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Computer-based and Screencasts Approach in the Signal Processing Basics Electrical Engineering Course: Does Blended-learning Work to Motivate Students?

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Abstract

This paper presents the first experience of the computer-based and screencast approach used in the Signal Processing Basics course to motivate first year electrical engineering students to assess their own knowledge and skills. Signal Processing Basics is a freshman course with up to 240 students. With the increasing number of students at the Electrical Engineering department (Eindhoven University of Technology), it becomes essential to pay attention to the prior knowledge and to provide sufficient feedback on their progress. The rationale behind is that through continuous online formative feedback on content progress students can make choices on the topics they still need to work on before taking the exam. The instructional design of the Signal Processing Basics course consists of lectures and instructions supported by computer education in the form of online quizzes and assignments with feedback and tutorials. In addition, screencasts are provided as a video-clip short summary of a basic building block or a small set of fundamental topics. Despite the educational value of this blended-learning approach students' pass rates in this first experiment are slightly similar than in previous years, although students' perceptions on the educational approach is positive.

Keywords: Engineering Education, Computer-based learning and instructional technology; Screencasts-based learning; Formative feedback and assessment.

Introduction

Preparing electrical engineering students to take control of their studies and to become more self-regulated learners has been the drive to re-design the Signal Processing Basics course. The initiative to adjust this course is also based on meeting the current challenges raised by the Eindhoven University of Technology (TU/e) policy. The purpose is to educate the *Engineers for the Future* as people-oriented generalists with strong disciplinary basis, skills and an entrepreneurial attitude able to solve societal problems. In addition, the purpose is to increase the students' intake is one of the targets. Within the framework of this policy, the electrical engineering study program contains major and elective courses which are open to other students from other engineering departments. Consequently, the number of students has grown and the need for tailor-made education has become a priority that pays attention to individual learning demands.

The objective of this study is to research the effects of computer-based education on first-year electrical engineering students, and to present the design of an instructional technology model suitable for engineering education.

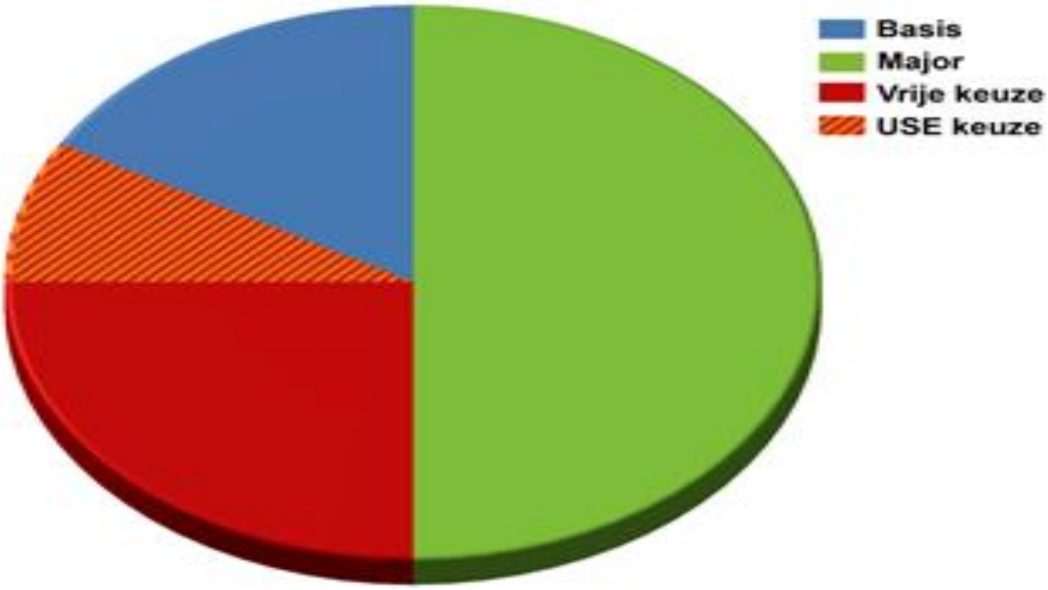
The *Engineers of the Future*: A Curriculum Shift

The vision of the Eindhoven University of Technology (TU/e) is to educate the *Engineers of the Future* lies on providing engineers with a broad disciplinary basis, skills and entrepreneurial attitude. This vision implies considerations for a radical transformation of the curriculum to make significant and innovative contributions to the society. Based on this rationale, the content and form of the study programs needed to be drastically adjusted [1]. Furthermore, other types of considerations following the dramatic figures on drop-outs led to take policies in action to reduce drop-outs, to make the study programs more attractive, and to draw more different types of engineer students. In addition, educating the *Engineers of the Future* ask for a paradigm shift in the teaching and learning methods. Within this framework of radical transformations, the vision of education 2030 was started up.

Transforming this vision in a realistic scheme [1], the curriculum for the different study programs therefore comprised the following (see also *Fig. 1*):

- Major disciplinary courses (90 EC) specific to each study program;
- Elective courses (45 EC);
- Basic compulsory courses (30 EC) for all engineer students;
- USE (User, Society and Enterprise 15 EC) courses for all engineer students;
- Professional Skills (Communication, written and presenting;
- Reflection; Planning and organization; Dealing with scientific information; and Collaboration – 5 EC).

Figure 1. *Overview Structure Bachelor Curriculum for all TU/e Study Programs*



The Context for the Redesign of Courses

One of the consequences of this transformation in the TU/e educational vision is the growth in the students' intake. Within the context of the increasing number of students, new educational challenges arise. First of all, the classroom composition is heterogeneous as students follow the courses in our Electrical Engineering department. This entails sometimes lack in prior knowledge as well as differences in learning styles. Secondly, other educational policies such as the quality of assessment and exams, and blended-learning, request from teachers to undertake major innovations in educational methods.

With this clear education policy agenda, the Electrical Engineering faculty staff is integrating computer-based learning tools and blended-learning approaches into the teaching practices [2]. The educational benefits of the use of computer-based and blended methods are that the teachers' working load is reduced, students' individual needs are addressed and the self-study time is maximized. Students get feedback on progress, can identify lacunas in prior knowledge, differentiation in learning styles and levels is tackled and students get motivated [3-4].

Theoretical Background

The classroom experiment of the Signal Processing Basics is imbedded in the theories of motivation of students and constructivism. In addition, the current trends in blended-learning together with the university education policies to enhance quality, i.e. assessment and exams, and performance, have framed the approach used in this computer-technology based course.

There are many definitions, theories and viewpoints regarding blended-learning. The amalgam of terms such as blended learning, hybrid learning, technology-mediated instruction, web-enhanced instruction, and mixed-mode instruction are often used interchangeably in the research literature [5]. Although all these terms have several aspects in common such as the integration of IT tools in education, flexible form to provide education and feedback, the combination of the contact hours and online self-study, etc., the differences lie in its application within a specific context of a course [6-9].

Examples and research on the benefits of computer-technology based abound in the literature. Differences are often times little and these lay mainly on the combination of instructional modalities or delivery media in the combination of instructional methods, or in the combination of online and face-to-face instruction [5].

Recent research on the effectiveness of blended-learning in classroom practices shows that this type of technology-based combined-type of instruction is more effective than only face-to-face teaching. The added value of the application of the blended-learning concept is that it can reach every single student within large-size classrooms addressing individual needs in learning styles and pace, and conceptual understanding.

Furthermore, the implementation of blended-learning implies a different approach to teaching from the side of the teachers, and to learn from the side of the students. Just as in the constructivism theory of learning, the students are central in this process to take responsibility on their studies as self-directed learners, as they get formative feedback and continuous assessment on assignments via the online platform. The implementation of blended-learning implies as well a different structure in the preparation of lessons. While students spend more effort in the self-study time, in doing assignments and in preparing the readings for the next day lecture or instruction, the teachers are to use the contact time more efficiently as they observe students' progress through the online assignments. In this manner, the teaching staff is able to gain a quick view and feedback on the students' results in understanding and calculation exercises. Teachers know what the problems and mistakes are and can use and flip the structure of the classroom [11] as time is devoted during the lecture or instruction for additional assignments, extra explanations or hands-on exercises.

One of the key elements of successful implementation of blended-learning is the motivation of the students to take up the responsibility for their own learning. Self-determination theory suggests that to optimize motivation a learning environment that satisfies individuals' needs to include the following components: means to provide autonomy, to foster competence, and relatedness [12]. In addition, the combination of these elements with the provision of positive feedback [13] may produce important gains in learning.

The theoretical insights of these components have outlined in general the design of the Signal Processing Basics.

The Design of the Signal Processing Basics Course

The Content and Focus of the Signal Processing Basics Course

The Signal Processing Basics course focuses on describing the nowadays processing of analog, or continuous-time, signals in the digital, discrete-time, the domain is pervasive [14]. In the current days, digital signal processing techniques are used in many devices such as in digital photo cameras, MP3 players, mobile phones to automobiles and advanced medical equipment. We have observed, however, that for the students the digital signal processing concepts are oftentimes abstract mathematics. Actually, the course Signal Processing Basics fills this gap by moving from simple continuous-time signals, to discrete-time signals and systems, then back to the continuous-time. This is because many practical analog signals can be described by sums of sinusoidal signals. The course begins very simply with a detailed discussion of continuous-time sinusoidal signals and their representation by complex exponentials. The course proceeds afterwards with an introduction of the spectrum concept. Actually, this happens by considering the sums of sinusoidal signals with a brief introduction to Fourier series. The sequence the course follows is a transition to discrete-time signals by considering sampled sinusoidal signals. In this course, important issues in sampling without the additional complexity of Fourier transforms are introduced by relying on simple mathematics of sine and cosine functions. The basic linear system concepts are introduced with simple so called Finite Impulse Response (FIR) filters. The course tackles as well the derivation and interpretation of the key concept of frequency response for FIR filters.

The 'Blended' Redesign of the Signal Processing Basic Course

To apply the learning outcomes of this course and within the educational framework described in the section on Theoretical background, the Signal Processing Basics course is an example of a computer-based and instructional technology model that meets the TU/e educational policies and students' individual learning needs. The Signal Processing Basics course had a traditional structure of lectures and instructions with no e-learning support platform. The classroom size is up to 240 students. Although the self-directed motivation theory and other components described in the theoretical section in this paper were not consciously introduced by the teacher in the Signal Processing Basics, the rationale and the setup of the redesign of this course resembles some of the components. The redesign of this course comprises a number of didactical components:

- Formative assessment;
- Individual feedback on progress, and tutorials with additional support to remediate drawbacks with extra exercises;
- Tailor-made education: meeting individual learning needs by providing short summaries through screencasts on key parts of the lectures.

- Motivating students to challenge their own knowledge by practice quizzes and make-your-own-test approach.

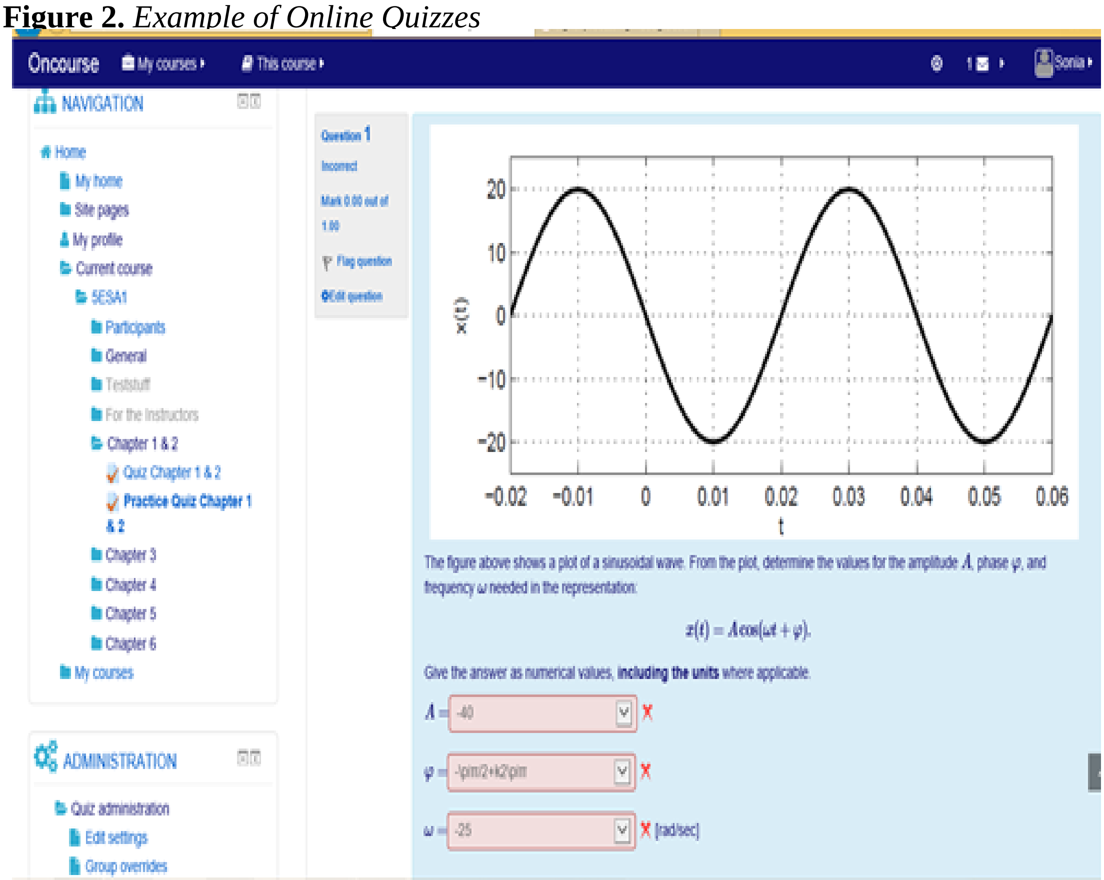
Method and Approach

Formative Assessment and Computer-Based Learning

With these educational components in mind, we integrated a weekly online multiple-choice and randomize practice quizzes in a moodle platform, Oncourse (Figure 2) as formative assessment. The weekly online quizzes are meant to serve as an *assessment for learning tool* to provide students with information on progress on knowledge and skills. After each lecture, students have access to the online assignments that they do during the self-study time and homework. These e-quizzes do not count as a mark of the continuous assessment process but it is meant to work as motivation for students to assess their own progress. This computer-based learning program allows students to get access to the overview of answers as the system immediately provides the results of the solutions inserted by the students as shown below in Figure 2.

The e-quizzes are both multiple-choice types of questions as well as questionsin which students are to provide numerical or symbolic answers based on open types of questions.

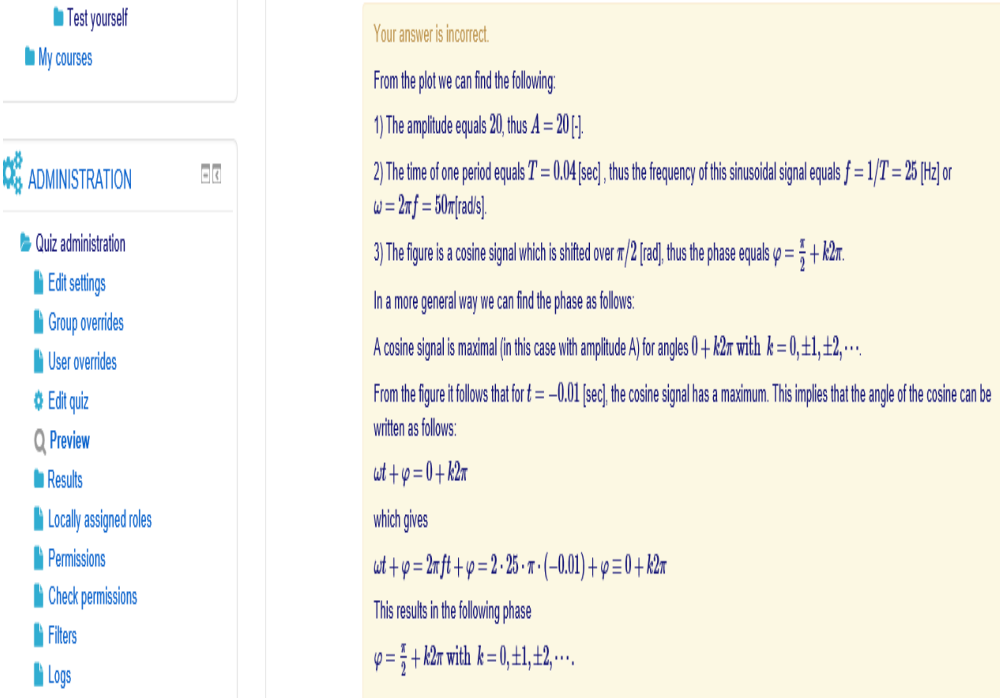
Figure 2. *Example of Online Quizzes*



Individual Feedback on Progress and Tutorials

The added value of this digital individual feedback method is that the students also get access to tutorials. After inserting the answers, the computer-based system identifies whether the answer is correct or a mistaken. The system is programmed to provide information in the form of a tutorial accompanied by an explanation on the mistakes. The didactical approach in this regard, is to tailor-made the education to the needs of each individual student by providing just-in-time feedback and feed-forward on to improve. (See Figure 3).

Figure 3. *Online Tutorial to Explain Mistakes*



Tailor-Made Education

The instructional design approach followed in the Signal Processing Basics course is aimed at tailoring the education and meeting the individual learning needs of the students. The design approach of this course consists of four categories of questions to support the students' self-assessment of knowledge and skills.

This computer-based model also consists of having access to online quizzes after each chapter book from which they get a bonus point after completion. The instructional model of this blended course is divided into four categories of questions or assignments:

- The practical quizzes to practice after each lecture and instruction. This allows the students to identify whether they have the basic required knowledge. This form of feedback with the tutorial system helps the students detect what still needs to be done or study to reach the desired level. In this regard, we target to give students the autonomy to practice in case the results in the e-quizzes indicate low positive answers.

- The weekly quizzes both multiple-choice questions and open answers that students' provide based on diagrams, drawings or calculations. Students insert numbers or symbols. This category of questions provides students with feedback on to what extent they manage the expected test level as the questions resemble the exam questions. The feedback however is not immediate but just after three days in order to give students the chance to ask questions during the lectures and instructions on issues they still find difficult. By doing so, we foster the development of competence in the students.
- In addition, the screencast short films (some of them still in development) provide a summary after each chapter with an outline of the main concepts addressed in the weekly lectures. This includes also Matlab images.
- Finally, with the option 'Test yourself' students have access to a representative exam with randomized questions. Students can construct their own exam and practice on the type of level and questions they don't manage yet. In this sense, we address relatedness with the expected understanding and connection with the test level.

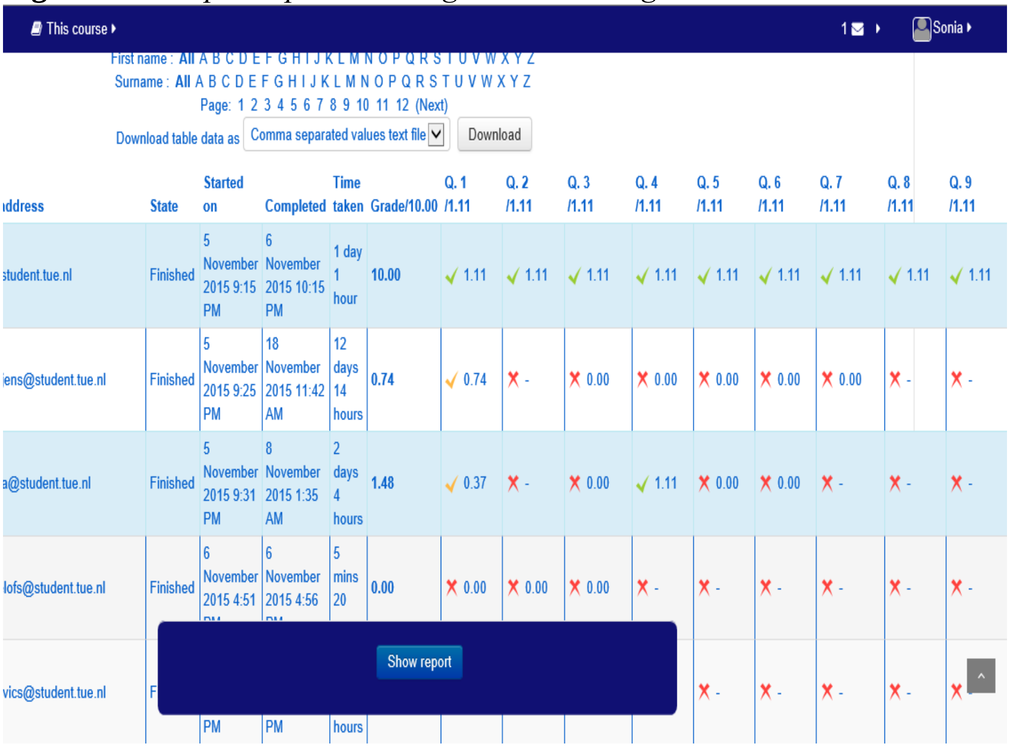
  By introducing all these categories of questions and additional resources it is encouraged that students with different learning styles and lack of knowledge and skills in different topics can have enough variation in educational material to practice and learn at their own path. The rationale behind is to stimulate self-directed learning as students are independent learners in assessing their own needs.

Motivating Students to Challenge Own Knowledge by Practice Quizzes and Make-your-Own-Test Approach: The Power of Feedback

The online moodle system, Oncourse, allows the possibility to provide prompt feedback on students' practical assignments and quizzes (see Figure 4). By doing so, student's get an immediate overview of the progress, understanding of concepts and calculations, and mistakes they make. The students' answers in this system are also used as feedback for the teacher who follows weekly the students' results on the assignments. The feedback on the progress is used both by students and teachers to monitor the development.

In addition, the teaching staff uses the results to come back to common mistakes during lectures and instructions and to provide additional explanation on theoretical issues or the step-by-step mathematical strategy for problem solving.

Figure 4. *Example Report Showing Students' Progress*



Results

Student's Pass Rates in Different Cohorts

In order to evaluate this classroom experiment we used the pass rates to see whether there are some effects on students' gains. We compared the pass rate of the previous years with this last academic year. Results of this first experiment indicate similar or even a lower pass rate. Reasons for this may be encountered in the students' motivation to take and practice the content voluntary through the online quizzes is low since the quizzes are not part of the final score. Although computer-based education has significant advantages for teachers and students, the students' motivation to practice to learn and to rehearse for the exam is still a challenge.

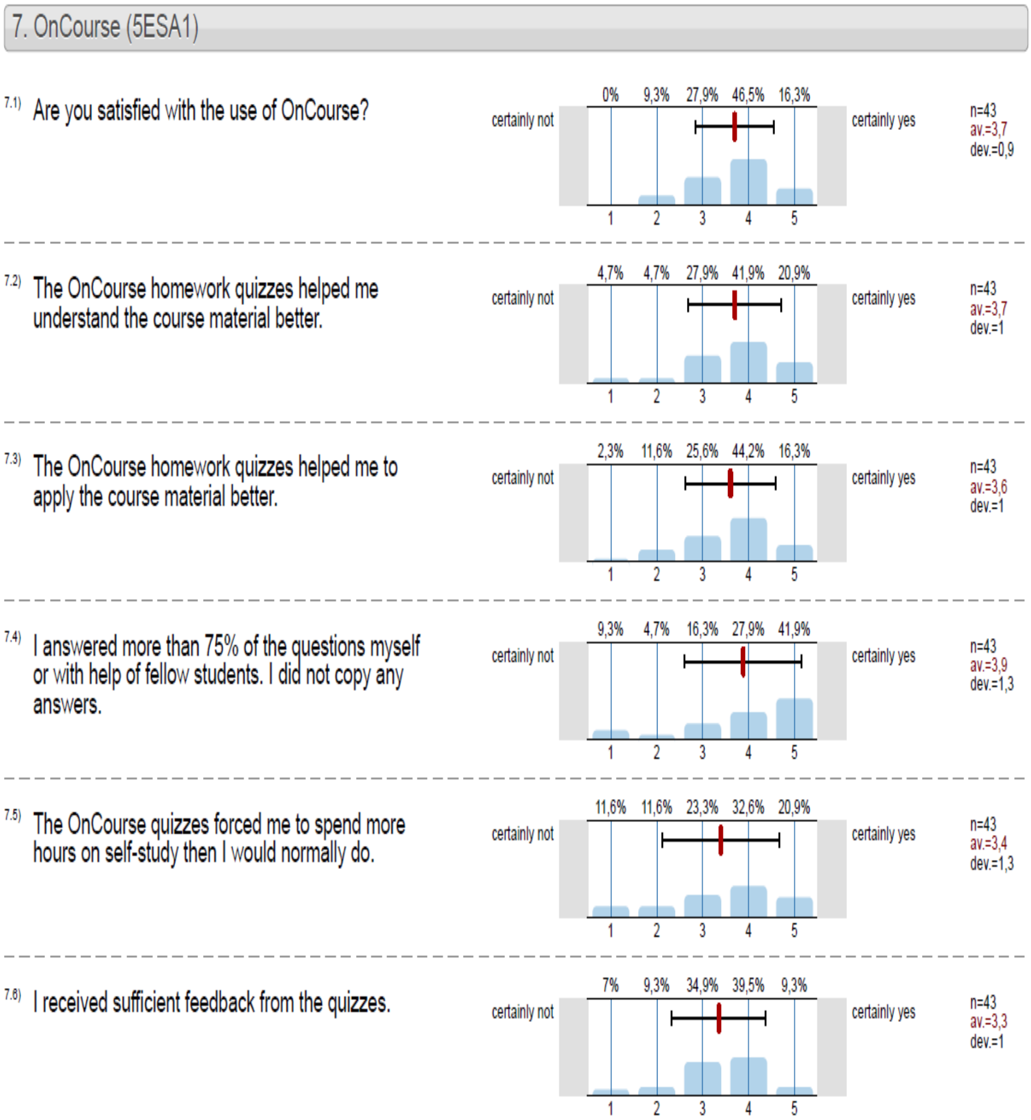
Table 1. *Overview Students' Results Cohorts 2014/2015 and 2015/2016*

Cohort 2014/2015		**Cohort 2015/2016**	
	%		%
	53		45

Measuring Students' Perceptions on Computer-Based Learning

To measure the students' satisfaction we used a likert scale 1 to 5 questionnaire. We measured the students' satisfaction regarding the computer-based learning tool Oncourse, the feedback they receive from online quizzes, whether the online assignments supported them to understand and apply the material better, and whether the students worked more during the self-study time. The results of students' perception are quite satisfactory. Results are very positive as students indicate to have gained sufficient feedback on progress, but also that helps to understand and apply better the content learned in the lectures and instructions. In addition, students reported that computer learning supported them to work harder during the self-study time. Further improvements include the development of an online lab assignment; the production of a database of online item bank and feedback, and including quizzes as part of the assessment score. In Figure 5 we show the students' perceptions from the EvaSys official quality assurance system.

Figure 5. *Students' Satisfaction on Online Assignments*



Conclusions and Discussion

In this study we aimed at exploring the suitability of computer-based learning to teach the Signals Processing Basics course. The instructional method included a four-fold approach, e.g. practice quizzes with feedback and tutorials, the test quizzes, screencasts, and make-your-own-test, and has provided sufficient opportunities to the students to get formative feedback on their progress as an assessment method for learning. The significance of this study and its results is also valuable, as the Electrical Engineering faculty staff is currently experimenting with computer-based teaching methods in order to make education more efficient and address the students' individual needs. Replicability and dissemination of these practices are crucial to search the means to improve the quality of education and innovative classroom practices.

In addition, student's perceptions on computer-based learning are positive as this online system allows students to get prompt feedback and to monitor their progress. The feedback produced by the e-quizzes moodle Oncourse system allows the teacher as well to gain an overview of the students' gaps in knowledge and skills. This enables the teacher to address lacunas and misconceptions during lectures and instructions.

Despite the fact the educational and theoretical elements framing the instructional design of the Signals Processing Basics, the expected outcomes in terms of higher pass rates and intrinsic motivation of the students as self-directed independent learners to take initiative and lead own progress has not yield the results as estimated. The reasons may be encountered in that the students' intake is broad and differences in prior knowledge still remains a challenge. Moreover, the fact that this *'assessment for learning'* approach consisting in practice and weekly e-quizzes is not marked may cause that students do not see the added value of working on the assignments as they do not receive any grading for it. In this regard, motivation based on monitoring and assessing their own progress has not contributed to higher pass rates.

Although blended-learning has been a positive vehicle to address the students' needs by monitoring progress and by giving feedback, this approach has not had direct effects on the students' motivation. The combination of blended-learning and an adjusted assessment strategy would have benefits on students' learning.

The results are still promising as students indicate the added value of the computer-based learning method of this course regarding receiving feedback, enhancing the self-study time and helping to understand better the study material.

The results of this first experience serve to create a new iteration in the instructional design of this course. Some adjustments in this method for further implementation in the coming academic year include first of all, that the practice and weekly e-quizzes will be marked as part of the formative assessment approach of this course. Secondly, to encourage students to prepare the lectures and instructions by first having them to watch videos and screencasts and answer some specific e-questions on the one hand. On the other, clicker questions with a response device will be asked during lectures to recall the material seen during the self-study time. Finally, the feedback and tutorial approach to provide students with information based on the mistakes the make while filling in the e-quizzes will include hints, solution or full explanation depending on the assignments.

In addition, lab assignments are integrated to have students to work on the content through lab assignments as well where also important knowledge and skills are practiced.

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