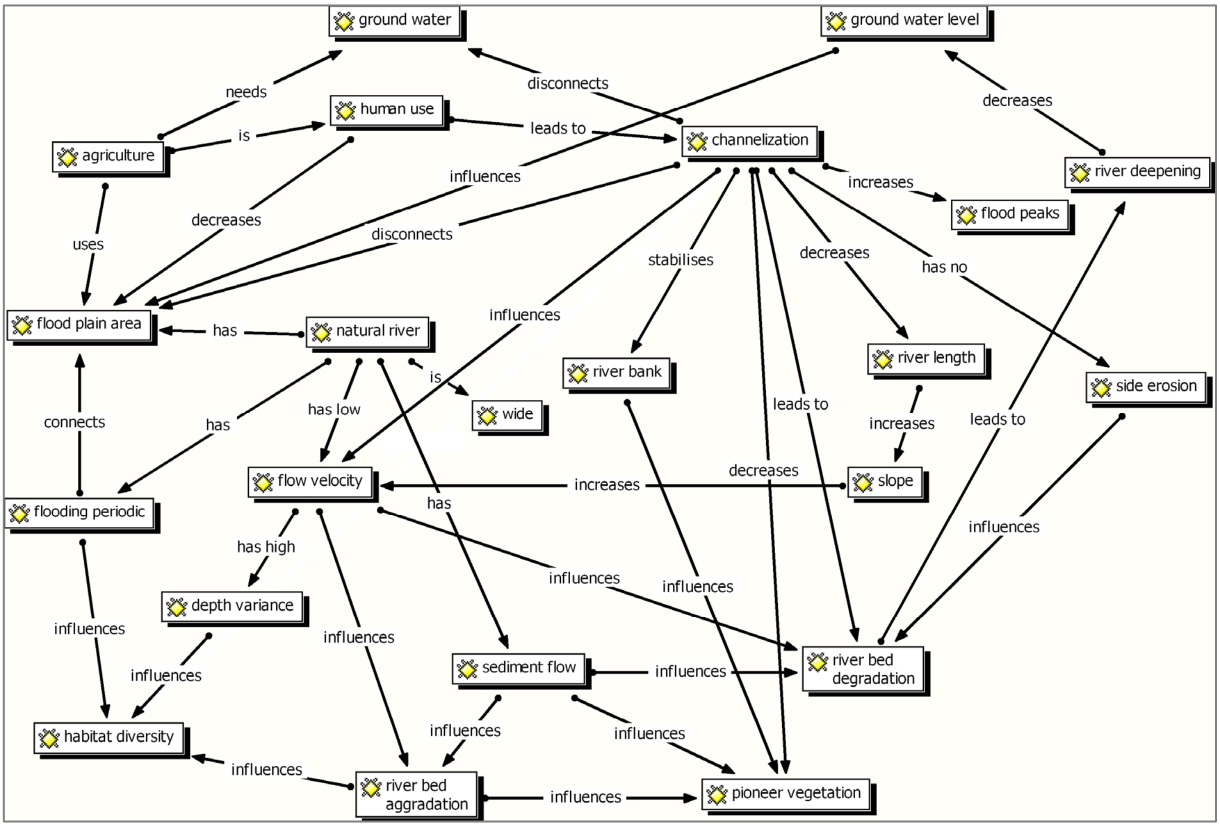

Figure 8.33: Post-test network view of the BOKU evaluations (student 2).

8.3.3. List of selected causal verbal expressions

To do something (sth.) to achieve sth.; sth. has an effect on sth.; sth. causes sth.; if you change sth., sth. else will change; influence; increases/decreases/goes down because; due to; sth. influences sth.; because; hence; sth. leads to sth.; sth. is reached by sth.; sth. happens due to/by sth.; depends on; so; sth. sinks/rises/increases/decreases and therefore sth. other happens; sth. leads to a loss/increase/decrease; after; sth. produces sth.; sth. effects sth.; without an effect on sth.; sth. is done to achieve; changes or effects occur due to; if - then; sth. is the cause for sth.; sth. is followed by sth. because of; sth. takes place because of; sth. is done because of; sth. is regulated by; sth. changes another thing; the more - the more; sth. happens due to, sth. is changed due to; sth. depends on; change of, lack of; supported by; has impact on; .

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