Students' Attitudes Towards the Hypermedia Learning Environment "Physics for Medical Students"

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Abstracts

English

At the Heinrich-Heine-University, Düsseldorf, a hypermedia learning environment (HML) called "Physics for Medical Students" has been developed and evaluated (Theyßen 2002, Theyßen & Hüther 2003). For already several terms now it has been an integral part of physics education of medical students at three German universities. Students do not participate in the traditional lab work session any more, but instead work out the same content by means of the HML. This implementation of e-learning at university level was evaluated with regard to several aspects.

This paper deals with the students' attitudes towards the HML, especially concerning its advantages and disadvantages compared to a lab work session. The methods and results of two subsequent surveys are presented and discussed below.

German

An der Heinrich-Heine-Universität Düsseldorf wurde eine hypermediale Lernumgebung zur "Physik für Mediziner" entwickelt und evaluiert (Theyßen 2002, Theyßen & Hüther 2003). Diese Lernumgebung ist bereits seit sieben Semestern fester Bestandteil der Physikausbildung Medizinstudierender an drei deutschen Universitäten. Die Studierenden nehmen nicht an den herkömmlichen Praktikumsversuchen teil, sondern bearbeiten die gleichen Inhalte mit Hilfe der hypermedialen Lernumgebung. Diese eLearning-Implementation in der Hochschullehre wurde unter verschiedenen Aspekten evaluiert.

Gegenstand dieses Artikels sind die Einstellungen der Studierenden zur Arbeit mit der hypermedialen Lernumgebung, speziell zu deren Vor- und Nachteilen im Vergleich zu herkömmlichen Praktikumsversuchen. Die Methoden und Ergebnisse zweier aufeinander folgender Befragungen werden im Folgenden vorgestellt und diskutiert.

Keywords

Distance learning, e-learning, hypermedia learning environment, science education, medical studies, students' attitudes

Topics

Introduction

In Germany, physics education of medical students is usually implemented in the first academic year and comprises a lecture and a lab work course. In a typical lab work course, students work in pairs. They conduct experiments and evaluate and interpret their measurements.

Various objectives can be attributed to such lab work courses (Welzel et al., 1998), e.g. linking theory to practice, learning experimental skills or fostering motivation, personal development and social competency. This variety of possible objectives demands clarifications and restrictions with regard to each target group (Séré 2002).

Surveys among physicians and lecturers of medicine reveal the main objectives, which these experts attribute to physics lab work for medical students:

- Students are meant to learn physics related content relevant for their further studies and professional life.
- Students should be enabled to link theory to practice and especially how to apply the physics related content to medical problems.

In contrast to the lab work courses for physics students (Neumann, 2005), the acquirement of experimental skills is a subsidiary objective for medical students.

During lab work, medical students are supposed to use experiments in order to produce, observe, and investigate physics related phenomena and correlations. The experimental setups and their handling are only secondary. Thus the question arises whether expensive experimental setups are necessary. Today, new media allow for multiple representations of physics related phenomena. As photorealistic representations like videos or Interactive Screen Experiments (see below) are normally based on empirical data (measurements), students can use such representations to investigate phenomena and correlations. Graphical representations such as animations and simulations are based on theory (calculations) and can be used to illustrate same.

These potentialities of the new media were one of the reasons for the development of the hypermedia learning environment (HML). Further reasons were:

- Medical students extremely differ in their previous knowledge of physics and mathematics (Theyßen, 2005; Heise & Mittner, 1975). A hypermedia learning environment allows for repetitions and the compensation of individual deficits.
- A hypermedia learning environment is particularly suitable to illustrate the multiple interdisciplinary coherences between physics and medical science.
- The first year of medical studies is usually characterized by a strict time schedule. A HML, which is provided via the Internet, allows for an individual time structure.

The Hypermedia Learning Environment

The HML can be characterized as a digital textbook with interdisciplinary, multimedia, and interactive features. It consists of hypertexts with multimedia elements. In order to properly deal with its contents, the structure of the HML offers a prepared learning path, taking into account that the students' previous knowledge in physics usually falls short of a reasonable and successful self-directed navigation (Gerdes 1997). A glossary and additional, optional hyperlinks enable the students to look up terms or to deviate from the suggested learning path.

Multimedia Elements:

The multimedia elements consist of computer simulations, figures, videos, and, as a substantial feature, Interactive Screen Experiments (ISEs). ISEs are digital representations of real experiments. Compared to a normal videotape, the important additional feature of an ISE is the user's option to manipulate several parameters of the experimental setup via mouse clicks and directly within the representation of the experimental setup. The user "seizes" and moves objects within the ISE with the mouse's pointer. There is no need for data input via the keyboard or the use of slide controls. Compared to the real experiment, the number of parameters that can be manipulated is usually restricted and can be chosen according to the educational objectives (Kirstein 2001).

Interdisciplinary Features:

The content is restricted to physics related topics relevant for medical students. In order to illustrate the interdisciplinary correlations, the physics related content is always embedded into a medical context. For example, the basic principles of geometric optics are related to the function of the human eye and worked out by means of a model of the dioptric apparatus of the human eye, represented by ISEs. The physics related aspects of blood circulation are elaborated using a simplified model of a blood circuit, again represented by ISEs. Labwork tasks and explanations written in the lab guide refer to the medical context. Additional tasks and questions require the students' application of the physics related content to medicine related problems (transfer).

Interactive Features

First of all, the hypermedia structure of the HML and the handling of Computer simulations and ISEs demand an interactive occupation with the content. The cognitive activity is enhanced by several tasks contained within the HML: observations and measurements have to be carried out with the ISEs or with simulations, conclusions must be drawn from the observations and measurements, calculations have to be carried out and, as mentioned above, a transfer of the results into the medical context is demanded. Input boxes for observations, answers, data, and results are provided. Additional input boxes can be used for personal notes. Any entry into these boxes is assigned to the user and stored in a database. Thus the HML becomes a very individual digital textbook. Several of those observations, answers, data, and results that have to be filled into the boxes are crucial for the understanding of the subsequent sections. Thus, advices and example solutions providing gradual support for answering the questions have to be at the students' disposal.

The HML is available on the Internet which implies that students have access to the content from wherever they want to and at any time. Repeating experiments and related observations is always possible.

Figure 1 shows a screenshot of the HML. The thumbnail contains a preview of an ISE.

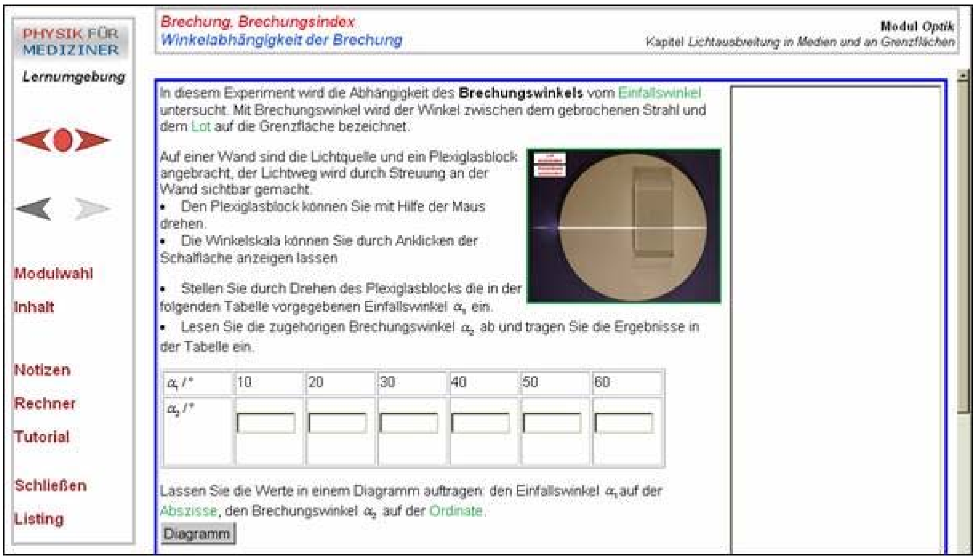

Figure 1. Screenshot of the HML with a preview of an ISE

Implementation of the HML in Physics Education of Medical Students

Concerning the main objectives and the characteristic features that result from these objectives, the HML is very similar to a previously developed lab work course (Theyßen et al. 2001). For example, both learning environments (HML and lab work course) deal with the same content and experiments, both of them contain numerous questions and tasks which demand the verbalisation of observations, the interpretation of measurements, and the transfer of the results into the medical context. The main differences are the media. Whereas in the lab work course, students work with a lab guide and handle experimental setups, they use a hypertext and various multimedia elements, especially ISEs, in the HML.

Usually, the learning efficiency of new media depends highly on the setting in which they are applied (e.g. Clark 1994, Kerres 2001). Thus, for the evaluation of the HML, the setting had to be clearly defined. The general idea for the implementation of the HML was that a complete lab work session - comprising the preparation, the experimental phase, and the post processing - could be replaced by a section of the HML.

Two settings with different boundary conditions for the students' occupation with the HML were applied and evaluated concerning the learning efficiency. In both settings, students working with the HML and those participating in the lab work session achieved the same learning increase concerning the physics related knowledge and its application in physics and medicine related problems (Theyßen & Hüther 2003, Hüther & Theyßen 2005).

One setting was very similar to a lab work session. The experimental setups and the lab guide were merely replaced by the HML and its ISEs. A group of about 20 students worked with the HML in pairs. Time and location (a workroom in the faculty) were fixed like for a lab work session, and a tutor was present.

This paper only deals with the second setting, which taps the full potential of the HML with regard to the individual structuring of the learning process. It is described in detail below.

Since the HML is available on the Internet, the time schedule and the location for dealing with its content can be arranged individually and according to personal preferences. Students are allowed to work at home, in the university or even in an Internet cafe and may work any time of the day or night, during weekends and so on. Additionally, they are free to choose the social form (e.g. teamwork or individual work) they prefer for learning. Repeats of experiments and simulations are possible, and the total amount of time spent on the content is up to the individual student.

The individual choice and combination of boundary conditions is only confined by external limitations, e.g. by the opening hours of the university's computer rooms. As a consequence, the support by tutors is restricted. Tutors can only be consulted via email or telephone. To compensate for this restriction, advices and example solutions are available in the HML and provide additional support.

In this setting, the HML was applied for several terms at three German universities: Düsseldorf, Aachen, and Greifswald. In Düsseldorf, students had an additional choice: they could either participate in a lab work session or develop the same content by means of the HML. Due to the lack of adequate experimental setups, the free choice between a lab work session and a HML could not be realized both in Aachen and in Greifswald. Therefore, all students from these places had to work with the HML.

During lab work sessions the students are not only supported but also supervised by a tutor. If the HML is applied within the setting described above, lecturers or tutors will need a tool that allows for a monitoring of the students' activities. Such a tool has been realized and provided together with the HML. All page requests and entries can be recorded and assigned to the user. Lecturers and tutors can use a web-interface to look at a student's entries in the original context of the HML, they can generate listings of selected entries and control the time a student spends on a certain section of the HML. Usually, printed listings containing the most important results and the total amount of time spent on the HML were used to assess the students' work. Subsequent content related tests or interrogations, which are common practice in lab work courses, were applied to verify and supplement this assessment.

The learning efficiency of the HML has been verified by empirical studies, and lecturers' acceptance of it has been supported by a detailed and reliable monitoring tool. As a third crucial aspect for the implementation of the HML, students' attitudes towards this alternative kind of lab work had to be investigated. Two subsequent surveys concerning this aspect were carried out.

First Survey: Open-Ended Questions

The first survey was conducted only in Düsseldorf and during the summer term of 2003, as the HML had not yet been implemented at other universities. A questionnaire with open-ended questions was used to collect opinions and ideas concerning the advantages and disadvantages that students attributed to the HML.

This questionnaire was distributed on the Internet as an appendix to the HML. Students who had been working with the HML were asked to answer it.

The total lab work course comprises eleven sessions. Those students who chose to work with the HML replaced only one of the sessions and experienced both learning environments, enabling them to compare their advantages and disadvantages.

The central question of the questionnaire was:
What are the advantages and disadvantages of the HML compared to a textbook, a lecture, or a lab work course?

Almost all statements concerning the advantages and disadvantages of the HML either referred explicitly to the lab work session or did not specify the aspect of comparison. The only three statements explicitly referring to a lecture or a textbook were not taken into account for the further analysis.

In total, 78 statements of 39 students could be evaluated. 42 statements attributed advantages to the HML, 36 attributed disadvantages to the HML.

The diagram in Figure 2 shows the distribution of these statements. Similar statements referring to the same aspect were summarized here. The white bars indicate how often this aspect was stated as an advantage of the HML, the black bars indicate how often it was stated as a disadvantage.

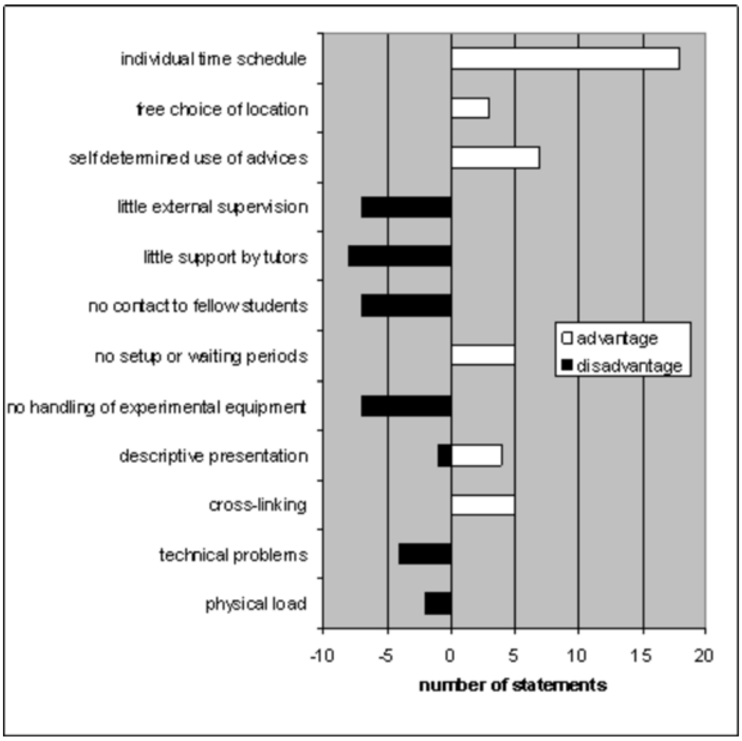

Figure 2. Advantages and disadvantages identified from the first survey

From the students' point of view, the most important advantage of the HML is the individual time schedule it permits. This aspect subsumes statements that refer to the free choice of time, to the individual timing during the occupation with the HML, and to the option of repeats. A sufficient discrimination among these aspects was not possible for most of the statements. Together with the statements concerning the free choice of location, which is closely related to the choice of time, 21 statements were in favour of the flexibility of the work with the HML.

A second important advantage can be seen in the self determined use of the advices within the HML, which implies a certain degree of self-control of the learning process. This is almost complementary to the next aspect: missing external supervision. Students criticized that without a tutor on the one hand, but with integrated written advices and exemplary solutions on the other hand, a lot of self-discipline was necessary to ensure efficient learning. Thus the integrated offer of gradual support combined with the reduction of external supervision is a controversially rated feature of the HML among the students.

It was felt that the most important disadvantage of the HML was the missing contact to tutors (8 statements) and fellow students (7 statements). However, it has to be taken into account that the students were free to choose their social form of work and that in principle, teamwork would have been possible.

Another further important disadvantage stated by the students was that within the HML, the handling of the experimental setup and the non-visual impressions connected with this handling were missing. On the other hand, they appreciated the time saving they achieved with the ISEs which usually do not need any setup and reduce waiting periods. Thus the replacement of real experiments by ISEs has been the second controversially rated feature of the HML.

Second Survey: Closed-Ended Questions

Reduced to the 6 features listed below, the results of the first survey formed the basis for the development of a second questionnaire (abbreviations used in the following diagrams in brackets).

- The HML allows for a flexible choice of time and location in order to deal with the content (flexibility).
- The HML allows for an individual pace of work and the repetition of experiments (individuality).
- When working with the HML, a tutor is usually not present (no tutor).
- When working with the HML, there is - except for teamwork - no contact to fellow students (no fellow students).
- The HML allows for and requires self dependent work, e.g. using the advices (self dependency).
- When working with the HML, handling the experimental equipment is not necessary (no handling).

The features "flexibility" and "individuality" distinguish between the free choice of time and the individual structuring of the learning process. "Flexibility" summarizes furthermore the individual time schedule and the free choice of location (see Figure. 2), since they are very closely related.

The features "no tutor" and "no fellow students" distinguish between the necessary limitation ("no tutor") and the self determined choice of the social form ("no fellow students").

The feature "self dependency" summarizes in a neutral formulation the controversially discussed aspects of missing external control and the self determined use of advices.

The feature "no handling" similarly summarizes the saving of setup and waiting periods as well as the lack of hands on-activities.

Students were asked to rate these features on a five-step scale between 5 = "great advantage" and 1 = "great disadvantage" (3 = "neutral").

An important aspect of the design of the second questionnaire has been that the features, which had to be rated, were not set by the researchers but extracted from the first survey. Thus it can be assumed that they represent the full range of students' perceptions of the HML. In the second questionnaire, all students were requested to rate all features, even those ones they would not have thought of when answering an open-ended question. They were also asked to specify the location and the social form (individual work or teamwork) they had chosen for their engagement with the HML.

The survey was conducted during the summer term of 2004 in Düsseldorf, Aachen, and Greifswald, during the winter term of 2004/2005 in Aachen and Greifswald, and during the summer term of 2005 in Düsseldorf.

As mentioned above, in Aachen and Greifswald, all students had to replace two labwork sessions by the work with the HML, whereas in Düsseldorf, the choice of the learning environment (HML or labwork session) was up to the students. Apart from this aspect, the conditions for the work with the HML were very similar for all students.

As in the first survey, the questionnaire was distributed on the Internet as a part of the HML. Every student who had worked with the HML was asked to answer the questionnaire. In addition, a print-out version was distributed in the summer term of 2004 for those students who did not fill in the electronic version of the form. The following table gives an overview of the collected data:

Table 1. Collected Data

University	Term	Number of questionnaires
Düsseldorf	Summer 2004	18
Düsseldorf	Summer 2005	14
Aachen	Summer 2004	50
Aachen	Winter 2004/2005	24
Greifswald	Summer 2004	18
Greifswald	Winter 2004/2005	20
in total		**144**

The following diagrams (Figure 3 - 5) show the medial values of the ratings for different groups of students. Error bars indicate the statistical uncertainty of measurement within each group.

Figure 3 presents the medial values for all students who filled in the questionnaire (n = 144).

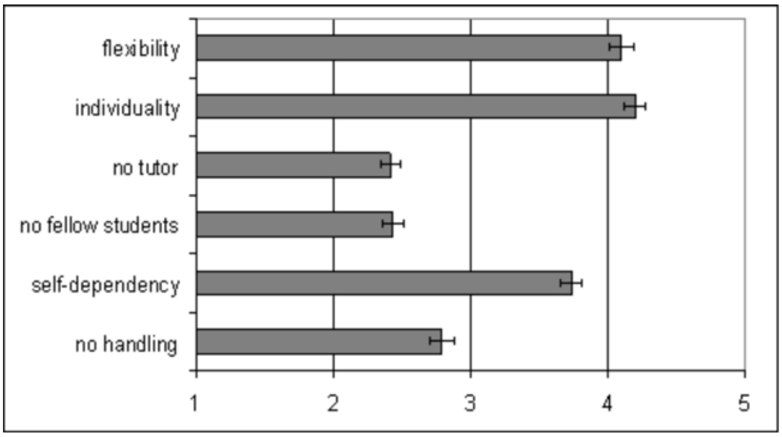

Figure 3. Results from all questionnaires.
(1: great disadvantage, 3: neutral, 5: great advantage)

The diagram shows a differentiated rating, confirming overall the results of our first survey. Most students found that the most important advantages of the HML were the flexibility and individuality it allows for. This is in accordance with the students' specifications concerning their preferred location. 47 % of them chose homework, i.e. they worked with the HML only at home or at a friend's, 20 % worked only at the university (library, computer centre or PC-workrooms of the faculty), and 33 % used both alternatives. Thus, when dealing with the HML, 80 % of the students chose homework at least partially.

The most important disadvantages seen by students were the missing tutors and fellow students. Concerning the latter, this can be attributed to a student's choice of his or her social form of work. 70 % of the students stated that they worked with the HML on their own, whereas only 30 % of them worked together with fellow students all the time (21 %) or at least temporarily (9 %). As the combination of homework and teamwork might have been somewhat difficult to organize, it seems likely that most students skipped teamwork in favour of a more flexible choice of time and location.

The self-dependency of learning was rated an advantage rather than a disadvantage. The missing contact with experimental setups ("no handling") was rated a disadvantage rather than an advantage, but fairly neutral. Both results verify those of the first survey.

The medial value calculated for all features and questionnaires is 3.3, reflecting a slight positive attitude towards the HML (a neutral attitude would correspond to the value 3.0).

However, averaging all students conceals the differences between certain groups, some of which are discussed below.

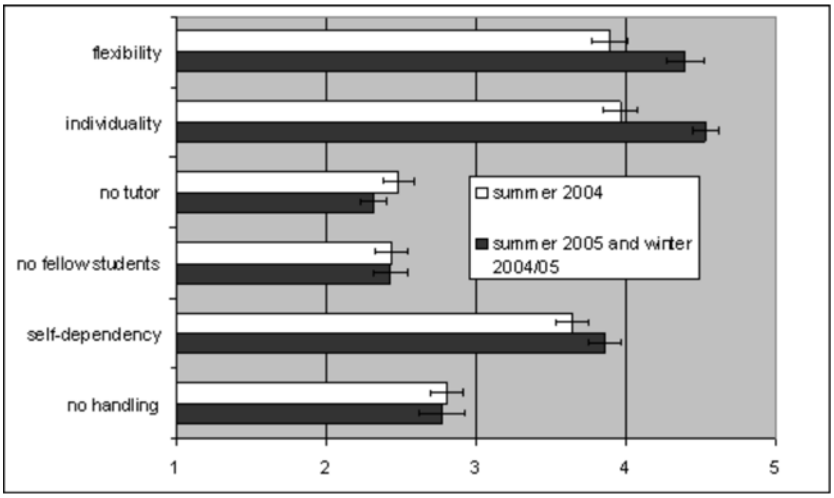

Figure 4. Results differentiated by cohort

In Figure 4, the results have been differentiated by cohorts, with the white bars indicating the results of the summer term of 2004 (all students from Aachen, Düsseldorf and Greifswald), and the black bars indicating those from the cohort of the winter term of 2004/05 (Aachen and Greifswald) and the summer term of 2005 (Düsseldorf) respectively. From the first cohort, 86 questionnaires, and from the second cohort, 58 questionnaires were evaluated. In most aspects the students' ratings did not differ, however, regarding the flexibility and the individuality of learning, the ratings of the second cohort were significantly more positive than those of the first one. It seems that these advantages gain more and more importance for the students.

Figure 5 shows the results of the surveys with closed-ended questions partitioned along the students' universities.

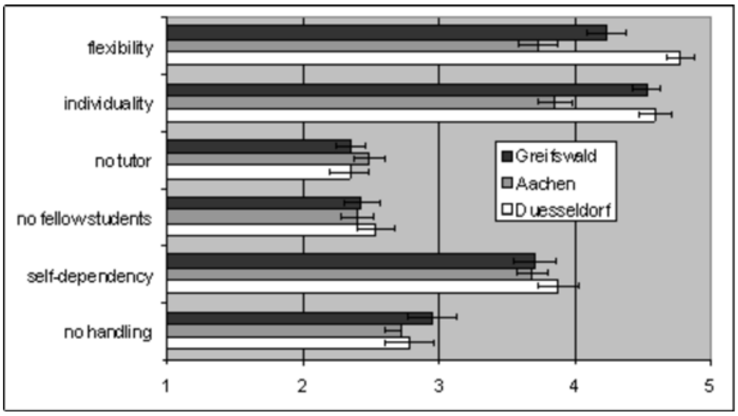

Figure 5. Results differentiated by university

Again, it is in the area of flexibility and individuality of learning where the most important differences occur.

Concerning the flexibility, the differences between the universities of Aachen and Düsseldorf and even between Greifswald and Düsseldorf are highly significant. Between Greifswald and Aachen they are still significant.

Concerning the individuality, the differences between the universities are highly significant.

The remarkably high appreciation both aspects achieved in Düsseldorf can probably be attributed to the difference in the settings for the use of the HML. Whereas in Aachen and Greifswald, all students had to work with the HML, in Düsseldorf the choice was up to the students. They were given the opportunity to work in the evenings and at weekends instead of a determined time slot when dealing with physics lab work. This opportunity was a crucial argument for the choice of the HML. Students not appreciating this opportunity normally did not choose the HML and thus did not answer the questionnaire. In Aachen and Greifswald, those students who would have preferred a given time slot and location for dealing with the HML had to set up a general framework themselves. Thus, the rating of this aspect shows a wider statistical spread. The high rate of approval in Greifswald is striking and could suggest an even stricter time schedule for medical students at this university.

Gender Aspects of the Use and Evaluation of the HML

In Düsseldorf, additional data indicating the gender of the participants were available so that different attitudes of female and male students – if any – could be discussed. The results of the surveys of 2004 and 2005 (closed-ended questions) are summarized for the discussion below.

In the survey of 2003 with open-ended questions, differences between female and male students could be detected.

The whole cohort in 2003 comprised 369 students, 63 % of which were female and 37 % were male. This is a distribution in general representative for a term's composition of medical students in Düsseldorf.

The distribution of gender among those students who decided to work with the HML (63 students: 40 female, 23 male) was exactly the same as in the whole cohort. An avoidance of the HML, as it might have been expected according to literature (Schinzel 2001), was not observed. Among those students voluntarily completing a questionnaire, the percentage of female students amounted to only 54 %. Figure 6 shows the ratings of advantages and disadvantages of the HML (see also fig. 2), differentiated by gender.

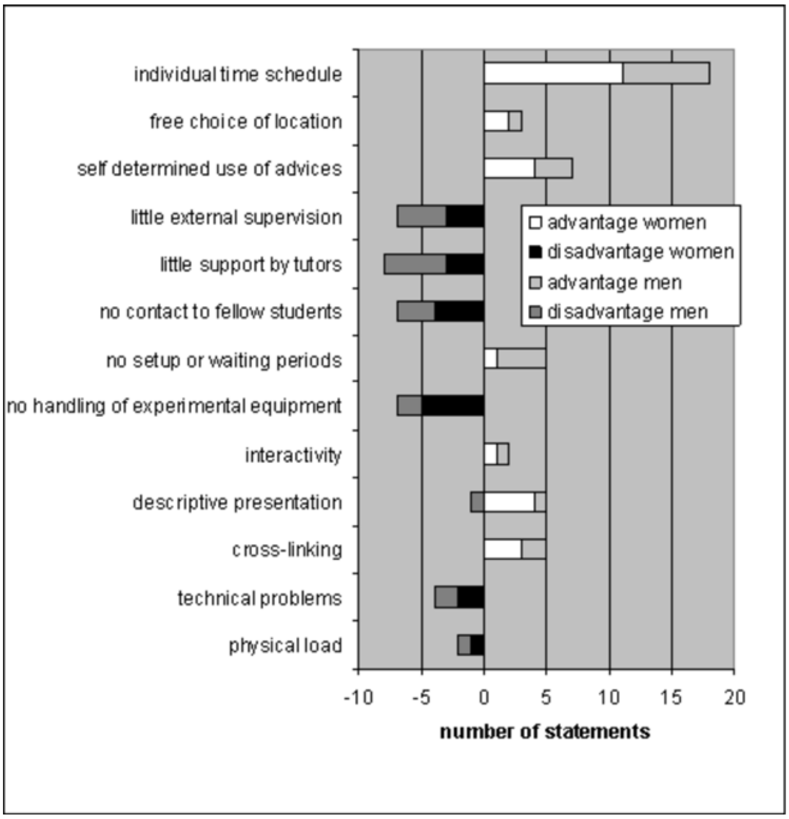

Figure 6. Features identified from the first survey, differentiated by gender (see also Figure. 2)

On average, female students expressed a more positive attitude towards the HML than male students. The medial ratio between positive and negative statements rated 1.4 among female students and 1.1 among male students. Female students particularly favoured the individual time schedule and the free choice of location. It is assumed that additional tasks like e.g. childcare or housekeeping still draw more intensely on female students than on male ones. This might explain the women's higher appreciation of flexible learning conditions.

Apart from the aspect of flexibility, the most prominent difference between the ratings of male and female students concerns the handling of experimental equipment and the reduction of setup and waiting periods due to ISEs. Apparently, female students miss the handling of experimental equipment more often than male students, whereas male students seem to favour the time saving due to ISEs more than their female fellow students.

Altogether, the differences in ratings between the male and female students were so minimal that they could not be verified in the results of the closed-ended questions surveys in Düsseldorf in 2004 and 2005. Figure 7 shows the medial ratings differentiated by gender. All differences are within the range of statistical fluctuations. The proportion of female students among those completing the questionnaire was identical to that of female students in the whole cohort (63 %).

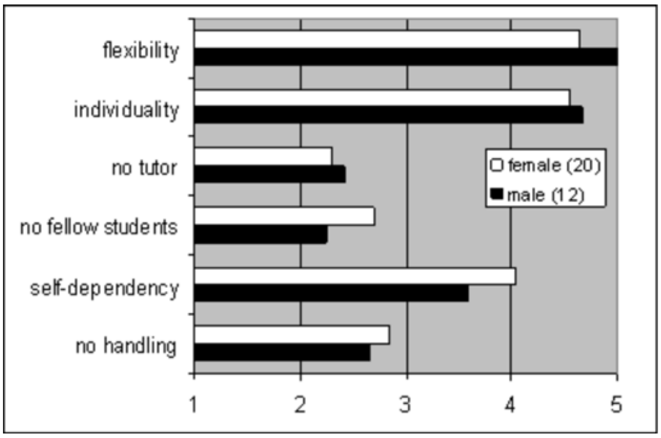

Figure 7. Results of the closed-ended questions surveys (Düsseldorf) differentiated by gender

According to Blum (1998), female students usually prefer cooperative learning both in campus-based studies and in distance learning, whereas male students in general prefer individual learning. This is not reflected in the results of the rating. Little support by tutors and missing contact to fellow students are stated as disadvantages by female and male students alike, and particularly by male students surveyed in 2003. In 2004 and 2005, both gender groups gave quite neutral ratings concerning the two aspects in question. However, the different preferences were reflected in the students' choice of the social form of learning. In the questionnaire students were also asked whether they had worked with the HML on their own or in groups of fellow students. A majority of 66 % had chosen to work alone, but among the remaining 34 % who had chosen the teamwork option, 91 % were female students. In total, 50 % of all female students and only 8 % of their male counterparts decided for the teamwork. This may explain the fact that most female students do not complain about the missing contact to fellow students all too often.

Summary and Conclusions

Between 2003 and 2005, the HML "Physics for Medical Students" was implemented at three German universities in the context of physics lab work courses. Depending on each university's curriculum, it was either a voluntary or an obligatory substitute for selected lab work sessions. The acceptance on the lecturers' side was mainly based on two aspects:

- The technical realisation allows for a detailed and reliable monitoring of the students' activities.
- Empirical studies have shown that concerning the physics related knowledge and its application to physics and medicine related problems, the learning efficiency of the HML does not differ to the learning efficiency of the lab work session (Theyßen & Hüther, 2003).

Apart from the technical realisation and the learning efficiency, the students' attitudes towards a new learning environment are crucial for its long-term success and dissemination. Thus the students were investigated by means of two subsequent surveys at the three universities that had implemented the HML.

Overall, the students expressed a positive if differentiated attitude towards the HML. They appreciated the flexibility and individuality that the work with the HML offered, and they made use of the opportunity to work at home and at any time they liked. This did not only apply for those students who voluntarily chose the HML but also for those who were obliged to work with it. However, they criticized social aspects such as the remote tutor and a lack of teamwork which resulted from the frequent choice of individual homework. The self-determined learning and the lack of hands-on activities received ambivalent ratings depending on the different types of learners.

An analysis differentiated by the cohort reveals that the importance students attribute to the flexibility and individuality of the learning process is significantly higher in the second cohort. In order to fully appreciate a learning environment, a self-determined time-schedule seems to be of increasing relevance to the students.

The influence of gender was quite small. In the first survey conducted with open-ended questions, female students expressed a more positive attitude towards the HML than their male fellow students, especially with respect to the advantages of flexibility and individuality. In the second survey, these differences cannot be reproduced. In all three cohorts in Düsseldorf, the percentage of female students choosing the HML over the lab work session was equal to the percentage of female students in the cohort. They did not avoid the new technology.

The overall positive attitude and the equal acceptance among male and female students have been encouraging the further development and implementation of the HML.

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A demo version in German is available at http://www.mm-projekt.uni-duesseldorf.de, an English version is in progress. For access to the full version of the HML, please send your request to heike.theyssen@physik.uni-bremen.de.

Acknowledgements

I would like to thank Dieter Schumacher and Jochen Riks (Düsseldorf) for the close cooperation in the development and evaluation of the HML, and to Heidrun Heinke and Christian Wilke for supporting the surveys in Aachen and Greifswald.

The development of the HML was supported by the German Research Foundation (http://www.dfg.de).