A new web based eLearning Platform for Building Simulation

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Abstract
The use of web based building simulation enables students to study building's performance under various aspects and to explore interrelations between different physical phenomena. The platform EnOB:Lernnetz enables students to acquire knowledge on new topics or consolidate knowledge. It offers also the application of theoretical knowledge on virtual buildings. By the use of a central project data model it is possible to serve different simulation applications with uniform data. Projects can be totally modelled within a web-browser. The platform is designed for educational work. Technical barriers for students are reduced and self-organized learning is enhanced.

Keywords: Building Simulation, Building Physics, eLearning

1 Introduction

In the fields of energy and building physics there is a lot of simulation software on the market ranging from simple to specific and very complex.
If a student wants to do artificial or daylight simulation for a room or a building, there are various applications available. Some are designed for planning artificial lighting and obtaining the necessary certificates. Other software is kept universal, that theoretically nearly every lighting situation can be calculated with. But the latter is hard to learn.
Interrelations between artificial light and daylight, like daylight autonomy or the electricity demand can be calculated rudimentary. But the results are not very satisfactory, because essential aspects like the shading of the windows are not considered. To calculate the total energy demand for the regarded zone, it is necessary to switch to other special software for energy calculation. The consequence is, that the already modelled zone has to be modelled again or must be described by numbers.
If a student investigates interrelations by varying parameters, like the shading or the window geometry and quality, it would be necessary to change the parameters in two different applications. Should other aspects like acoustics or thermal comfort additionally be taken in account, the number of used software increases. Multiple modelling and the handling of different applications make the creation of variants more difficult. Not all software is available for the common operating systems. Additionally, a student may be constrained by software licences.
Complex simulation software is often not suitable for student work because of its multiple options. This is of special importance for students, who are new to a topic. If self-organized learning should be encouraged, it is necessary to reduce technical barriers as much as possible.

2 Learning with virtual buildings

The learning platform EnOB:Lernnetz empowers students to acquire self-organized fundamental knowledge about energy-optimised constructions and building physics. The cooperative project is funded by the German Federal Ministry of Economics and Technology. Project partners are Bergische Univeristät Wuppertal and Universität Dresden.
The platform is structured in a content based area and an experimental area. With interactive learning modules students can acquire knowledge on new topics or consolidate knowledge.
The experimental area offers the application of theoretical knowledge on virtual buildings. Energy and building physics simulations can be done for any building.
Until the end of the project, the simulation modules will cover the features energy, visual comfort, light, heat, humidity, acoustics and fire-protection.

2.1 The learning platform

The learning platform is web-based so that it can be used with nearly all browsers available on the market. Having an account for the platform, licences for different simulation applications don't have to be considered anymore.
Limitations by operating systems are kept as small as possible, so that the platform can be used on the common operating systems entirely. This reduces technical barriers for students evidently.

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The conceptual design of the platform emphasized the use of components and modules. Graphical components are editing elements which can be used even without the Lernnetz in energy, and building physics applications. An example for such a graphical component is the editing dialog for surface colours. Modules are clearly separated program parts that can be executed and reused within the Lernnetz.
Components and modules are used on the one hand because of technical and rational reasons. On the other hand the usability of the platform is increased. It becomes a uniform surface for users which looks and behaves the same way in any situation. This reduces the time of incorporation and enhances intuitive handling.

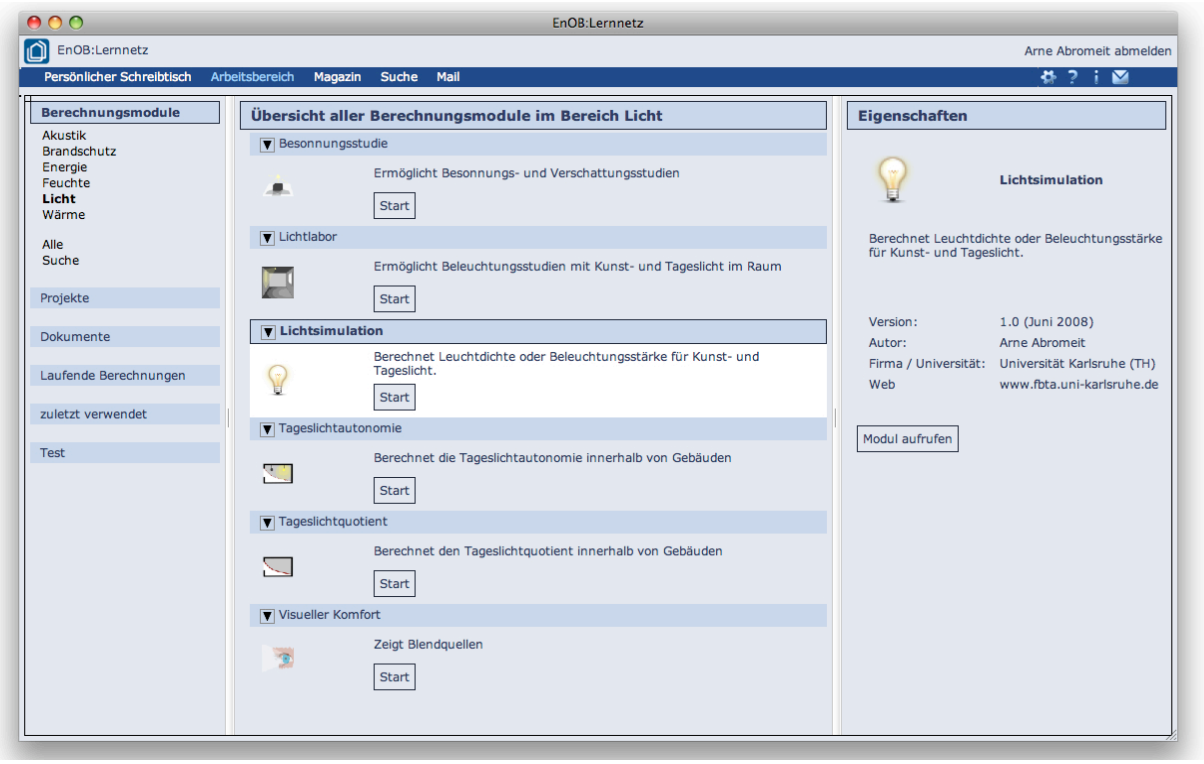

Figure 1. The learning platform in a browser – overview over simulation modules for the topic light

2.2 Technical design

The system for the EnOB:Lernnetz is JAVA based, modular and portable. The usage of JAVA as the programming language ensures that software is executable on different operating systems and can be used in a plugin for web-browsers. On client server systems the great advantage is that identical code can be executed on the client as well as on the server.
The module concept ensures an independent development for every module. The usage of ready to use components and the binding of existing modules in new ones reduces the work for new modules.
The system is kept abstract and can be implemented in a web-based context as in a native environment as well without modifying any module's source code. This makes the system portable to different environments.

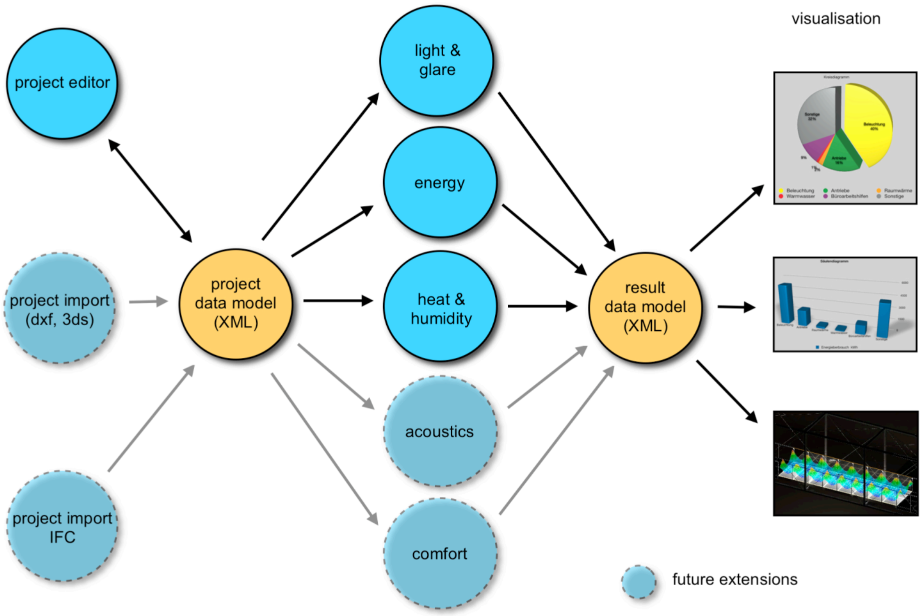

Figure 2. Simplified modular design of the system – project- and result data are essential parts of the EnOB:Lernnetz

As a base for the new learning platform the learning management system ILIAS [1] is used. It offers fundamental eLearning components like forums, queries, tests and learning modules.
To implement the experimental area in ILIAS, new dynamic web-pages were created to integrate the existing ILIAS pages in the new platform.
The complete new system with components and base modules is established as an Open Source project. The future integration of commercial modules is permitted. The licence for the project is "GNU Lesser General Public License" (LGPL).

3 Building simulation

For empirical learning it is reasonable to offer multiple paths to the user. Simulation modules therefore should allow for multiple entry points. For a lighting simulation one path could be for example to model a whole building or residential area and pick out some rooms subsequently for lighting studies. An alternative path could be to start from scratch with only few parameters and do an artificial lighting simulation in a single room.
The alternative path depends on the respective questions and topics. Simulation modules have to be designed and programmed to offer these different entry points.
Whatever path is taken it leads to a uniform project data model. Modules related to another topic can be executed with the same project data. This enables to perform an acoustics or thermal simulation for the same room, which formerly was studied in respect of light. The uniform project data model builds the base. Various simulation modules can read from the project data model and add additional data to it.

3.1 Project data model

For the description of buildings, rooms, single building elements and their associated properties an XML-document format [3] is used. The XML schema for the project data model was developed in the project "Multimediales Lernnetz Bauphysik", funded by the Federal Ministry of Education and Research [4].
The XML-based document format is structured hierarchically and relationally. This means, that within a building the different levels, the elements within one level and so on are stored. This hierarchical structure starts on site level with multiple buildings and surrounding parameters and reaches to element level like windows or luminaires. Besides the hierarchical structure relations between elements are described. This enables for example to find out which elements are associated with each other or which rooms are next to the elements. This is the precondition to deliver the same project data to different simulation modules. For lighting simulation modules this hierarchical and relational data structure also reduces rendering times.
For all objects three-dimensional data is available. Surface properties are stored simplified with colour and reflectance and complex with additional mappings. Luminaires are stored with light emitting data and a short description. For daylighting simulations glazing information is included for every window element.

3.2 Modelling projects

For modelling buildings and projects there is an editor module which reads and writes the XML-project data format. The editor module is a simple CAAD (computer aided architectural design) application. Multilevel buildings with free design of rooms and walls can be modelled. Objects like windows, furniture or luminaires can be placed into rooms or onto walls.

For further description of details there are properties for every object. Such properties are for example layer sequences or surface properties of walls, slabs and roof elements. For property editing there are special components like a surface colour dialog.

A detailed building can be created with little effort in the project editor module, by simple geometric drawing and few editing steps in object properties.

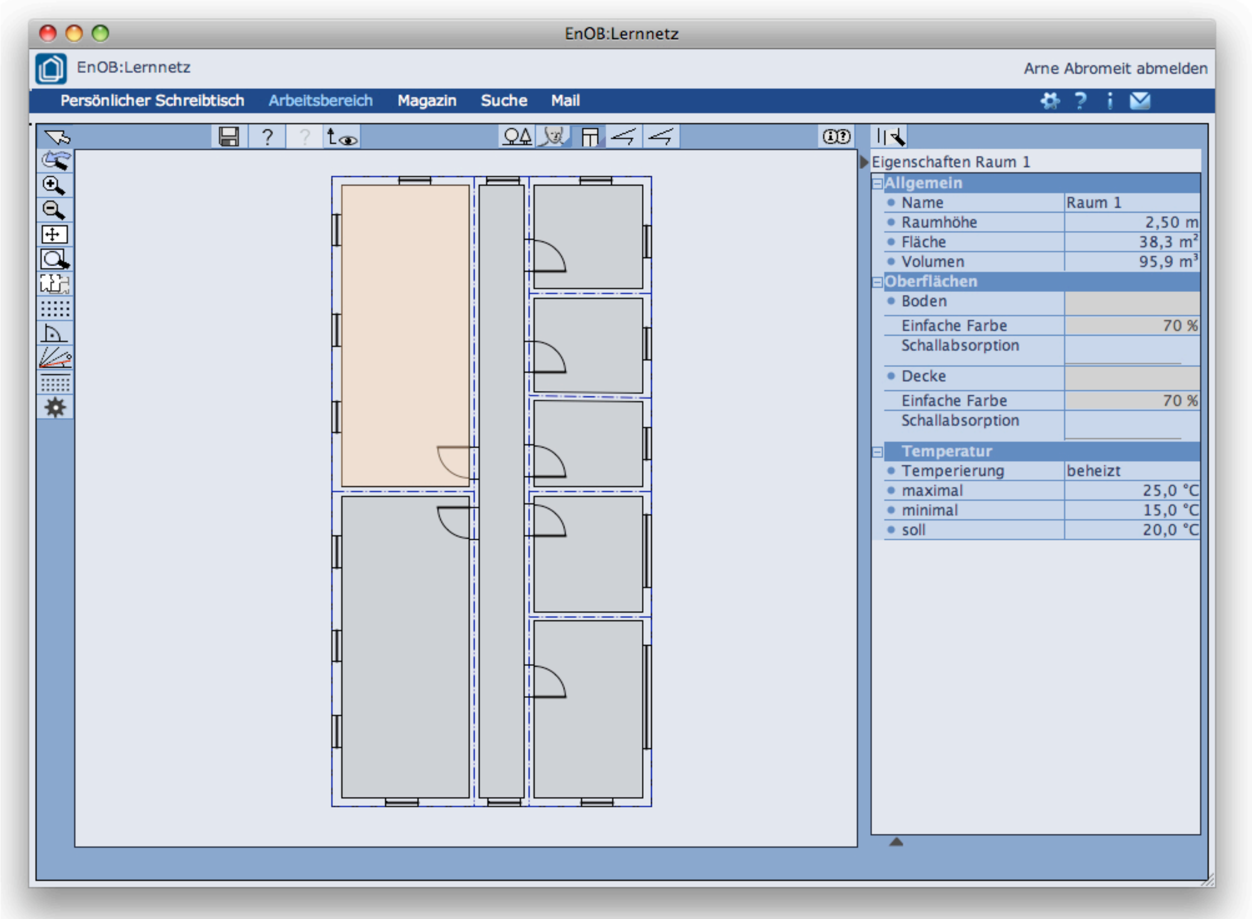

Figure 3. Module for modelling of buildings (plan edit mode)

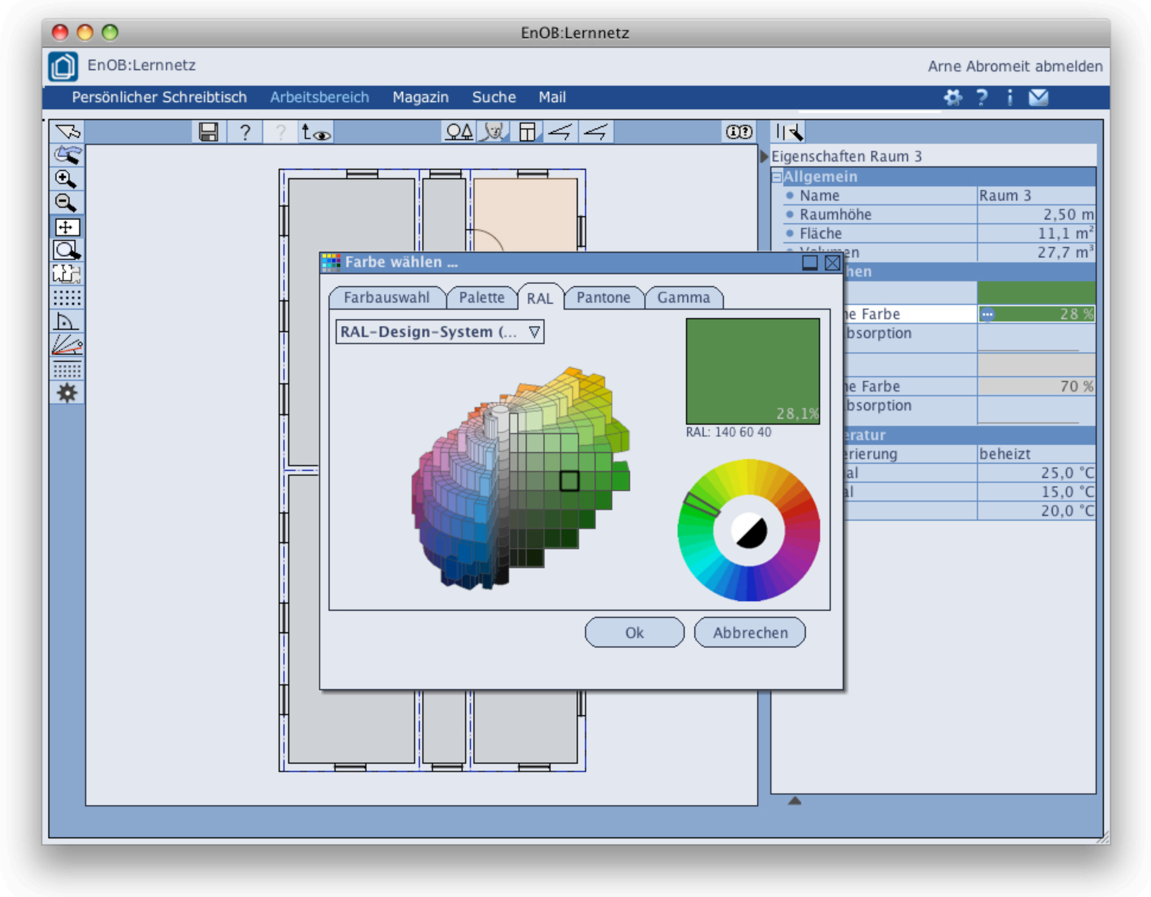

Figure 4. Graphical component for surface colour editing

3.3 Simulation modules

Energy and building physics simulations can have different complexity. Therefore simulation modules can be simple dialogs with low calculation time. But it can also be necessary to control extensive native simulation software. To enable this the system offers various technologies, which can be used by simulation modules. Server-side services provide the outsourcing of application parts from the client to the server. This technology can be used to avoid huge data transfers to the client. With the use of tasks native applications can be included in simulation modules. The native tasks are executed on a special task-server. This enables executing complex native software like RADIANCE [2] in simulation modules.

Lighting simulation modules are using these technologies to improve the performance for users. With the help of server-side services only a small part of data is transferred to the client to prepare the simulation settings. The simulation itself is prepared on the server and is send to the task-server. On the task-server a RADIANCE simulation is executed. Results are stored on the server and can be analysed on the client with visualization modules.

3.4 Results and visualization

Besides the uniform description of building data the format and organisation of result data are important aspects. Results are stored by the system hierarchically. The system also saves project data, which were relevant for the calculation of the result. This enables the retracing of building and environment parameters for a result at later times. The retracing of parameters is very important for self-organized learning.

The format of results is uniform for all modules to allow the comparison of results and the creation of variants to observe relations. A further advantage of the uniform result data format is that simulation modules do not need special visualization components. To visualize result data simulation modules can take use of existing visualisation modules. There are visualization modules for several chart types like line, bar or pie charts. For image based results like luminance images there is a visualization component which allows analysis of image data and false-colour rendering.

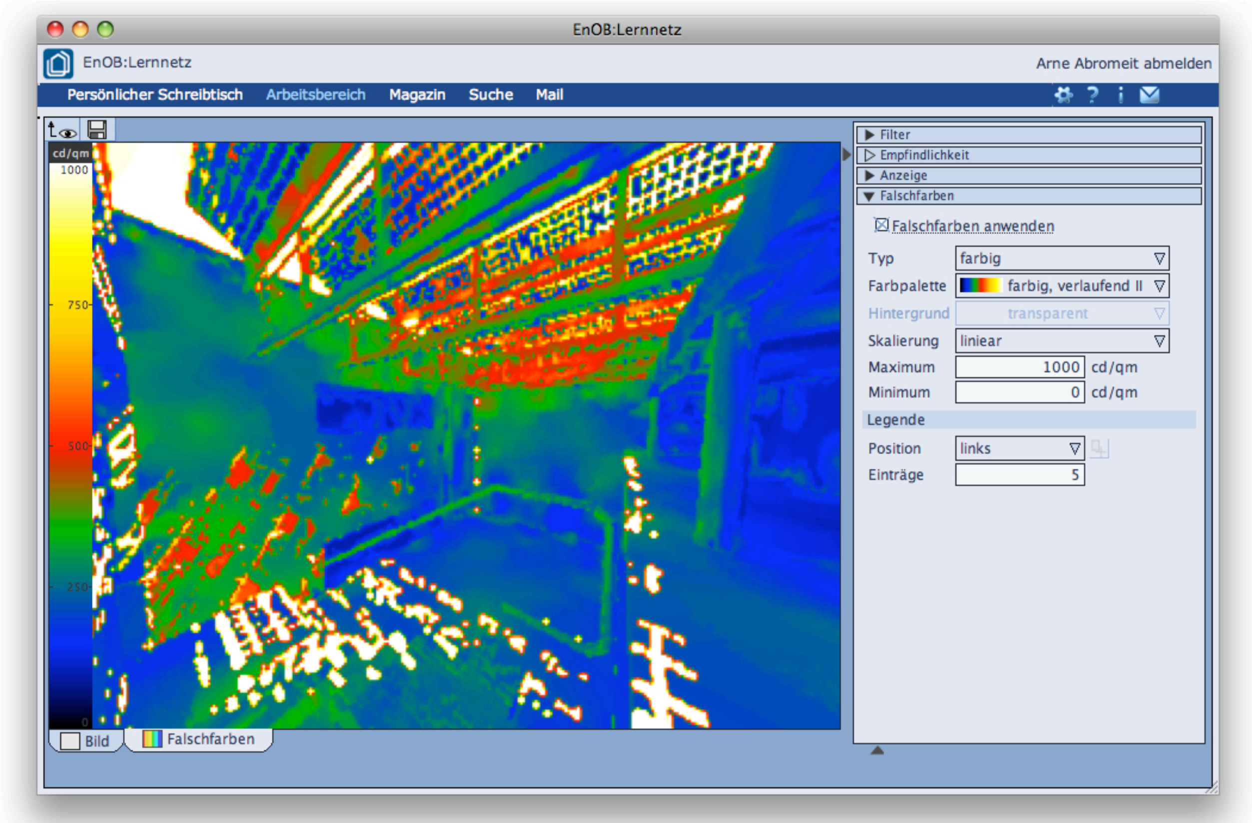

Figure 5. Module for luminance image analysis

4 Current state and perspective

Actually the platform, the simulation and the visualization modules are in alpha state. This means that there is still a strong dynamic in development.

The complete platform will reach beta state in January 2010. This means, that the functionality of the platform and modules will change only slightly. Then emphasis will be given to removing errors during this state.

In autumn 2010 the platform will be tested in practice within a summer academy. Positive and negative feedback can be considered and improve the platform till the end of the project. The management of the platform and the coordination of further development will organized by the non-profit association "Lernnetz-Bauphysik" [5].

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