2nd International CDIO Conference
Linkoping University
Linkoping, Sweden
13 to 14 June 2006

A DIVERSIFIED APPROACH TO THE WORK SESSION PHYSICS

A. Van Deynse[1], B. Nouwen[2], I. Claeys[1]

1. Departement INWE, Hogeschool Gent, Gent, Belgium
2. Departement BIOT, Hogeschool Gent, Gent, Belgium

ABSTRACT

Implementation of the Bologna agreement between EU members causes big changes in the higher education in Flanders, Belgium. As a result the subject physics is reduced in the revised curriculum for engineering sciences. To maximise the benefit given the limited time, we work out a new approach for the work sessions physics.

Our experience shows that the students have great difficulties writing solid reports. Therefore we emphasize the importance of the written report in the first bachelor year. However as a test, we introduced peer assessment for learning purposes: we let the students perform an experiment with the aid of a report written by one of their colleagues. Additionally the students are asked to review the original report. The results bear out neither obvious positive or negative influence on the student's lab skills. Therefore several refinements are suggested.

In the second bachelor year, in addition to a reduction of the number of experiments, we diversify our goals. The students have to study 4 experiments profoundly. Assessment relies on a written report, an oral presentation, a practical test and a written test. Moreover, the students are asked to formulate some test questions themselves.

The presentations and reports are evaluated by the teacher-expert. For a small test group we also use formative peer assessment. The score given by the teacher and the averaged ranking given by the fellow students correlates rather well. Therefore the peer assessment can be extended to evaluate the presentations. The assessment of the own presentation on the other hand gives no correlation with the expert's score.

Comparing the scores to those of previous year, shows no main differences. The appreciation of the students although, as appeared from a small inquiry, is much higher.

INTRODUCTION

The higher education in Flanders undergoes big changes due to the Bologna agreement between the EU members. Starting from the academic year 2004 – 2005 the so-called BAMA (Bachelor – Master) structure is gradually introduced. Hand in hand with these changes, curricula are reviewed. As a result the subject physics is reduced in the revised curriculum for engineering sciences. In the 1st bachelor year the theoretical lessons are concentrated to 2 hours a week during 1 semester (12 weeks) implying a reduction of 50%. The work sessions accompanying the theoretical lessons on the other hand are extended from two hours to three hours a week during 1 semester, an increase of 33%. In the 2nd bachelor year the amount of theoretical lessons stays the same (2 hours a week in 1 semester) but the work sessions are cut from two to one hour a week during 12 weeks. A brief overview of these changes is presented in Table 1.

Due to all these changes we found it necessary to adapt the approach in the work session physics. In the first bachelor year we focus on the basic skills to achieve during the work sessions, i.e. we emphasize on the importance of the written report. In the second year we diversify our approach starting from the academic year 2005 - 2006.

Table 1: Summary of the subject physics in the curriculum for engineering sciences.

	Old regime (pre - BAMA)		New regime (BAMA)	
	1st year	2nd year	1st year	2nd year
Academic year	Before 2004 - 2005	Before 2005 - 2006	From 2004 - 2005	From 2005 – 2006
Semester	1 + 2	1 + 2	2	1
Theory hours	48	24	24	24
Work sessions				
Number of sessions	12	12	12	12
Hours per session	2	2	3	1
Number of experiments	9	8	9	1
Number of reports	9	8	9	1
Assessment	Reports Practical and written tests	Reports Practical and written test	Reports Peer assessment Written test	Report Presentation (peer assessment) Practical and written test

GOALS AND TASKS

General goals

The work session physics is a multidisciplinary experience where the students carry out concrete, practical tasks from different disciplines of the bachelor curriculum. The students learn to assess the accuracy of results and to interpret them correctly, formulate conclusions and make a solid report within a certain time.

Within the revised curriculum general, scientific and technical competencies which the students have to achieve during the physics work sessions are formulated. These stated that, among others, “the students have to be able to carry out experiments and tasks in a team”. More scientific competencies are “the students have to be capable to solve simple scientific-technical problems in an adequate manner and to communicate and report efficiently about it” and “the students have to prepare the upcoming task independently”. In addition some technical competencies such as “the students have to be able to understand and explain simple scientific-technical problems from the relevant disciplines of the exact and applied sciences” and “the students have to be able to give an oral or written presentation of their work” have to be achieved.

Specific tasks

In order to sufficiently achieve the above mentioned goals we found it necessary to diversify our approach. In the first bachelor year we focus, besides on enhancing a critical attitude, on the solid reporting, especially the written report. In the course of a 3 hours during work session the students are expected to carry out a specified experiment and write a scientific report about it. The experiment is known beforehand and the students have to prepare it profoundly to optimise the given time. In such a way they have to study profoundly 9 different experiments in small groups (2 or 3), i.e. they must be capable to carry out the experiment and understand the fundamentals of it. At the end of the semester this is tested in a written test. During the semester the students are asked to make a formative peer assessment of one of the reports of their colleagues. This is conceived as a co- and self assessment as reported by Dochy [4].

In the second bachelor year the approach is diversified in various ways [1, 2]. The number of experiments is reduced; only 4 experiments have to be studied profoundly. At the end of the semester this is tested in a written and a practical test. The students are allowed to train the live experiment weekly in small groups (2 - 4). In addition the students themselves are asked to formulate a few model questions as could be used for the written test. As such they are obliged to reflect about their work. For only two out of the four experiments they present the results: of one by means of a written scientific report and for another we expect them to give a ten minute oral presentation explaining to their fellow students the main goal, principle and results of the experiment. The students are allowed a large degree of freedom to plan their work themselves. The written report has to be finished by the middle of the semester and the presentations are held in the second half of the semester. However they are also left with the responsibility of 2 additional experiments that will be tested only at the end of the semester. Each presentation is followed by a discussion which is a great opportunity to develop the interpersonal skills. As such not only the teacher but the students as well have to take their responsibility in giving appropriate feedback and the students are obliged to learn from each other. At the end of the semester the students are tested by both a practical and a written examination (see also Table 1).

CDIO STANDARDS IN THE WORK SESSION PHYSICS

The above specified approach of the work session physics can be implemented in the CDIO model. We tried to adopt a few of the typical CDIO model standards as stated on the website of the CDIO organisation [3]. As the physics experiments are already designed and tested, it is hard to speak about a CDIO project or design-build experience. Although we tried to enhance the personal skills as critical thinking, experimentation and knowledge discovery by writing a syllabus focused on problem solving and by introducing formative peer and self assessment (Standard 2, 7 and 8). The interpersonal skills as group interaction and teamwork are also considered. Moreover the laboratory, in combination with the different tasks, is conceived to support learning from each other and interacting with other groups (Standard 6). This is also encouraged as we prefer that the students first discuss the problem with each other before they come to us for help. The assessment of the student’s learning is more diversified as it includes written and oral tests, observation of student’s performance, student’s reflections, reports, peer and self assessment (Standard 11). By doing so, the assessment addresses disciplinary knowledge, as well as personal and interpersonal skills.

RESULTS

As the changes are the most important in the second bachelor year and the score is more diversified, we focus on the scores of that year.

Scores

The score for the different parts of the work session are summarised in Table 2 (score with a maximum of 10 ± standard deviation). All assessment and scores are given by the teacher-expert. A few remarks have to be made in order to get a good comparison of the results. For the year 2004 – 2005 the score for the report is the average of 8 reports per student (see also Table 1). This allows room for improvement due to specific feedback. In 2005 – 2006 there was only one report per student. These students receive no systematic and written feedback of all the experiments (i.e. the practical test involves the 2 experiments on which neither a report nor presentation was made). The only feedback the students get, comes from the oral presentations of the different experiments, encouraging the students to enhance their interpersonal skills.

Table 2: Scores (max 10 ± standard deviation) for the different parts in the work session.

	Number of students	Report	Presentation	Practical test	Written test
2004 – 2005	232	6.6 ± 1.3		6.2 ± 1.9	4.5 ± 1.7
2005 – 2006	226	6.5 ± 1.2	6.6 ± 1.0	5.8 ± 2.4	4.6 ± 1.7

From Table 2 no major differences between the scores in 2004 – 2005 and in 2005 – 2006 can be concluded. We could remark that the score on the practical test is a bit lower in 2005 – 2006. The standard deviation on the practical test in 2005 – 2006 is a bit higher suggesting that there is a wider variation in the scores.

We compare these scores to the results obtained in the first bachelor. For the 208 students of the year 2004 – 2005 (concerning approximately the same students as in the second bachelor in 2005 – 2006) this results in: an averaged score for the reports of 6.0 ± 1.4 and a score for the written test of 4.3 ± 1.7. In 2005 – 2006 we have 218 students in the first bachelor year who score 5.7 ± 1.5 as an average on their reports. As such we can conclude that the skill of writing good reports is improved during the first year (see also further) resulting in a higher score on the reports during the second bachelor year. The results of the written test in the first and second bachelor year are comparable meaning that we don't completely succeed in enhancing the insight in the physics behind the experiments.

Appreciation

Besides giving scores to the students we also performed a small inquiry about how the students experience the work session. The students are asked, after giving the presentations and before they have performed any test, to give their opinion about a few quotes. The results are summarised in Table 3.

Table 3: Results of the inquiry concerning the new approach.

Quote	Agree	Disagree	No opinion
When I heard the task for the first time, I was enthusiastic	34 %	29 %	36 %
I prefer giving an oral presentation above writing a report	42 %	42 %	16 %
The preparation for the test is more difficult because I didn't make a report	51 %	32 %	17 %
Due to the presentations I get enough information about the experiments	58 %	26 %	16 %
I get enough feedback	53 %	17 %	30 %
I prefer this approach for the work session above "just writing reports"	77 %	8 %	15 %

From Table 3, we can see that although there is no difference in the scores between the old and the new regime (as mentioned in Table 2), the students appreciate the new diversified approach and prefer it above "just writing reports". According to the students the preparation of the test is more difficult which might explain the lower score on the practical test. A majority of the students finds the presentations valuable to get information about the experiments. The preference between giving an oral presentation and writing a report depends on their personal character as follows from the open questions. Writing reports is less confronting but it is probably necessary that the students get opportunities to practice the skill of giving a good presentation.

PEER, SELF AND CO-ASSESSMENT

Peer assessment can be described as a process where students evaluate the products of their fellow students. It is important to emphasize that peer assessment is not only giving scores, but is also a part of the learning process at which certain skills will be developed. As such peer assessment can be considered as a part of self assessment and cannot fully be separated from it [4]. To develop the skill of critical thinking we opted for formative peer assessment, assessment for learning, in stead of summative peer assessment, assessment of learning. The students have the opportunity to evaluate each other but the final score is given by the teacher-expert, the so called co-assessment.

Peer assessment in the first bachelor year

Next to learning to perform measurements accurately and qualitatively good the emphasize in the first bachelor year lies mostly on developing the skill of making good written reports. A chief goal of a good report is that it must be readable for a (large) public. We want to confront the students with the reports that we receive and hope to enhance their critical mind by having them read another student's report. As written by Dochy [4] the important benefits of this are that the students have higher rates of productive time on task and a reduction of cumulative error. It is also a great opportunity to develop social and communicative skills as working and learning in team, active learning, evaluating, giving feedback and diplomatic handling.

After the students have written 5 reports of different experiments we asked them to evaluate the report of a fellow student. Most often the fellow student is present during the work session offering them the opportunity to communicate about the reports. The evaluation form as stated in Appendix 1 is used as a guideline. They are asked to give a score based on a few criteria for a good, written report. To evaluate the content the students perform the measurements themselves and make the necessary calculations and graphs. Thus, the peer assessment is more intended as an assessment for learning, a self assessment for their own reports. The students are evaluated on their ability to give a profound and well-founded evaluation of the report on one hand and on the other hand on their own measurements, calculations and graphs. As experts we evaluated both reports, namely the original report on which the evaluation of the students is based (further indicated as original) and the peer assessment of the students based on this original report (further indicated as evaluation). We compare the measurements and conclusions of the original and the evaluation and give a higher score to the evaluation if the evaluation was well-founded and/or the measurements are improved. If the students make the same mistakes as in the original the score is diminished. We want to enhance the critical attitude and reduce the cumulative errors, which are not only made in the original report but also in their own (previous) reports.

The result of this peer assessment is summarised in a few histograms (Fig. 1, 2 and 3). The full data set consists of 122 reports. First we want to remark that 71 evaluations score better or at least the same as the original, 51 reports worse. Averaged the score is enhanced with 0.2 suggesting that there is a diminishing of cumulative errors. The histograms indicate the frequency of the difference in the score between the evaluation and the original. If this difference is positive this means that the report is improved by the evaluators, a negative score means a worse report. Figure 1 shows the total frequency of this difference. As can be seen there the histogram peaks at a result for the evaluation that is 0.5 or 1 point less than the original.

A bit surprised as we were by this result, we made a more profound evaluation. We divided the scores on the reports in three categories namely: bad report: score ≤ 4.5; average report: score between 4.5 and 7 and good report: score ≥ 7. First we divided the original reports in the above stated categories and look at the frequency as shown in Fig. 2. The relative frequency is presented as a function of the difference in the score. Fig. 3 shows a similar histogram but now focusing on the evaluation reports. The respective absolute numbers are summarised in Table 4 and 5.

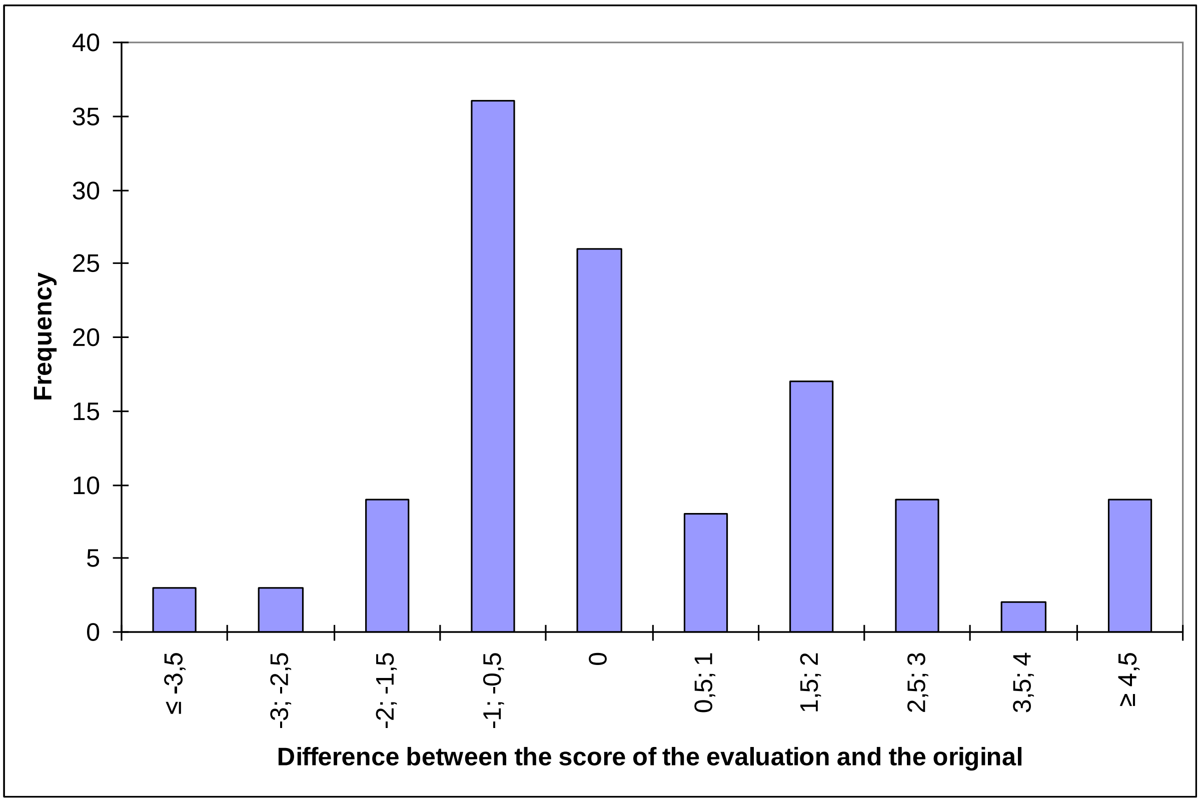

Figure 1: Global histogram.

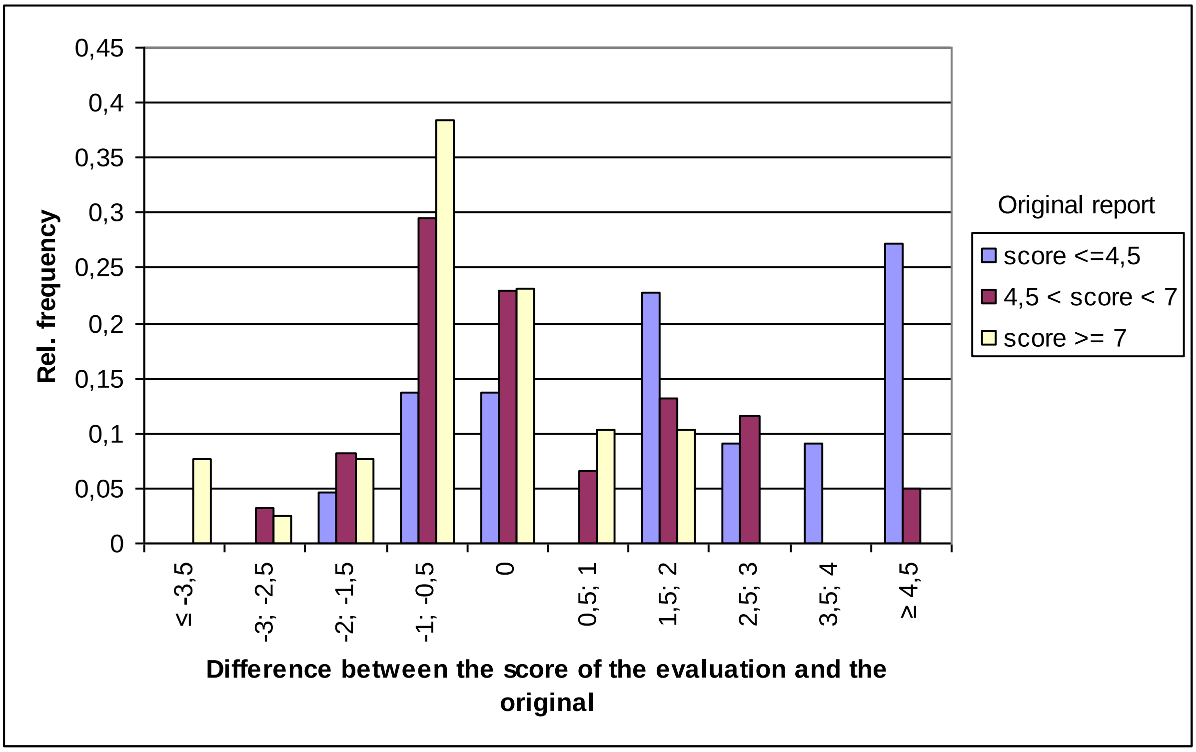

Figure 2: Histogram focused on the score of the original report.

Table 4: Summary of the data focused on the original report.

	The original report was		
Number of students who scored on the evaluation	Bad	Average	Good
Worse (negative difference)	4	25	22
Equal (difference = 0)	3	14	9
Better (positive difference)	15	22	8

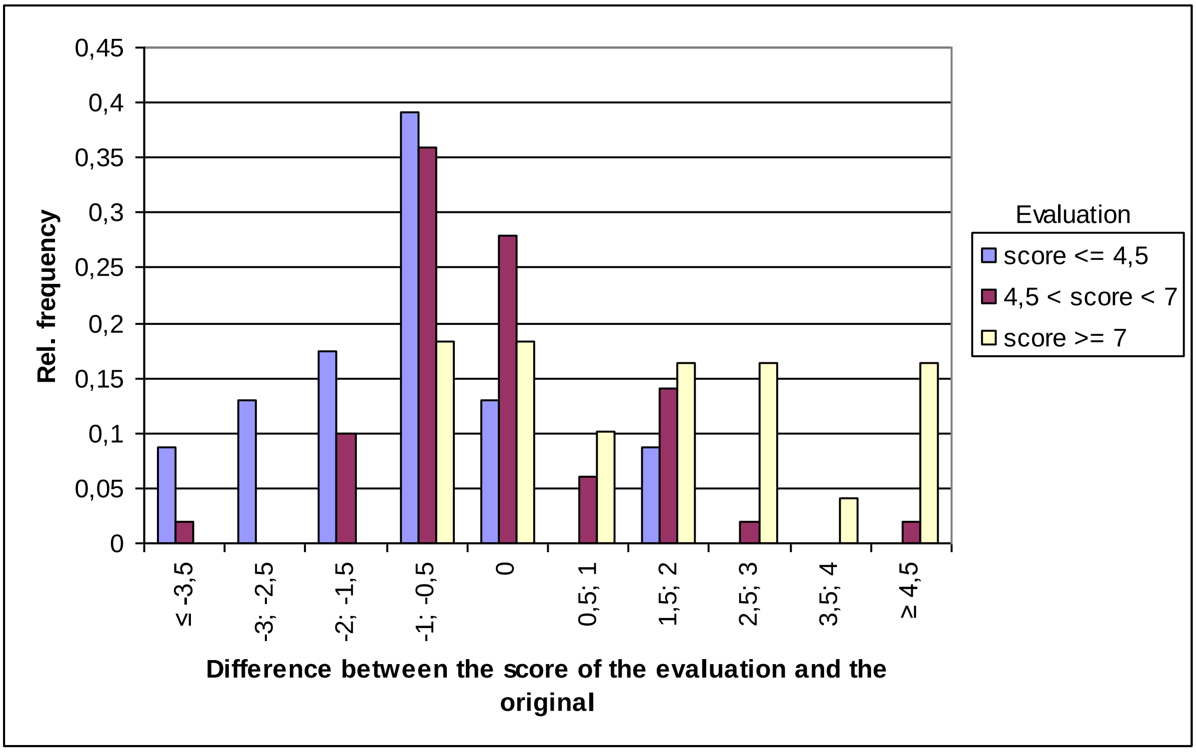

Figure 3: Histogram focused on the score on the evaluation.

Table 5: Summary of the data focused on the evaluation.

	The evaluation was		
Number of students who scored on the evaluation	Bad	Average	Good
Worse (negative difference)	18	24	9
Equal (difference = 0)	3	14	9
Better (positive difference)	2	12	31

From Fig. 2 and Table 4 we can conclude that the influence of the quality of the original report is not that big. A bad report is mostly improved as could be expected but a relatively large part of the good reports are also made worse. If we focus on the score of the evaluation as presented in Fig. 3 and Table 5, we see that if the evaluation is good this is mostly due to improved measurements and conclusions and a bad evaluation means worse measurements than the original. Perhaps the student's preparation of the experiment was less than normal due to the fact that they don't have to make a report. We think that some students rely too much on the data presented in the original report and let it bias their own data. It also indicates that the students do not sufficiently understand the experiments as was also reflected in the score of the written test last year. A bit of training in evaluating is certainly necessary and a more critical attitude towards the measured data should be encouraged. In the future we intend to give the 'original' report not at the beginning of the work session but in the last hour hoping to put the focus first on doing good measurements and draw good conclusions without the influence of the data presented in the original report. It is perhaps necessary to redo this peer assessment experiment before we can draw major conclusions about it but time lacked to do so this year.

An attempt is made to assess the learning effect due to the peer assessment. We compared the averaged scores of the successive reports. We want to investigate if the evaluation of a report gives a higher score for the next report taking into account that the score will enhance during the year as the students get feedback and improve in writing ‘good’ reports. This data is summarized in Fig. 4. For the first report, EHB, all the students performed the same experiment namely the study of the periodic harmonic motion and were guided throughout their report. R4 is the “original” report, R5 the peer assessment report and R6 the report of interest, after the evaluation. From Fig. 4 we can conclude that there is no direct effect on the score due to the evaluation. The enhancement of the score for R8 includes probably that we were mild for the last report.

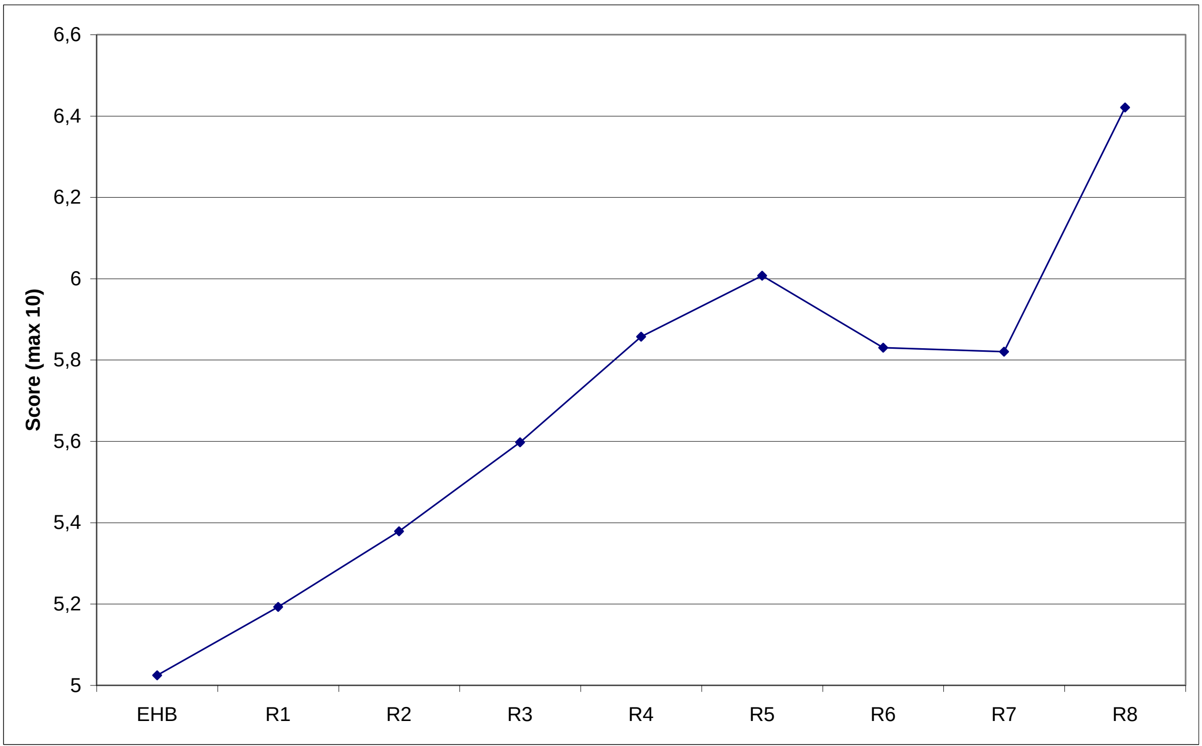

Figure 4: Averaged score at successive reports.

Peer assessment in the second bachelor year

In the second bachelor year the work session physic is more diversified. As a consequence the score is also divided in different parts. All presentations are evaluated by the teacher-expert who is also responsible for the final score at this part. For a small test group (48 students and 16 presentations) the students are asked to perform a formative peer assessment. Independent of the given score by the expert, they give a ranking score between 1 and 4 at the different presentations. There are a few conditions making it impossible to give all their colleagues 4. They are also asked to evaluate their own presentation. We compare the average of the peer score, linearly extrapolated to a score at 10, with the score of the expert as presented in Fig. 5. The error bars indicate the standard deviation on the peer score.

From the data presented in Fig. 5 we conclude that there is a clear linear correlation between both scores (correlation coefficient $R^2 = 0.67$). The slope is 1.07 ± 0.03 meaning that the ranking given by the peer group is comparable with the score of the expert. This assumes that there is a strong parallelism in marking criterions although they are not specified by the expert. The self assessment of the presentation (average of the 3 or 4 members of the group) shows no correlation with the score of the expert ($R^2 = 0.14$) nor with the score of the peer group ($R^2 = 0.15$). Therefore we conclude that the self assessment is not objective.

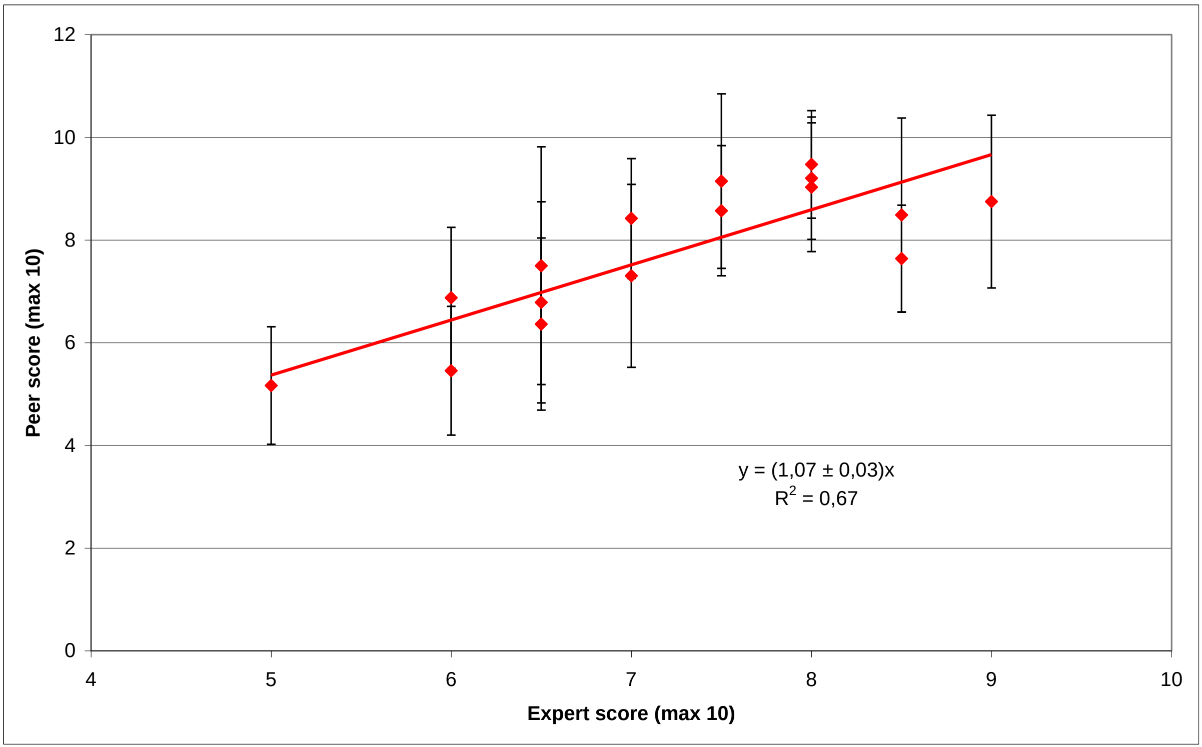

Figure 5: Comparison of the peer score and score of the expert.

FUTURE IMPROVEMENTS

This being the first attempt to change and activate the work session we take a critical look at the results and think about some improvements. The first goal of the work session is to enhance the insight in the theoretical lessons by carrying out relevant experiments. As observed previously, connection with the theoretical background and understanding of the experiments is rather poor. Therefore we opt now to change the written test in an open book test evolving to an overall test. In doing so we hope that the students will focus more on insight and less on reproduction.

We also want to reduce the cumulative errors in the written reports of the experiments. This is also one of the main reasons to introduce the peer assessment of the reports. Here, as we conclude that the experience of the students is still not sufficient to interpret a report correctly, we are considering enhancing the feedback given by the expert by introducing an assessment form. Therefore we will create a similar form as presented in Appendix 1 with a few criterions of importance and fill in the form systematically for all the reports, besides the written and oral feedback on the reports. Maybe this is more surveyable for both the student and the expert.

The results of the peer assessment of the oral presentations proof that it is reasonable to allow the students a responsibility in the assessment. In the future we would like to evolve to a score based on co-assessment of both peer and expert. This will stimulate the student’s attention and criticism.

CONCLUSIONS

Due to a change in the curriculum for the engineering sciences we opted to work out a new, diversified approach for the work session physics in both the first and second bachelor year. Besides the traditional performing of experiments and training the skill of making good written reports we introduce more freedom, oral presentations and peer assessment. So far the scores indicate no big changes during the years but the appreciation of the students, as appeared from an inquiry, is much higher. They prefer the new approach above the method of merely writing reports of all the experiments.

Peer assessment is introduced for the first time in the first bachelor year. The students are allowed to train an experiment with the aid of a report by one of their colleagues. In addition they have to review the report. Major conclusions regarding the effect cannot be drawn from it at this moment, as it is too soon. Obviously although, the students are not used to interpret measurements and must train in doing so. In combination with an enhanced feedback of the expert, we believe this can be a useful tool for the future to reduce cumulative errors.

In the second year, where the students are asked to assess oral presentations, the averaged score from the class group is comparable to the score of the expert within the given set-up. This allows us to use the peer assessment as a summative assessment and to evolve to co-assessment of both peer and expert. In this context self assessment appeared is not objective.

The new approach addresses more skills than before, therefore also asks for new forms of assessment. In diversifying the assessment not only the disciplinary knowledge but also other skills are included in the final result. As such we hope to introduce a few of the CDIO standards in the work session physics.

REFERENCES

[1] Van Deynse A., Nouwen B., Claeys I., "Diversifiëren van assessment voor het labo fysica", Evalueren in competentiegericht onderwijs, Gent, 2006.

[2] Van Deynse A., Nouwen B., Claeys I., "Een andere aanpak in het labo", Reflexie, nummer 57, p. 4, 2006.

[3] CDIO standards, www.cdio.org

[4] Dochy F., Admiraal W., Pilot A., "Peer- en co-assessment als instrument voor diepgaand leren: bevindingen en richtlijnen", Tijdschrift voor het hoger onderwijs, Jaargang 21, Nr. 4, p. 220-229, 2003.

APPENDIX 1: THE USED PEER ASSESSMENT FORM

Evaluation form

Report	Title	______________________________
	Authors	______________________________
Evaluators		______________________________

Legend:"0" = insufficient /"1" = can be improved /"2" = good /"3" = very good

Form	**Evaluation** (0,1,2,3)	**Remarks/example**
Structure		
Surveyability		
Language use		
Other….		
Contents		
Measurements		
Calculations		
Graphs		
Conclusions		
Whole/task		
Fully carried out		
Report forms a whole		
The most important results are accomplished		

Remarks (optional)

Appendices		
	X	Measuring results of the evaluators
	X	Calculations and graphs of the evaluators
		Alternative goal
		Alternative conclusion
		Other ____________