IV International Conference on Civil Engineering Education
EUCEET 2018
J. Turmo, & J.A. Lozano (Eds)

AN E-LEARNING-CONCEPT FOR RESEARCH BASED LEARNING IN STRUCTURAL DYNAMICS

JUDITH C. BEIER[1], JÖRG LANGE[2], WOLFRAM KUHLMANN[3]

[1]TH Köln (University of Applied Sciences),
Betzdorfer Straße 2, 50679 Cologne, Germany
judith.beier@th-koeln.de

[2]TU Darmstadt
Franziska-Braun-Straße 3, 64287 Darmstadt
info@stahlbau.tu-darmstadt.de

[3] TH Köln (University of Applied Sciences),
Betzdorfer Straße 2, 50679 Cologne, Germany
wolfram.kuhlmann@th-koeln.de

Key words: Education, E-Learning, Methodology, E-Learning, Wiki.
Abstract. As part of a joint research project between TH Köln and TU Darmstadt an e-learning-concept is being developed. This concept provides students with an opportunity to engage in research regardless of their semester and specific time within the academic year.

The project focuses both on educational development and on engineering research.

The engineering part is about the load model for human induced vibrations, described in the guideline VDI 2038. The current load model needs revision and must be completed because of missing values for horizontal loads and differences compared to the latest load models used in biomechanics.

The e-learning-concept is evaluated in different areas, like the achievement motivation of the students, the acceptance of the concept and its effectiveness. Therefore, it can be regarded as a Scholarship of Teaching and Learning project.

The concept includes a wiki containing all basics of structural dynamics and measuring technology as well as information on the load model. The students work on small projects. The scope of their study is based on the required workload of the respective module. The students summarize their results in a new wiki page that subsequent students can use for their projects. The students shall obtain a good understanding of the connections between different modules and constitute a research community. They can participate in the research project in two optional modules within their bachelor curriculum, two optional modules within their master courses and in their bachelor and master thesis.

The results during the first year after implementation are predominantly positive. The students are commonly motivated and get a good understanding of the subject. The connection between research based learning and e-learning enables the instructor to supervise a lot of different student projects and the students can apply the newly learned contents to a larger research project.

1 INTRODUCTION

At TH Köln an e-learning-concept is being developed, which gives students an opportunity to engage in research projects. Optional modules, in which the students learn about carrying out experiments and measuring technic, are often chosen by few students only. Due to the fact that there is only a small laboratory with few employees there has not been going on larger research projects and there has been no link between education and research. This is the main reason why students have not participated in these optional modules. The e-learning-concept is developed to link education and research over a long time period and to enable students to work in small projects related to the research topic.

2 ENGINEERING RESEARCH

The engineering research focuses on dynamic forces caused by walking or running pedestrians. The guideline VDI 2038 – Part 1 [1] describes these loads as

$$F_{vp}(t) = F_G + \sum_i \cdot F_G \cdot \alpha_{vi} \cdot \sin(2 \cdot \pi \cdot i \cdot f_{vp} \cdot t - \varphi_{vi}) \quad (1)$$

for vertical loads and

$$F_{hp}(t) = F_G + \sum_i \cdot F_G \cdot \alpha_{hi} \cdot \sin(2 \cdot \pi \cdot i \cdot f_{hp} \cdot t - \varphi_{hi}) \quad (2)$$

for horizontal loads.
In these equations F_G is the weight of the pedestrian, f_{vp} and f_{hp} are the excitation frequencies of the pedestrian and t is the time. A table shows the values for the load coefficient α_i and the phase angle φ_i. As seen in figure 1 this table is incomplete.

Type of movement	**Frequency** f_{vp} resp. f_{hp} in Hz	α_{v1}	α_{v2}	α_{v3}	α_{h1}	α_{h2}	**Density of persons** in Pers./m²
Walking	1,6 to 2,4	0,4 to 0,5	0,1[a] to 0,2	0,06[a] to 0,1	0,1	[c]	0,5 to 1,5
Running	2,0 to 3,5	to 1,6	to 0,7	to 0,2	0,2	[c]	0,5 to 1,5
Jumping (sport)	1,8 to 3,4	1,7 to 1,9	1,1 to 1,6[b]	0,5 to 1,1[b]	[c]	[c]	0,25 to 0,5
Climbing stairs	1,2 to 4,5	to 1,1	to 0,2	[c]	[c]	[c]	[c]
Dancing	1,5 to 3,0	to 0,5	to 0,15	to 0,1	[c]	[c]	4 (to 6)
Jumping, bobbing up and down (events)	1,5 to 3,0	(2,1…0,15) f_{vp}	(1,9…0,35) f_{vp}	(1,25…0,33) f_{vp}	[c]	[c]	4 (to 6) resp. 1 pers./seat
Applauding (unseated)	1,5 to 3,0	0,17 to 0,38	0,01 to 0,05	0,02 to 0,04	[c]	[c]	4 (to 6)
Applauding (seated)	1,6 to 2,4	0,02 to 0,17	0,01 to 0,05	0,01 to 0,04	[c]	[c]	2 to 3
Swaying horizontally	0,4 to 1,5				0,25 to 0,5	to 0,05	4 (to 6) resp. 1 pers./seat

[a] $\varphi_2 = \varphi_3 = \frac{\pi}{2}$ [b] $\varphi_2 = \varphi_3 = \pi(1 - f \cdot t_{Bodenkontakt})$, $\varphi_1 = 0$ [c] Reliable figures are not available.

Figure 1: Table 3 of VDI 2038-Part1: Recommended ranges for frequencies, density of persons and load coefficients of excitation for different types of movement

During the research project students will carry out experiments to concretize the values of the table and compare them with the load models used in biomechanics [2].

3 DEVELOPMENT OF THE E-LEARNING-CONCEPT

3.1 Description

The e-learning-concept sets up on the e-learning-functions of the learning-management-system (LMS) ILIAS. Wikis, a glossary and a tool called “spaces” are used.

The wiki and the glossary are used to impart the basics of structural dynamics and the results of preceding student-projects (see figure 2). “Spaces” is a platform used to communicate and discuss fundamental questions. It can be compared to a social media platform like Facebook, but it is a closed platform and only used for topics related to the research project.

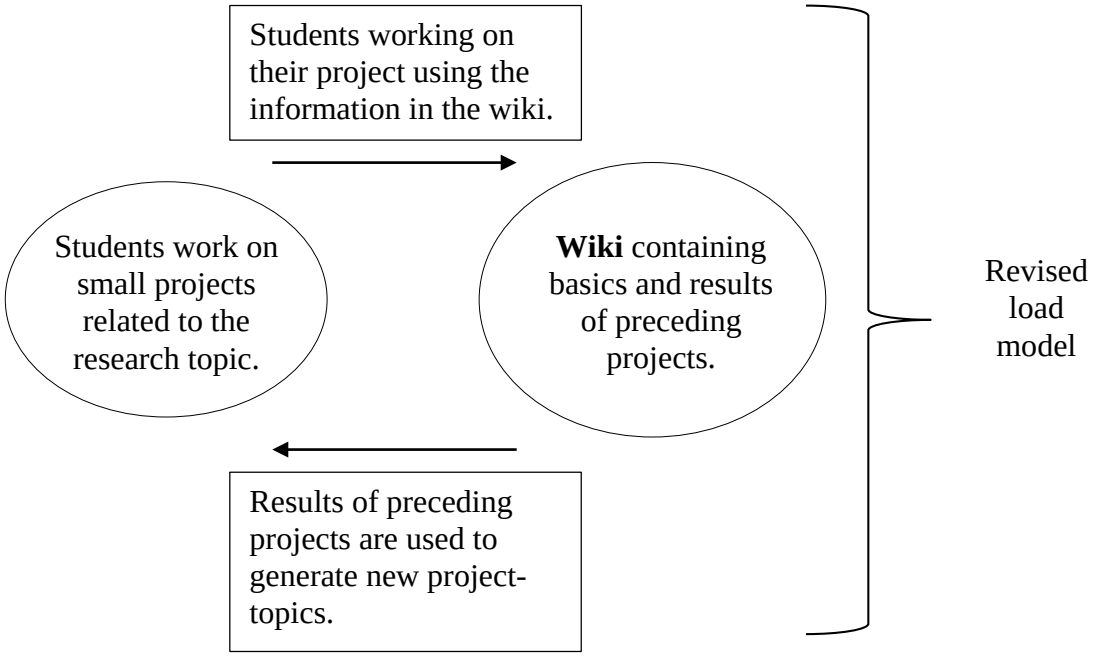

Figure 2: Schematic representation of the e-learning-concept

While knowledge transfer is based on e-learning-tools, students have the opportunity to get consulting and support in meetings with the academic supervisor and discuss problems in spaces with other project-groups.

Students can participate in different optional modules in their bachelor or master curriculum or in their bachelor or master thesis. The topics of their projects are based on the focus of their optional course and the workload of their chosen module or thesis. Therefore, there are projects with a main part in carrying out experiments and using measurement technology and there are other projects which focus on mathematical evaluation and comparison of different load models.

At the end of the particular modules the students have to write a new wiki-page and a scientific elaboration of their results. They also have to take part in an oral examination to measure whether the intended learning outcomes are reached.

3.2 E-learning tools

The LMS ILIAS uses courses to sort different tools and contents. All e-learning-tools and documents needed for participating in this research project are in an ILIAS-course where the students are invited to by the lecturer.

3.2.1 Wiki

The primarily used e-learning-tool in this concept is a wiki. The wiki starts with a main page (see figure 3), describing the main topics like basics of structural dynamic, measurement technology, the measurement software (MEDA), and human induced vibrations. In the pages are texts, pictures and videos to explain the topic to the students. The hyperlinks in the text link to related pages. It is important to keep the wiki well structured, because it is a nonlinear tool.

Figure 3: Screenshot of the main page.

For the students a table of contents is provided as well as an overview which page they could read next. To support the students in using the wiki every topic has a main page where every related page is described. This enables them to learn the content of the pages which are relevant for their project.

The ILIAS-course contains another wiki called “HowTo: Wiki”. This wiki contains detailed instructions for generating a new wiki-page and how to structure the page. By using this second wiki the quality control for the student-generated pages is much easier and the pages generally have a good quality.

3.2.2 Glossary

The glossary (see figure 4) is a separate tool in ILIAS where terms of structural dynamics are defined in small articles. The glossary is created by the lecturer and the terms are linked in the wiki. The students mostly do not have a good understanding of structural dynamics when they choose to participate in the project because the first optional module in which they can take part is being taught before the (also optional) module “structural dynamics”. The glossary allows students who are not confident in using the technical terms of structural dynamics to learn the necessary basics easily.

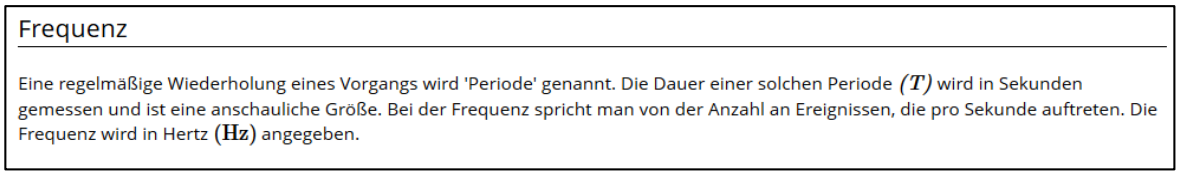

Figure 4: Glossary entry explaining the term frequency.

3.2.3 Spaces

“Spaces” is a new tool used at TH Köln enabling the students to communicate with each other and the lecturer. The students are supposed to write an “update-post” every week summarizing their work of the previous week. By using this tool, the lecturer is always informed about the students’ progress, even if there are no mandatory events. The students can use this tool to organize experiments and discuss their experiences during the project.

3.3 Quality assurance

To make sure that all wiki-pages written by students are in a good quality they are evaluated by the lecturer and other students in a peer-review process.

The wiki-page summarizing the results of a project is part of the grading. If there are mistakes in the page (for example wrong use of terms or discrepancies between the results) the lecturer corrects them in the page. This is important because the subsequent students use the page to learn about the content.

Every student has to evaluate a page chosen by the lecturer in a peer-review process. The main criteria for this process are completeness, reasonable use of media and connection to related pages. If there are any issues the students have to revise the page.

4 MEASUREMENT OF THE INTENDED LEARNING OUTCOMES

4.1 Requirements for the student-projects

Students can participate in different optional modules or their thesis in both the bachelor or master curriculum. The modules are chosen by their suggested content. The modules focus on measurement technology and test evaluation. For their bachelor and master thesis the students can choose the topic from the entire field of civil engineering. Depending on module or thesis the workload and intended learning outcomes varies. Every project work has to be aligned in scope, main focus and workload depending on module or thesis.

4.2 Grading

Regardless of the chosen module or thesis the students have to develop a written draft and a wiki page. After the grading of the written report by the lecturer the students have to take an oral examination. In this examination the students have to give a presentation about their topic and answer questions of the lecturer.

5 EVALUATION OF THE E-LEARNING-CONCEPT

The concept is being tested until summer 2020 regarding to the described research topic in structural dynamics. It started in May 2017 and is going to be evaluated and adjusted every semester. The evaluation focusses on the content of research and the concept itself. Therefore it is a scholarship of teaching and learning project [3]. Problems can be detected and (if necessary) removed. The evaluation is also supposed to clarify whether the concept can be used in non-optional modules as well.

The evaluation focusses on the achievement motivation of the students, the progress of every small project regarding to the research project, the ability to generate new project topics based on preceding projects and the effect and acceptance of the concept for students.

5.1 Achievement Motivation Inventory

For measuring the achievement motivation, a psychological test developed by H. Schuler and Michael Prochaska [4] called Achivement Motivation Inventory (AMI) is used. For each participant it provides information which item of intrinsic motivation has the highest value and the lecturer can evaluate if there are any coherences between the students who choose to participate.

The LMI divides the intrinsic motivation in 17 different items. These are *Compensatory Effort, Competitiveness, Confidence in Success, Dominance, Eagerness to Learn, Engagement, Fearlessness, Flexibility, Flow, Goal Setting, Independence, Internality, Persistence, Preference for Difficult Tasks, Pride in Productivity, Self-Control* and *Status Orientation.*

Every student has to do this test; the outcomes are handled anonymously. To be able to compare the results and draw conclusions all students in a semester have to do this test (as a reference group).

5.2 Progress

For measuring the progress of every small project work a scale is developed. It values the projects regarding to following questions:

- What are the results of the project work?
- Are these results important for the research project?
- Which scientific methods has been used to get to these results? Are the results solid?
- What new assignments can be defined based on these results?

Using a scale like this ensures that there is progress in the research and the students-projects are linked to preceding projects.

5.3 Effort and acceptance

Most students are used to classic education concepts and are participating in a research project for the first time. By interviewing the students after their project (which is mandatory) it is investigated which experiences they have had, what they think about the concept using the wiki, how they get along by learning the contents of the research project and what kind of problems occurred. Assessing the answers helps to improve the e-learning-concept and to draw conclusions whether the concept is transferable to other research projects and non-optional modules.

6 PREVIOUS RESULTS

The research project and evaluation of the concept is going to last till summer 2020. The previous results are predominantly positive.

Table 1: Achievement motivation Inventory (Status April 2018)

Item	Median reference group (n=53)	Median participants (n=10)
Compensatory Effort	49,38	47,90 (-2,99%)
Competitiveness	43,58	37,50 (-13,95%)
Confidence in Success	48,38	50,40 (+4,00%)
Dominance	47,53	47,60 (+0,14%)
Eagerness to Learn	43,11	42,10 (-2,34%)
Engagement	41,91	39,90 (-4,79%)
Fearlessness	39,74	44,50 (+10,69%)
Flexibility	47,36	47,50 (+0,29%)
Flow	51,06	51,60 (+1,05%)
Goal Setting	46,51	43,30 (-6,9%)
Independence	41,92	42,20 (-0,66%)
Internality	49,08	56,50 (+13,13%)
Persistence	44,47	47,60 (+6,57%)
Preference for Difficult Tasks	44,90	46,20 (+2,81%)
Pride in Productivity	56,60	57,10 (+0,86%)
Self-Control	46,10	46,00 (-0,21%)
Status Orientation	47,15	42,00 (-10,92%)

As seen above in table 1 there are significant differences in Competitiveness, Fearlessness, Internality and Status Orientation. These results suggest that the students who choose to participate in the research project have a higher value in Fearlessness and Internality and a lower value in Competitiveness and Status Orientation. These data have to be validated when there have been more participants.

Every past group-project contributed to the progress of the research project and the results can be used for new projects. To get a statistically significant value of data some assignments with experiments have to be done again and the new results have to be compared to the data of the previous group.

The interviews have shown that the students are satisfied with the e-learning-concept and the opportunity to join a research project. The concept provides them to choose where and when they want to work on the project and gives them flexibility.

In conclusion, it can be stated that the research-project started very well and this e-learning-concept is useful to link research and education.

REFERENCES

[1] Verein Deutscher Ingenieure, VDI 2038 Part 1: Serviceability of structures under dynamic loads, Methods of analysis and evaluation in structural dynamics, Issue German/English, Verein Deutscher Ingenieure, Düsseldorf, 2012, confirmed 2016.

[2] D.A. Winter, Biomechanics and motor control of human movement, 4th ed., Wiley, Hoboken, N.J, 2009.

[3] L. Huber, Scholarship of Teaching and Learning: Konzept, Geschichte, Formen, Entwicklungsaufgaben, in: L. Huber, A. Pilniok, R. Sethe, B. Szczyrba (Eds.), Forschendes Lehren im eigenen Fach: Scholarship of Teaching and Learning in Beispielen, 1st ed., Bertelsmann W. Verlag, s.l., 2014.

[4] H. Schuler, M. Prochaska, Leistungsmotivationsinventar: Dimensionen berufsbezogener Leistungsorientierung. Manual, 1st ed., Hogrefe Verlag für Psychologie, 2001.