

University Physics

A studio-classroom course on Electromagnetism

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Abstract

The first year bachelor courses "Waves" and "Electromagnetism" at the University of Amsterdam (UvA) are given in the studio-classroom format. We outline the structure of the electromagnetism course and discuss some experiences as (studio-) lecturers. To actively involve the students during the sessions, the course contains a mix of illustrative slides, animations, in-class demonstration experiments, web-based exercises with automatic feedback and laboratory experiments. The course is well received and the studio-classroom format appears beneficial for many students

Introduction

Research over the past decade has shown that modern education models that employ interactive teaching increase learning significantly (see [1]). The studio-classroom concept aims at interactive teaching and learning by a combination of standard lectures and traditional exercise sessions, using computer technology intensively. The traditional lecture room is replaced by a classroom (see pictures below) with the facility to present a (short) lecture and is configured such that students can work on exercises with the possibility to use a computer.



The problem with traditional teaching is the passive role of the students sitting in the large lecture rooms with a lecturer speaking for two hours or so. After some time, usually the student's attention fades away, resulting in a large discrepancy between what is taught and what is actually learned. The studio-classroom concept aims at improving this by activation of the students.

The first year bachelor courses "Waves" and "Electromagnetism" at the University of Amsterdam (UvA) are given in this format. Besides illustrative slides, animations and in-class demonstration experiments, the

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web based exercises play an important role. The primary goal of the, also integrated, laboratory experiments (practicum) is to contribute to understanding the theory. In this paper we outline the structure of the electromagnetism course, present our experiences and discuss the results of a questionnaire.

Course Electromagnetism

The lectures are presented in an interactive manner by raising questions about demonstration experiments, computer animations or a specific problem to ensure the students remain engaged. During the sessions, the exercises are mostly based on physics problems to solve with pen and paper. A substantial number of web-based exercises embedded in Blackboard (see [2]) with automatic feedback enables the students to work, interactively again, outside the sessions. Collaboration and discussions during the sessions is encouraged, while the lecturer and an assistant are always present and circulate to ask and answer questions. The ‘transmission line’ between lecturer and student is short, always open and above all bi-directional.

Course setup

The course consists of a total of 19 sessions of 3 hours each and represents 7.5 EC. Three main physics topics are discussed in the following order:

- Electrostatics (8 sessions of which 2 laboratory experiments),
- Magnetostatics (6 sessions of which 2 laboratory experiments),
- Electrodynamics (5 sessions of which 3 laboratory experiments).

The final exam is a combination of homework (25%), lab reports (25%) and two standard tests (50%), weighted as indicated.

A typical session is structured in the following way:

1. discuss topics/problems previous lecture (sometimes by student), 15 min.
2. lecture (demonstration, questions, discussion), 30 min.
3. example and/or work out a problem together, 15 min.
4. students make exercises, 30 min.
5. repeat 2,3 and 4 once.
6. At home or during session: web-based-exercises (Blackboard).

The course is developed with the help and advice of the Amstel Institute (see [3]) of the UvA.

Laboratory experiments

The primary role of the lab work in our course is to illustrate the theory. Naturally, in addition the students obtain experimental skills and get experienced in writing reports.

For logistical reasons, the lab experiments fill a complete session and take place in a dedicated room. The students have to conduct two types of experiments, which we call ‘short’ and ‘long’:

- The short experiments take typically one to two hours. These experiments usually directly illustrate electromagnetism as taught in the lectures and more or less enforce the students to study the theory.
- The long experiments take a full session. These are mostly great classical experiments, simplified for first year physicists.

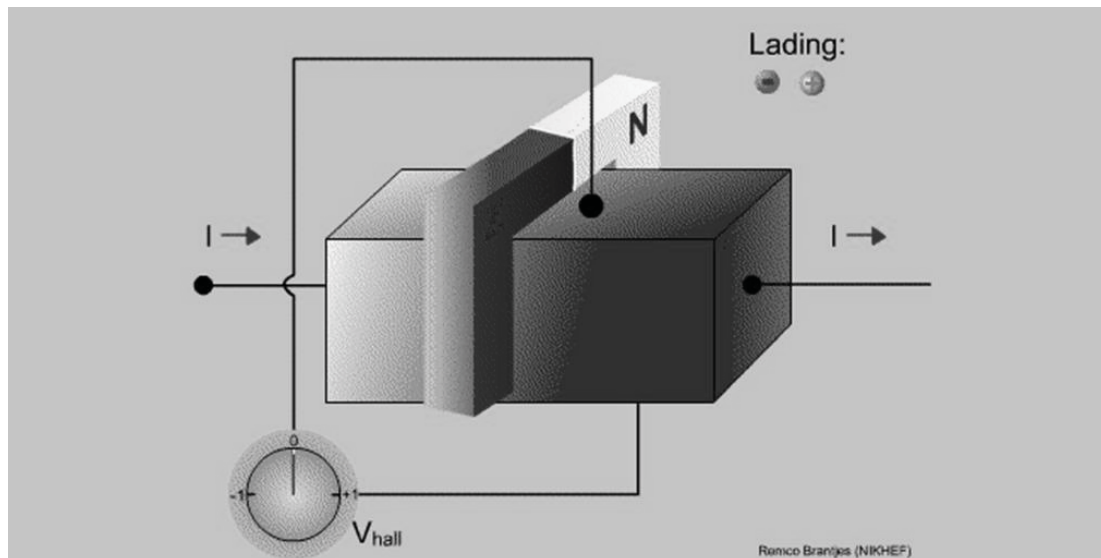
The table below lists the available experiments, separately for the two categories.

Short experiments	Long experiments
Plate-capacitor	Millikan (electron charge)
Cylinder-capacitor	Polarization of light
Mirror-charge	Michelson (interference)
Torsion balance (Lorentz force)	
Toroid magnet with slit (measurement with Hall sensor)	
Solenoid (with and without core)	
Magnetic induction	

An example of the studio mix

We consider as an example the lectures (see [4]) on static magnetic fields and especially the Hall effect. As an illustration of the theory we included a lab experiment that involves a measurement of a magnetic field with a Hall sensor. Various exercises are dedicated to this subject. Furthermore, we use a (self-made) computer animation (see screen-shot below) to get the students familiar with the Hall effect. The animation visualizes a current of negative (or positive charge) carriers and the induced Hall potential is shown. The students have to use the animation to answer some web based questions (and thus not just ‘play’ with the animation).

Note that the lab experiment illustrates the theory, while the lectures and exercises are a preparation for the lab work. This synergy is a very relevant advantage of the studio-classroom concept, because many students nowadays don’t prepare much: just ‘being 21’ is already a full time job!



Increased learning?

It is difficult to judge, based on a single course or two, on whether the studio-classroom format improves learning. For that we have to rely on the positive conclusions of the aforementioned educational research. We summarize here our findings that apply to our course without the intention to make general statements. First of all, the atmosphere during the sessions is excellent, especially during the concluding poster session that really triggered the students. Since the start of the course in 2001, on average, 45 students apply the course each year. The overall exam success rate reaches 75%. Furthermore, the success rate approaches 100% for those students who attend all sessions, make exercises and hand-in homework. This group comprises about half of all students.

Before we discuss the results of a questionnaire, we wish to remark that in our opinion especially the (sub)average students benefit most of the studio-classroom format. The student is confronted with the theory at least twice and often more (i.e. interactive lectures, exercises, experiments) which allows to gradually grasp the big picture. Note that the information density is not high, but the information diversity is. This could be a problem for excellent students that can handle more information in a faster way. Finally, the studio teaching is reasonably intensive, both for the lecturers as the students.

Questionnaire

According to a study performed in the university-year 2004/2005 based on a questionnaire, the students find the lectures very interesting as shown in the table below (the percentage represents the students who answered in the affirmative). Remarkably, most students appreciate when the lecturer slowly goes through the slides and uses the whiteboard to work out examples. This is somewhat in contrast with the studio-classroom principle, which aims at a more active attitude of the students.

Sessions	Yes
Electromagnetism is interesting	90%
The lectures are interesting	95%
The lecturer should go briefly through the slides, such that I can start quickly with exercises.	30%
I like it/understand stuff better when the lecturer occasionally uses the whiteboard instead of slides.	95%

The laboratory experiments are not so well appreciated according to the table below. During the lab sessions, not all students are enthusiastic. It is necessary to convince the students that they cannot just believe everything that is written and have therefore to measure and so check theoretical predictions themselves. Above all, there wouldn't be physics in the first place without experiments. However, the students affirm that lab experiments contribute to their understanding of the theory. Obviously, to achieve this purpose the lab experiments should physics-wise connect to the lectures as much as possible.

Lab Experiments	Yes
I find lab experiments challenging	70%
I obtain practical skills	100%
I learn to critically interpret measurements	85%
Lab exp. contribute understanding the theory	90%

Conclusions

We developed a studio-classroom course on electromagnetism which comprises lectures, demonstrations, animations, web-based exercises with automatic feedback and lab experiments. The studio-classroom format allows interaction with the students and so keeps the student actively involved during the sessions. The course is well received and the power of the studio-classroom mix appears beneficial for many students.

Innovativeness

Experience with the full integration of lectures, demonstrations, animations, web-based exercises with automatic feedback and lab experiments in electromagnetism teaching is sparse. The presented course on electromagnetism is the first course in the studio-classroom format in the physics bachelor at the UvA.

References

- [1] Next Generation Studio: A New Model for Interactive Learning., Lister, Bradford C., <http://www.ciue.rpi.edu> (the webpage of the Anderson Center for Innovation in Undergraduate Education of the Rensselaer Polytechnic Institute)

- [2] Blackboard is a commercial software package to create a web based learning environment. <http://www.blackboard.com>.
- [3] The Amstel Institute is the educational research center for beta-sciences of the University of Amsterdam. <http://www.science.uva.nl/amstelinstituut/home.cfm>.
- [4] The Electromagnetism course web pages.
Electro- and magnetostatics: <http://www.nikhef.nl/~h73/knem.html>
Electrodynamics and light: <http://www.nikhef.nl/~h73/kned.html>