

## Project 3: Signals & Systems AP-EE-ME: implementing interdisciplinary challenge-based learning

### Applicants

Main applicants:

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### Project proposal, introduction, objectives and results

In line with the development of engineering education, the course Systems and Control (3BYX0) at the Applied Physics department, has evolved from a classical course (lectures and exercises) from 1961, to a mix of lectures and laboratory classes (practicum) in the period 2004-2015, to Design Based Learning in 2016. This has been a successful transition in terms of effectivity and student satisfaction. In the current educational form of the course, groups of students work together on one challenge: to float in thin air a plastic ball with a permanent magnet hidden in it, by lifting it with an electromagnet. In the current set-up there are no lectures or instructions. The students work in teams on an open-ended problem. Furthermore, various professional skills are embedded in the course. Feedback from the students in the course survey (2017-2018) indicate that students appreciated the amount of freedom they were given in this course. The project gave the students the opportunity to explore, integrate and reinforce their ongoing learning by actually making something. Furthermore, by working in project groups their motivation for the course was enforced<sup>13</sup>.

Based on the positive feedback from students, and the strategy 2030 of the TU/e on strongly enhancing challenged-based education in the near future, this proposal predominantly aims at the actual construction of an interdisciplinary AP-EE-ME challenge-based course on Signals & Systems with a new, open-ended technology challenge covering the three disciplines. Integration of the program development with theoretical knowledge obtained from Educational Research (Taconis et al.) will be crucial for the actual implementation of educational knowledge, needed to reach this objective. See Appendix 1 for a summary. Within this project, two phases can be discriminated:

**PHASE 1** is dealing with the preparatory innovations towards challenge-based education (academic year 2018/2019 and 2019/2020), aiming at a further optimization of the existing AP-course on Signals & Systems:

- The quality and weight of individual component of student assessment will be increased e.g. individual on-line tests on control technology
- To enhance interdisciplinary and to avoid 'cross talk' between groups and years, the number of different experiments will be expanded from one to at least three; from ME, their long-lasting experience with 'robot-arm' technology can be fully integrated

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<sup>13</sup> Survey results for the course 3BYX0 - DBL signals and systems 2017/2018 B3

- Development of learning objectives that will meet the requirements of each involved education program.
- Towards interdisciplinary integration, students from EE and ME will be enabled to follow this course instead of (or in conjunction with) parts of their own mandatory or non-mandatory curriculum;

**PHASE 2** is the actual construction of the 3-faculty interdisciplinary AP-EE-ME challenge-based course on Signals & Systems with a new, open-ended technology challenge. In the academic year 2019-2020 it will overlap with the advancements made in the preparatory phase, whereas in 2020-2021 the full implementation in the curriculum of three faculties will be realized. The following aspects are crucial for a successful implementation:

- For all students, interdisciplinary guest lectures from AP/EE/ME are integrated in the course line to illustrate the different flavors of control technology in the three different departments. The students should, from the start of the course, feel the need for an interdisciplinary approach as well as a strong disciplinary component.
- As a crucial and most advanced step, the project requires the design and construction of an open-ended Signals & Systems technology challenge for the 3-faculty multidisciplinary AP-EE-ME course. In the development of this technology, the disciplinary background of the participating students should be sufficiently visible. It is necessary that all students have a critical contribution, each with their own expertise and disciplinary background.
- The development of the multidisciplinary challenge should go hand in hand with theoretical educational aspects of knowledge development within this course, which requires strong interaction with the researchers in the project from Educational Research (Taconis et al., see also Appendix 1). This includes the design and implementation of a well-balanced assessment plan including sufficiently strong individual components.
- In the realization and implementation phase, Innovation Space at TU/e is a likely choice for all experimental student activities, profiting from state-of-the-art facilities and integrated technical support.

The aim of the project is that students acquire their knowledge on Signals & Systems by engaging in real-life challenges, by selecting and applying the knowledge that they need to solve the problem. In this process the responsible lecturers of the course will act as coaches, supporting the students in finding the right knowledge. This approach will result in a better understanding and integration of knowledge and skills among the students. Furthermore, just like during their future careers, students will experience working in an interdisciplinary team with members with different backgrounds in skills and in knowledge on an open-ended, real-life project. Moreover, by offering students various ways in which they can collect and select the information they need to solve the problem self-directed learning will be stimulated.

### Project design and management

The goal of this project is, to start piloting this interdisciplinary AP-EE-ME challenge-based course on Signals & Systems with a new, open-ended technology challenge in the academic year 2020-2021. In the academic year 2019-2020 it will overlap with the advancements made in the preparatory phase, whereas in 2020-2021 the full implementation in the curriculum of three faculties will be realized. In order to reach this goal the project will be divided into 2 phases. Phase 1 is dealing with the

preparatory innovations towards challenge-based education (academic year 2018/2019 and 2019/2020), aiming at a further optimization of the existing AP-course on Signals & Systems. Phase 2 is the actual construction of the 3-faculty interdisciplinary AP-EE-ME challenge-based course on Signals & Systems with a new, open-ended technology challenge.

**PHASE 1**

For the course in Q3 of 2018-2019 a digital assessment of the course content will be implemented in order to increase the quality and weight of individual component of the student on control technology. The implementation of the individual assessment of the students’ knowledge on control technology will be evaluated and an advisory report will be written.

<p>Design phase February – August 2019</p>	<p>During the design phase of Phase 1 several meetings with the responsible lectures and students of the course will take place. During these meetings an inventory of the wishes and needs will be made. This will form the basis of the set of requirements for the redesign (including individual assessment) of the course in 2019-2020.</p> <p>Furthermore, a design will be made for a number of different experiments with in the course will be developed.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An approved course design, including:             <ol style="list-style-type: none"> <li>a. The design for at least 3 different experiments for the challenge based, open-ended problem central in this course, including a test plan for testing these experimental set-ups</li> <li>b. The learning objectives that will meet the requirements for each education program</li> <li>c. A set-up for digitized learning that will support personal learning paths of our students</li> </ol> </li> <li>2. An approved assessment design, including:             <ol style="list-style-type: none"> <li>a. A plan for individual, digitalized assessment</li> </ol> </li> <li>3. An approved evaluation plan for the course</li> </ol>
<p>Production Phase August – October 2019</p>	<p>During the production phase different experiments will be developed based on the requirements. An implementation plan will be developed in order to enable students from EE and ME to follow this course.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An approved implementation plan of the course in the curricula of AP, ME and EE.</li> <li>2. three challenge based, open-ended experiments</li> <li>3. An online learning environment which support students in learning the theoretical knowledge that they will need to come up with a solution for the open-ended problem.</li> </ol>

<p>Testing Phase October – December 2019</p>	<p>During this phase a small group of students will test the redesign, incl. the assessment, of this course and especially:</p> <ul style="list-style-type: none"> <li>• The experiments</li> <li>• The online learning environment</li> </ul> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An evaluation report of the course, including a proposal for adjustments (if needed).</li> </ol>
<p>Realization Phase February 2020 Q3 2019-2020</p>	<p>During this phase the course will run. During this time the project team will meet up several times to evaluate the ongoing course and to make a list of possible changes that could be implemented in PHASE 2.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. Intermediate evaluation report</li> <li>2. If needed, adjustments based on the intermediate evaluation</li> </ol>

## PHASE 2

During this phase the actual construction of the 3-faculty interdisciplinary AP-EE-ME challenge-based course on Signals & Systems with a new, open-ended technology challenge. In the academic year 2019-2020 it will overlap with the advancements made in the preparatory phase, whereas in 2020-2021 the full implementation in the curriculum of three faculties will be realized.

<p>Design phase February – August 2020</p>	<p>During the design phase of Phase 1 several meetings with the responsible lectures and students of the course will take place. During these meetings an inventory of the wishes and needs will be made. The redesign will go hand in hand with theoretical educational aspects of knowledge development within this course based on the project from Educational Education (Taconis et al.). This will form the basis of the set of requirements for the redesign of the course in 2020-2021. One of the important aspects of this redesign is the design and construction of an open-ended Signals &amp; Systems technology challenge.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An approved course design, based on the experiences of the course set-up in 2019-2020, including: <ol style="list-style-type: none"> <li>a. The design for an additional 2 experiments for the challenge based, open-ended problem central in this course, including a test plan for testing these experimental set-ups</li> <li>b. The learning objectives that will meet the requirements for each education program</li> </ol> </li> </ol>
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	<ol style="list-style-type: none"> <li>c. A set-up for digitalized learning that will support personal learning paths of our students</li> <li>2. An approved assessment design, including: <ol style="list-style-type: none"> <li>a. A plan for individual, digitalized assessment</li> </ol> </li> <li>3. An approved evaluation plan for the course</li> </ol>
Production Phase August – October 2020	<p>During the production phase different experiments will be developed based on the requirements. Furthermore, the course set up of 2019-2020 will adjusted based on the experiences in phase 1.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An approved implementation plan of the course in the curricula of AP, ME and EE.</li> <li>2. two additional challenge based, open-ended experiments</li> <li>3. An online learning environment which support students in learning the theoretical knowledge that they will need to come up with a solution for the open-ended problem.</li> </ol>
Testing Phase October – December 2020	<p>During this phase a small group of students will test the redesign, incl. the assessment, of this course and especially:</p> <ul style="list-style-type: none"> <li>• The course set-up incl. assessment</li> <li>• The experiments</li> <li>• The online learning environment</li> </ul> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. An evaluation report of the course, including a proposal for adjustments (if needed).</li> </ol>
Realization Phase February 2021 Q3 2020-2021	<p>During this phase the course will run. During this time the project team will meet up several times to evaluate the ongoing course and to make a list of possible changes that could be implemented in the next edition of the course.</p> <p>The outcomes of this phase are:</p> <ol style="list-style-type: none"> <li>1. Intermediate evaluation report</li> <li>2. If needed, adjustments based on the intermediate evaluation</li> <li>3. Final evaluation report incl. proposal for implementation of this pilot in the regular organization of the department</li> </ol>

### Dissemination and sustainability of the project

Within the TU/e the department Applied Physics is one of the precursors of hands-on, challenge based education. To share the experiences with this course potential users will be informed about this project through:

- Educational lunches / Education days, incl. the TU/e Innovation Day
- Meetings of the TU/e Program Directors

- Publications, for example related to AUTIQ (Advanced University Teaching Innovation Qualification)
- (International) Conferences on education innovation, for example the ICAB conference.

Concerning the developed experiments and involved equipment, all three departments will be responsible for the maintenance of the experiments and equipment developed for this course. The experimental set-ups will be stored at one or more departments. During the development of the experimental set-ups, it will be investigated whether it is possible to have the experiments set-up in Innovation Space during the duration of the course.