Leonard Pawelzik*, Elisabeth Ibenthal, Claus Backhaus

Learning by Researching – Students enhance perfusionist's workplace with data glasses in internships

Abstract: A new internship for the module human factors engineering of the study course biomedical engineering was developed on the concept of learning by researching combining the transfer of knowledge with gathering new and publishable findings.

Students pass the research cycle, investigating whether perfusionists strain can be reduced by utilizing data glasses. Corresponding to the concept of cooperative learning, students ($n = 40$) are divided into teams of five, giving each member a predefined expert role. Each expert is responsible either for physiological measurements, the perfusionists workspace, planning of usability tests, data glasses applications or team leading.

Following the research cycle, milestones are set at which the teams present partial results to the entire group. Initially, students immerse in the field of research by reviewing literature. They prepare and present research hypotheses and select one for their investigation. Proximately, each team develops and introduces their research design. Teams organize themselves with planning test days and inviting subjects ($n \geq 10$ each team). Finally, results are presented in group and collated by each team in a scientific paper. Every team reviews a scientific paper from another team and returns it before they are sent in for grading.

Evaluation shows higher workloads for students, but also relevant and interesting input. Two groups publish their papers in scientific journals.

Keywords: learning by researching, cooperative learning, data glasses, perfusionist, human factors engineering

<https://doi.org/10.1515/cdbme-2019-0033>

1 Situation

According to *Wilhelm von Humboldt*, learning by researching combines the transfer of knowledge and gathering new and publishable findings.

Learning by researching differs from other forms of learning by the fact, that students design, experience and reflect a research project in all essential phases of the research cycle. These phases comprise the development of questions and hypotheses, the choice and implementation of methods to the examination and the presentation of results [1]. Further, insights of the examined research issue are always relevant for third parties.

The research cycle according to *Huber* [1] consists of eight steps:

1. Perception of the initial problem
2. Definition of research questions
3. Development of theoretical approaches
4. Selection and acquisition of methods
5. Development of the research design
6. Conducting a research activity
7. Analysis and presentation of results
8. Reflection of the process

The main advantages and disadvantages of learning by researching are summarized in Table 1. While deep level learning and the promotion of action competences are desired in teaching, high workloads for students and supervisors or the complex concept may be responsible that the concept of learning by researching is not extensively propagated.

Table 1: Main advantages and disadvantages of learning by researching [1, 2].

Advantages	Disadvantages
Insights into current research by combining research and teaching	Complex and demanding teaching-learning concept
Teaching does justice to student diversity	Carefully planning is necessary
Deep level learning	High workload
Promotion of action competences	

*Corresponding author: **Leonard Pawelzik:** Centre for Ergonomics and Medical Engineering, FH Münster, Bürgerkamp 3, 48565 Steinfurt, Germany, e-mail: leonard.pawelzik@fh-muenster.de

Elisabeth Ibenthal, Claus Backhaus: Centre for Ergonomics and Medical Engineering, FH Münster, Bürgerkamp 3, 48565 Steinfurt, Germany

Though it was also mentioned by the *Bundesassistentenkonferenz* in 1970 [3], learning by researching is still not comprehensively acknowledged and transferred in engineering science.

The newly created module Human Factors Engineering II is offered to master students of biomedical engineering and industrial engineering in the department of physical engineering at Münster University of Applied Sciences. The module aims to supplement the students' contentual and methodological knowledge of ergonomics with contents in the fields of biomedical technology. The module manual demands further [4]:

"The students should become familiar with all important basics for the analysis, evaluation and design of work. The internship is intended to be applied in the form of independent projects and/or analytical practical course experiments".

Therefore, an internship based on the concepts of learning by researching and cooperative learning is developed, in which students try to reduce the strain at perfusionists workplaces using data glasses.

2 Methods

The internship is structured following the research cycle according to *Huber* [1]. The initial problem is the high workload at perfusionists workplaces due to monitoring tasks [5]. The students will perform usability tests to investigate to what extent the use of data glasses can reduce the physical and psychological strain of perfusionists and which effects result from their use.

Milestones are set to discuss the initial problem, find a research question, discuss the research designs and present the results. The supervisors give advice in the milestone-meetings and are addressable for questions in the meantime.

Utilizing the concept of cooperative learning, students are divided into teams of five giving each team member a predefined expert role [6]. Compilations with basic knowledge of the scientific area and introducing papers are deposited in the learning management system *Ilias* for all expert roles. The operating instructions of the measurement equipment and the template for the paper that will be submitted by the teams are also stored here.

The physiology experts familiarize themselves with the basics of movement and electrocardiogram measurements and learn how to operate the acquisition system Biopac MP 150. They are responsible for recording and evaluating measurement values during the trials and coordinate their work with the usability experts to support the design of test scenarios.

The data glasses experts work out the state of technology of data glasses, learn how to use the Epson Moverio BT-300, coordinate their work with the cardiotechnology experts to understand the workflows and support the usability experts in designing the test scenarios.

The cardiotechnology experts get used to the basics of cardiotechnology, build up the perfusionists' workstation and visualize the work processes of the perfusionist for coordination with the data glasses expert and support the usability expert in developing test scenarios.

The usability experts familiarize themselves with the basics of usability tests and the necessary technology. They learn to use data glasses applications and to develop test scenarios in coordination with the cardiotechnology, physiology and data glasses experts.

The team leaders are responsible for communication and organisation within the team, documentation and submission of interim reports, definition of work packages and milestones and the creation of a project schedule. Furthermore, they are responsible for the exchange of information with the supervisors as well as the organisation of usability tests and the acquisition of volunteers.

In the first meeting, finding a research question was given as a homework to the teams. When presenting the results in a meeting, after a two-week familiarisation phase of the experts, the teams came up with their own compiled research issues that were discussed and reviewed in the plenum. Afterwards, each group developed hypotheses to examine in a usability test.

The third step in the research cycle involves the development of information and theoretical approaches. Therefore, the teams searched for relevant literature and exchanged information within *Ilias* and the campus cloud *Sciebo*.

The next step was the selection and acquisition of methods depending on the chosen research question. This was also done as a homework by the students.

After some general input to research designs, students developed theoretical approaches for their research questions. The condition for conducting experiments was a sample of $n \geq 10$. The research designs were presented and discussed in another meeting two weeks later.

Once all research designs had been finalised, the research was conducted by the students. They independently organised the necessary material, rooms and test persons. In order to have sufficient subjects for all teams, every student had to take part in two trials of other teams.

After the trials, results were processed and presented by the teams in plenum. In this session, students had the last

opportunity to get feedback about the evaluation of data and the description of their results in the paper they had to submit.

The reflection as the last step in the research cycle took place in the feedback session and in each discussion chapter of the submitted papers.

The teams sent in their papers which were anonymized and randomly sent to another team. A check-list was developed to provide support for the students in the review process. After one week of review the teams had another week to revise their paper and sent it in for grading. Two papers were submitted for publication, one already published [7].

The evaluation of the internship was carried out using standardized questionnaires from the university.

3 Results

Students learned to model workplaces, as intended in the module manual, in a practical and cooperative way using modern technologies and expanding their methodological skills.

In the evaluation, students assessed the workload as very high. Particularly at the beginning of the internship, the students were overburdened with the demands of the internship. Furthermore, students mentioned in the evaluation that relevant and interesting topics were offered which compensated the disadvantages. The use of modern data glasses in the internship was also rated positively.

Additionally, it was a challenge for the students to deal with scientific working methods because they had not previously been taught in the undergraduate courses.

4 Discussion

Students familiarised themselves with a new scientific area and worked self-reliant on a research question on a current topic. The digital organisation of all necessary rooms, information and measuring equipment ensured smooth test days.

The problem of the high workload for the students will be taken into account in the next semester by reducing the technical effort on the measuring equipment and giving more prepared input to scientific research methods at the beginning.

Furthermore, a change in regulations and the creation of new modules, especially for undergraduate students, is desirable to bring in knowledge of statistics, research designs and the procedure for literature researches. With short

presentations at the milestones missing knowledge of students about scientific research and statistics should be compensated.

The submitted papers show the relevance of the research performed by students and the suitability of learning by researching in teaching engineering sciences.

Author Statement

Research funding: The author state no funding involved.

Conflict of interest: Authors state no conflict of interest.

Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration.

References

- [1] Huber L. Warum Forschendes Lernen nötig und möglich ist (engl. Research-based learning is necessary and possible). In: Huber L, Hellmer J, Schneider F, editors. Forschendes Lernen im Studium. Aktuelle Konzepte und Erfahrungen (engl. Research-based learning during studies. Current concepts and experiences). Bielefeld: UVW Webler; 2009.
- [2] Hellmer, J. Forschendes Lernen an Hamburger Hochschulen – Ein Überblick über Potentiale, Schwierigkeiten und Gelingensbedingungen (engl. Research-based Learning at Hamburg Universities - An Overview of Potential, Difficulties and Conditions for Success). In: Huber L, Hellmer J, Schneider F, editors. Forschendes Lernen im Studium. Aktuelle Konzepte und Erfahrungen (engl. Research-based learning during studies. Current concepts and experiences). Bielefeld: UVW Webler, 2009.
- [3] Bundesassistentenkonferenz, Hochschuldidaktischer Ausschuss. Forschendes Lernen - wissenschaftliches Prüfen: Ergebnisse der Arbeit des Ausschusses für Hochschuldidaktik (engl. Research-based learning - scientific testing: Results of the work of the Committee for Higher Education Didactics). 2nd ed. Bonn: BAK; 1970.
- [4] FH Münster. Modulhandbuch für den Masterstudiengang Biomedizinische Technik an der Fachhochschule Münster (engl. Module handbook for the Master's course in Biomedical Engineering at the Münster University of Applied Sciences). Version 2018.2, URL: https://www.fh-muenster.de/pt/downloads/studierende/modulhandbuecher/Modulhandbuch_Master_BMT_2018_2.pdf, last access 15.05.2019.
- [5] Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. TRBS 1151 - Gefährdungen an der Schnittstelle Mensch - Arbeitsmittel - Ergonomische und menschliche Faktoren, Arbeitssystem (engl. TRBS 1151 - Hazards at the human interface - Work equipment - Ergonomic and human factors, Work system). GMBI 2015. 340:17-18.
- [6] Brüning L, Saum T. Erfolgreich unterrichten durch Kooperatives Lernen: Strategien zur Schüleraktivierung

(engl. Successful Teaching through Cooperative Learning: Strategies for Activating Students). 1st ed. Essen: Neue Deutsche Schule Verlagsgesellschaft mbH; 2006.

- [7] Sannwaldt F, Huster C, Vincentz M, Sobkowicz S, Ewers A, Pawelzik L, Ibenthal E, Backhaus C. Augmented Reality in

der Medizintechnik - AR-Brillen als Assistenzsystem für die Kardiotechnik (engl. Augmented Reality in Medical Technology - AR Glasses as an Assistance System for Cardiology). mt-Medizintechnik 2018. 138(6):15-1