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# A Novel Blended Learning Environment for Sustainable Energy Management – First Evaluation Results

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## Abstract

*Developing competences for sustainable energy management does not only demand expertise in technology and physics, it also requires the ability of decision making under controversial constraints and insufficient evidence. BLUKONE ("Blended Learning Unterrichtskonzept zum Kompetenzerwerb Nachhaltiges Energiemanagement") is a Learning Environment accepting this challenge by blending content learning with personal, social and strategic skills within a serious game design. Eilks et al. [1] provided evidence that problems of open character with no unique expected solution can be used for training the students´ tolerance of ambiguity and that re-enacting such controversial situations is an ideal training on how to successfully deal with opposing opinions. Socio-scientific Issues (SSI) are widely used in the field of sustainability, following this same approach [2].*

*Thus the BLUKONE design tries to foster the students´ decision making skills by modeling realistic situations in a game based environment, offering one group discussion and several role plays. These situations are analyzed against the model of decision making developed by Eggert & Bögeholz [3] where the decision process consists of the steps "evaluation", "decision", and "reflection". In the last step students learn to analyze their own values and norms, as well as those of others.*

*The research questions of interest concern the change in the students´*
*(1) knowledge of energy and alternative energy issues and*
*(2) their decision making ability*
*while using the BLUKONE environment.*

*The first is evaluated using a survey based on parts of the Energy Concept Assessment by Neumann et al. [4] and the Energy Literacy Survey by DeWaters & Powers [5].*

*Data on the latter are available as audio- and videotaped presentations and group discussions which are part of the learning environment. They are analyzed using the "conversation analysis" method as described by Bohnsack [6].*

*The group discussions monitored indicate that the students´ decision making skills are not advanced in the beginning: Decisions are made mostly intuitively with post-hoc reasoning. In the upcoming small simulation games we hope to observe more complex patterns of argumentation, combined with a more elaborate use of factual knowledge.*

## 1. Introduction

The necessity of sustainable development was first reported by the United Nations Brundtland Commission [7] who then described it as development meeting "the needs of the present without compromising the ability of future generations to meet their own needs". International and national energy policies nowadays show the need for Sustainable Energy Management (SEM), leading to a new qualification sought for in the labor market. Thus, a blended learning course presenting Sustainable Energy Management – BLUKONE – was developed. It is a one year elective course designed for 11th grade students attending an Austrian technical college of engineering (HTL). The BLUKONE environment comprises a work load of about 50 hours, with cooperative phases and role-playing at school and solitary eLearning phases at home. Students, who already have considerable factual knowledge, are offered the possibility to train their social skills like decision making, communication, and presentation while at the same time acquiring more specific sustainable energy

knowledge. Completion of the course will provide the students with a certified qualification of "Sustainable Energy Management (SEM)" for the labor market.

## 2. Rationale

In a course on sustainable energy management students learn "that engineering operates in a broader societal context" [8] and that technical designs always have to satisfy the constraints of a complex societal system. Technological knowledge and knowledge of legal constraints are to be combined with ecological, economical, and social aspects when looking for a solution fulfilling the criteria of SEM [8]. Within the so called BLUKONE-*EcoQuests* students develop the competences necessary for SEM in interactive, realistic scenarios. The problems are taken from the context of companies and their energy management. As in socio-scientific issues (SSI) [2] the problems offered have more than one valid solution. The act of solving these problems is an act of negotiation which requires the ability to change perspective. Throughout the BLUKONE course students are exposed regularly to various interactive, realistic scenarios where decisions have to be made. The grand final of the course is a role-play where the students re-enact a SEM situation in a company, thus showing their progress in this field. Table 1 below gives an overview of the skills learned and exercised in BLUKONE.

| | knowledge dimension | procedural knowledge dimension | personal, social, and strategic competences |
|---|---|---|---|
| *EcoQuest1*<br><br>Introduction to SEM | - energy & efficiency (in the students´ everyday lives) | applying tools like input-output-analysis, cost calculations | group discussions, basic decision-making within a peer group |
| *EcoQuest2*<br><br>acquisition of information | information on: passive house / light & transport solutions / photovoltaics | creating presentations / sales quotes / information booklets | more complex decision-making |
| EcoQuest3<br><br>designing an energy policy | energy policy | implementing ISO 50001 | complex decision-making, giving feedback |
| EcoQuest4<br><br>goals and measures | correct phrasing (goals & measures) | creating goals & measures | marketing solutions |
| EcoQuest5<br><br>Role-play SEM | application of factual knowledge and skills acquired above; interaction with others in the role-play situation; very complex decision-making | | |

Table 1. BLUKONE course cooperative phase (*EcoQuest*) contents.

Eggert & Bögeholz [3] classify different types of decision-making, splitting the process up into the steps *evaluating*, *deciding,* and *reflecting* (Bewerten, Entscheiden und Reflektieren). The final step calls for reflection of one´s own values and norms, as well as those of others when searching for sustainable solutions.

## 3. Methods

BLUKONE is a research-development project. The learning environment is currently tested in a total of three classes of two schools. Class A1 is from a city school (IT branch) and has 22 students. Classes

B1 (23 students) and B2 (26 students) are from the electrical engineering branch of a school in the countryside.

Two main research questions are of interest during the first test run:

*How do the following characteristics change during the students´ use of the BLUKONE environment:*

*(1) the students´ knowledge of energy and alternative energy issues?*

*(2) the students´ decision making ability?*

The first research question is investigated in two ways: in a pre-post-test design evaluating the students´ energy literacy (cf. [5]) and knowledge of alternative energy issues in a questionnaire. By combining the Energy Concept Assessment by Neumann et al. [4] with the energy literacy survey by DeWaters and Powers (high school version, translated into German) the BLUKONE energy questionnaire was created. It can be completed about 45 min and is composed of five parts evaluating the following energy aspects: part 1 introductory questions, part 2 factual knowledge, part 3 concepts, part 4 behavior, and part 5 opinion. The identical questionnaire is applied before the start of the BLUKONE course and after its final session.

Of Neumann et al.´s assessment we chose ten items (of the 31 items published in the Technical Handbook) As the Energy Concept Assessment was originally designed to evaluate grade 6-10 students´ concepts with respect to four conceptions of energy: forms and sources, transfer and transformation, degradation, and conservation, we could not only choose items closely related to the BLUKONE course. In order to maintain the assessment construct we had to include a few items with a context differing from BLUKONE. We also omitted the helpful clues originally designed to offer items of variable difficulty for lower grade students as BLUKONE students are already in grade 11.

Only few questions of the Energy Literacy Survey were omitted, namely those related to national energy issues and those questions aiming at the students´ energy concepts.

Further information on the students´ opinion and knowledge concerning energy issues can be extracted from the video and audio recordings of the students´ discussions, presentations, and role-plays by analyzing it with respect to the content, i.e. to the students´ concepts of energy and the factual knowledge used.

For the second research question we also rely on the data provided through the monitoring of the student groups, but this time with respect to the quality of the argumentation and interactions, and the reflection of the decision making process.. For this purpose the recordings are analyzed using the “conversation analysis” method as described by Bohnsack [6]: beginning the analysis by identifying sequences in the conversations and paraphrasing their contents, following the “conversation analysis” we then choose the most promising sequences, transliterate them and analyse them according to the three categories described by Belova et al. [9]: *Domain*, *Level*, and *Reference*). *Domain* classifies the quality of the arguments used, identifying different sources such as everyday life, science, etc. (Thus, in the later stages of BLUKONE we also hope to find more arguments assigned to factual knowledge activated in the course). Belova et al. report that within the category *Level* “the level of an argument, which reaches from simply repeating a particular claim all the way up to constructing complex arguments composed of different claims with accompanying justifications and/or reflective elements” is analyzed. *Reference* refers to the interactions between the students during conversation.

If necessary (and feasible) we consider analyzing the students´ intermediate products like presentations, calculations, designs etc. to gather even more information about the students´ development within the BLUKONE course.

## 4. Results and Discussion

In the long run, the individual development of the students is of interest, not a detailed interpretation of their energy literacy status before the course. Therefore, for the time being, we will only present a short information on the classes´ performance in the questionnaire:

| | | energy facts | energy concepts |
|---|---|---|---|

| | | | |
|---|---|---|---|
| class A | 19 students | 43,9% | 27,4% |
| class B1 | 23 students | 70,7% | 33,0% |
| class B2 | 25 students | 66,2% | 36,0% |

Table 2. Correct answers per class on part 2 (energy facts) and part 3 (energy concepts).

Table 2 shows that the classes´ performance in part 2 (factual knowledge) is much better than in part 3 (energy concepts). Apparently students found the *10 energy concept items* rather challenging, as reflected in their performance on these items. Apart from that it is interesting to note that the two classes (B1, B2) from the same school (country-side school B) achieved similar scores.
Part 4 and part 5 of the questionnaire were dedicated to evaluating the students´ behavior and opinion regarding energy conservation and alternative energy issues. Our findings on the classes´ opinion on energy issues is, in fact, correlated to our observations during the lessons: school B (classes B1 & B2) displays higher motivation for BLUKONE – in the questionnaire about ¾ of the class assign energy issues more than average importance.
Interestingly enough, the opinion on the importance of energy issues and the students´ behavior do not coincide. (For example, of class B1 only three students affirmed more than average agreement with the following 2 statements: “I try to save water.” and “Many of my everyday decisions are affected by my thoughts on energy use.” Only one student affirmed more than average agreement with “I am willing to buy fewer things in order to save energy.”)

| | opinion | | | behavior | | |
|---|---|---|---|---|---|---|
| | more than average | Highest | High | more than average | highest | high |
| class A | 51,7% | 24,8% | 26,9% | 45,8% | 27,4% | 18,4% |
| class B1 | 71,4% | 37,3% | 34,0% | 39,6% | 20,9% | 18,7% |
| class B2 | 75,5% | 39,3% | 36,2% | 56,8% | 30,0% | 26,8% |

Table 3. Behavior and opinion on energy (conservation) issues.

For the second research question only few data are available so far. The few analyses of the video material already finished show that the students´ group discussions were hesitant in the beginning. Their argumentation and decision making skills are not very advanced yet. The decisions were mainly made intuitively with post-hoc reasoning.
As our research focus is on the development of the student groups over the course of the BLUKONE test run, we still have to collect more data from later sequences in the BLUKONE curriculum for further analyses.

## 5. Conclusion and Outlook

Currently the test run of the beta version of the BLUKONE learning environment has only reached the third (of five) phases.
After completing the entire test run the data on the development of the students will be evaluated. For this purpose it is possible to compare different entities. For the time being, our focus is on the development of student groups. Facing the same data with a different focus of either the individual´s development or the class´s development might be beneficial, though time-consuming.
After the final phase the students will, once again, be confronted with the same BLUKONE energy questionnaire. Their results then have to be compared with the initial findings. It is expected that their performance on the questionnaire will have improved, providing us with a measure of their gain in knowledge on sustainable energy issues due to the completion of the course. We might also detect a greater awareness of energy issues in the students´ replies (part 4 and part 5).

The analysis of the videos will also offer more data on the students´ performance in the field of decision making. Here, it is also expected to notice a clear improvement as students are repeatedly exposed to situations of required decision making. These situations are combined with phases of reflection on the students´ own performance in these situations. We expect to see a more deliberate use of decision making strategies and of more complex patterns of argumentation, combined with a more elaborate use of factual knowledge. This would be a sign of the students´ decision making skills improving.

The summer term 2014 will bring ten more classes registered for BLUKONE. Using data acquired from these classes we can hope to extend reliability of our data.

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