

‘Effective teaching and supervision of students through the support of blended- learning tools’

Applied Physics department – TU/e
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Submitted to:



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1. Project title and applicants

Project title: *'Effective teaching and supervision of students through the support of blended- learning tools'*

This proposal is submitted by the Applied Physics (AP) department at the Eindhoven University of Technology (TU/e).

The main applicants are:

- Dr. Sonia M. Gómez Puente, AP Education Policy & Quality Assurance Advisor.
- Prof. dr. Niek Lopes Cardozo, responsible teacher *Fusion Reactors: extreme materials and intense plasma wall interaction* – (3MF120) and director of the MSc. Science and Technology of Nuclear Fusion Program
- Dr. Roger Jaspers, responsible teacher *Magnetic Confinement and MHD for fusion plasmas* – (3MF110), Science and Technology of Nuclear Fusion
- Dr. ir. Jan-Jaap Koning MBI, AP *Physics of Engineering Problems* (3ME120) responsible teacher and Coordinator Stan Ackermans designer program Design and Technology of Instrumentation (DTI).

In consultation with Prof. dr. K.A.H. van Leeuwen, AP Director of Studies.

2. Background and justification of the project

With the implementation of the Graduate School (GS) new educational challenges arise. First of all, following the TU/e 2020 vision to educate 50% more engineers and to increase the variety of engineering profiles (industry, research, teaching), the Applied Physics (AP) and Science and Technology of Nuclear Fusion master study programs have been upgraded in order to meet this plan. Within the AP master study program two certificates have been introduced, one for physics research and one for physics engineering. The second certificate caters to the need for physicists with more inclination towards solving technological problems. The master course of *Physics of Engineering Problems* (PEP) is part of this certificate. In addition, students need to pursue an internship in the industry to gain a master certificate in Physics Engineering. This requires supervision and attention to individual needs and interests.

Secondly, some implications of the GS ambition is that the classroom composition is more multidisciplinary than ever as the Applied Physics, but more specifically Fusion courses attract students from other TU/e departments and from international universities. The students' intake differs therefore in terms of disciplines and background, prior knowledge and learning styles, but also in profiles, interests and in career perspectives. This requires individual attention to the students.

Finally, the supervision of the students during the courses and master research project becomes a crucial trajectory in order to stimulate students work independently but also

to become critical towards own work and that of others. This implies supervision on practical, research and design assignments and projects to develop abilities to analyze complex problems, creativity, 'out-of-the-box' and critical thinking expected in our future graduates to solve technological challenges. The development of professional skills in our graduates are also of paramount importance.

In order to face these challenges it is essential to innovate and adapt the educational and assessment forms to make education tailored-made to the engineering profiles, on one hand. On the other, we also consider crucial to meet the individual needs of the students and differences regarding:

- learning style and pace;
- lacunas and capabilities, such as analysis of equations, graphical representation and quantitative analysis; synthesizing and drawing conclusions.
- prior knowledge: understanding numerical methods.

Blended-learning provides opportunities to optimize education and intensify contact hours while making more efficient the students' self-study time.

Moreover, supervision forms that challenges and brings about opportunities to apply and to expand students' technological knowledge are crucial. These supervision forms, rooted in collaborative learning methods (i.e. *afstudeerkring*¹, small-group tutorial meetings and intervision, among others) are suitable to integrate in study practices to stimulate creative and critical thinkers, but also to improve the professional skills.

3. Objectives of the project

Our primary goal is to make education more efficient both for teachers and students, and tailored-made to the students' engineering profiles, disciplines and educational interests. This implies changes in educational methods, and a careful supervision on students.

The project has the following objectives:

- To upgrade educational methods that allows students to acquire engineering skills i.e. use and apply a systematic problem-solving approach to define, implement and validate multiphysics models. This will be achieved by the purchase of the software integrated user interface environment, COMSOL Multiphysics, designed for cross-disciplinary product development with a unified workflow for electrical, mechanical, fluid, and chemical applications. As an online classroom kit, COMSOL Multiphysics allows up to 30 students to in log and follow the lectures. This allows students to develop experiments and carry out simulations. This is an innovative tool as COMSOL has never been used within the context of higher education in the AP department.

¹ Romme, A.G.L., Nijhujs, J.F.G. (2002).

Furthermore, with this project and this tool we are trying to innovate educational methods which have a real meaning for the students preparation as graduates. In addition, we also want to make a breakthrough in teaching physicist to model engineering problems in our department. The acquisition of this tool will definitively influence teaching and learning.

- To integrate blended-learning in Science and Technology of Nuclear Fusion master courses (*Magnetic Confinement and MHD for fusion plasmas* - 3MF110- *Fusion Reactors: extreme materials and intense plasma wall interaction* - 3MF120) by incorporating IT tools (weblectures, screencast or pencasts, to address deficiencies and individual needs as mentioned above).
- To integrate a new supervision form based on small-group tutorials & intervision for master students carrying out master courses and research within the Science and Technology of Fusion and PEP study program.

4. Expected outcomes of the project

We expect to reach the following outcomes:

Physics of Engineering Problems. We aim to:

- Enhance the development of students' engineering profiles (from N=20 in 2015/2016 up to N=70 students from other TU/e departments such as Electrical Engineering (EE), Chemistry (ST), Urban Environment (B-Bouwkunde) and Mechanical Engineering (WTB) by supporting students to learn modelling and simulating of engineering problems and a systematic approach to define, implement and validate multiphysics models. The course has a multidisciplinary character.
- Upgrade the current educational and didactical methods and make self-study time more efficient for the course *Physics of Engineering Problems* (i.e. supporting learning with online teaching, COMSOL Multiphysics, and enhance self-study with weblectures and pencasts, etc.);
- Supervise students' progress by first identifying deficiencies and lacunas in prior knowledge at the beginning of the course. This will serve as a feedback moment. In addition, it will also be indicated what other assignments are to be completed and how (forward and feed-up tool) in order to have a suitable monitoring of students' individual assignments.
- Stimulate learning from peers by reviewing the work of the fellow students' assignments.

Within the Science and Technology of Nuclear Fusion MSc. courses (*Magnetic Confinement and MHD for fusion plasmas* - 3MF110- *Fusion Reactors: extreme materials and intense plasma wall interaction* - 3MF120), we aim to:

- Integrate blended learning in the *Magnetic Confinement and MHD for fusion plasmas* 3MF110- *Fusion Reactors: extreme materials and intense plasma wall interaction* - 3MF120 – (Science and Technology of Nuclear Fusion master courses. We will support students' learning by integrating weblectures in education. This is intended to diminish deficiencies in prior knowledge (e.g. enhance in-depth explanation of concepts, illustration of examples), to minimize the differences of the different type of students with diverse backgrounds, physics and engineers, and to address individual needs in learning styles.

Regarding the upgrading of the *supervision forms and methods*:

- For the *Physics Engineering Problems* master students a certificate is required to carry out a master internship in a company. Therefore, we would like to introduce a new form of supervising internship and graduation research by including intervision and small-group tutorial as a peer learning and group coaching tool. Supervision in this case includes both content-wise internship progress but also the process (e.g. report writing, presentations, etc). Through intervision and peer feedback students will take more responsibility by critically evaluating each other's work, sharing problems and providing advice.

- In addition, the current students' supervision practices of MSc. Science and Technology of Nuclear Fusion is based on presentations during lunch meetings in which peer feedback on assignments and master research progress takes place. This platform of information, knowledge exchange and peer collegiality has brought about students' positive reactions in previous years. Therefore, we want to build upon these results and enhance this platform by strengthening the lunch meetings. In doing so, we will use students' presentations as a vehicle to encourage 'out-of-the-box' thinking and stimulate creativity of the students attending those presentations. Moreover, at process level, feedback on the development of professional skills such as presentation skills and master thesis report writing will be also addressed by reviewing peers' work during the small-tutorial and master-ring meetings.

Students' recruitment	
<ul style="list-style-type: none"> Recruitment of students for the course <i>Physics of Engineering Problems</i> from other TU/e departments and international universities 	Jan. through September, 2016
Evaluation of results AP & Fusion courses (blended-learning)	2016/2017
<ul style="list-style-type: none"> Analysis of <ul style="list-style-type: none"> <i>Physics of Engineering Problems - 3ME120-(AP) Q2</i> <i>Magnetic Confinement and MHD for fusion plasmas - 3MF110- Fusion Reactors: extreme materials and intense plasma wall interaction - 3MF120 -(Science and Technology of Nuclear Fusion) Q3</i> <p>(pass rates and student questionnaires, interview with teachers, etc)</p>	<p>Feb. – March, 2016</p> <p>June, 2016</p>
<ul style="list-style-type: none"> Analysis and evaluation of supervision methods 	From March 2016 onwards
Dissemination	Sept. through Dec., 2016
<ul style="list-style-type: none"> Project presentation at annual conferences: 3TU CEE, SEFI 2016 (Tampere, Finland) 	
<ul style="list-style-type: none"> Conference paper 	Sept. through Dec., 2016
Final project report	December, 2016
<ul style="list-style-type: none"> Report writing: final report for 3TU management 	

Appendices

Appendix 1 – Description of *Physics of Engineering Problems* course

Name of the course/code	Content & Learning outcomes	Innovative character of this project
<p><i>Physics of engineering problems</i> (3ME120)-</p>	<p>Content Every engineer benefits in professional life from mastering a tool for simulations. This course deals with modelling of engineering problems and a systematic approach for the implementation. Relevant phenomena are to be combined in multiphysics simulation models.</p> <p>Students will:</p> <ul style="list-style-type: none"> • Apply a systematic approach to define, implement and validate multiphysics models. • Evaluate the model simulations in a learning cycle. • Judge the value of the simulation model, and communicate the simulation results. 	<p><u>New teaching methods:</u></p> <ul style="list-style-type: none"> • Expert weblectures & pencasts • Individual supervision of students by and web-based feedback on progress • By enhancing self-study through weblectures & pencasts face-to-face time will be more effective to teach (lectures are not every week only 5 weeks) and supervise students during Assignment 1 (2ECTS): simulation own project; and, Assignment 2 (3ECTS): group project. Supervision is group work based and feedback with rubrics. <p><u>New tools:</u></p> <ul style="list-style-type: none"> • COMSOL Multiphysics (new tool to teach & supervise simulations)
<p>Educational form</p>	<p>Lectures</p> <p>Problem/project based assignments</p>	<p><u>Application of existing educational methods in new context:</u></p> <p>Problem-based learning is innovative and it will be enhanced with the use of cases from the industry. This educational method is new in the context of Applied Physics.</p>

Appendix 2 – Description of Magnetic Confinement and MHD for fusion plasmas (3MF110) Fusion Reactors: extreme materials and intense plasma wall interaction (3MF120) (MSc. Science & Technology of Nuclear Fusion) courses

Name of the course/code	Content & Learning outcomes	Innovative character of this project
<p><i>Magnetic Confinement and MHD for fusion plasmas (3MF110)</i></p>	<p>Content This lecture course presents the principles of magnetic confinement in fusion reactors starting with Coulomb collisions of charged particles and how this leads to the need for confining the energy and the introduction of the “ignition criterion”.</p> <p>Students will explain:</p> <ul style="list-style-type: none"> • the need for confinement in fusion reactors and principles of magnetic confinement • the function of the different components of a fusion reactor • describe the operation of a fusion reactor • derive and use the MHD equations in the frame of fusion plasma equilibria and instabilities • explain, derive and use the (neo)classical heat and particle transport equations and resistivity. Being able to explain neoclassical effects such as bootstrap current and Ware pinch. • explain the principles of magnetic and electrostatic (interchange and drift wave) turbulent transport. • Use the knowledge on plasma equilibrium to run or simulate a confinement experiment 	<p><u>New teaching methods:</u></p> <ul style="list-style-type: none"> • Flip-the-classroom: weblectures will be used to enhance the self-study time and contact time will focus on dealing with problems solving and assignments, providing feedback, etc. • Weblectures will be used to explain physics and fusion concepts <p><u>New tools:</u></p> <ul style="list-style-type: none"> • Weblectures • Pencasts
<p><i>Fusion Reactors: extreme materials and intense plasma wall interaction (3MF120)</i></p>	<p>Content Learning to solve the challenges of fusion energy in the press is about the spectacular science of plasmas at a temperature in excess of 100 Million degrees, the stability of magnetic confinement.</p>	

<p>MSc. Science & Technology of Nuclear Fusion</p>	<p>Students will:</p> <ul style="list-style-type: none"> • analyse the whole chain of processes by which the power from the hot plasma is eventually transferred to the reactor wall • to describe the Scrape Off Layer (SOL) in terms of parallel and cross-field diffusivities, pressure balance and continuity • to explain the mechanisms of chemical erosion and discuss its importance for various wall materials used in fusion reactors 	
<p>Educational form</p>	<p><i>Magnetic Confinement and MHD for fusion plasmas (3MF110)</i></p> <p>Lectures Paper and project based assignments</p> <p><i>Fusion Reactors: extreme materials and intense plasma wall interaction (3MF120)</i></p> <p>Regular lectures interleaved with problem solving, hands-on experiments in PlasmaLab, practical assignments with finite element modelling tools, excursions to the world-leading Plasma Surface Interaction facility Magnum-PSI at DIFFER, a nuclear research lab and the Superconductivity lab at Twente University.</p>	<p><u>Application of existing educational methods in new context:</u></p> <ul style="list-style-type: none"> • Teaching physics by addressing deficiencies in prior knowledge, differences in background (physics and engineering) learning styles, through weblectures/pencasts in Fusion courses

Appendix 3 – Description of *Supervision methods*

Name of the course/code	Content & Learning outcomes	Innovative character of this project
Supervision methods	<p>Content</p> <p>Group discussions and presentations on technological problems, experimental, theoretical, applied and research topics are part of the regular lunch meetings in <i>Fusion</i> courses. The lunch meetings are used as an informal learning and exchange of information in <i>Fusion</i> courses but also during the master thesis trajectory.</p> <p>Intervision meetings in <i>PEP</i> courses and internship.</p> <p>Students will:</p> <ul style="list-style-type: none"> • Enhance academic review skills • Strengthen peer review and feedback • Improving writing and presentation skills • Stimulating creativity and critical thinking 	<p><u>New teaching methods:</u></p> <p>Intervision and graduate ring (afstudeerkring)</p> <p><u>New tools:</u></p> <ul style="list-style-type: none"> • Self-assessment instrument based on competence and competence profiles to monitor and better supervise students.
Educational form	<p>Group discussions</p> <p>Presentations</p> <p>Intervision</p>	<p><u>Application of existing educational methods in new context:</u></p> <p>Supervision methods and techniques (e.g. peer feedback/small tutoring group) applied to individual needs and tailor-made feedback on progress on writing skills</p> <p>Intervision meetings to share and give each other's' advice on both content-wise but also process-related issues, e.g. common problems on writing master thesis reports.</p>

		<p>Enhancing creativity and 'out-of-the-box' thinking by generating critical thinking in the students attending peers' presentations. Presentations will be used as a vehicle to stimulate academic peer review and will be used as a method to generate questions instead of only to give feedback to the presenter.</p>
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