Abstract — Self-assessment as a part of the active learning methodology is described on the examples in learning a series of electrical engineering disciplines related to electronics and electrical drives. A set of principles is postulated which acts as a prerequisite of successful self-assessment procedures in evaluation of theoretical knowledge, practical skills, and computer simulation experiences. Analysis of lesson attendance, participation in self-assessment, and final grades, show a number of benefits of the proposed approach.

I. INTRODUCTION

An active learning quickly finds favour in a lot of areas of knowledge transfer. This educational methodology first presented in [1] is based on a known precept of didactical theory that learners are most heavily motivated to solve problems they evidently perceive as a need to understand. Active learning concentrates on the students’ wish for learning moving the responsibility of knowledge acquisition on learners. A significant advantage of such a student-centred method focuses on transition from the time-based to achievement-based education. It depicts learning as problem formulation with following searching of appropriate issues and solutions where the students get ownership of their education. Simultaneously, the role of the teachers and academic staff transfers from “oracles” shared knowledge to “facilitators” who guide and support the learners in their own learning.

Active learning expands greatly the educational opportunities for various groups of students, including the strong and the weak ones. Applying this methodology, the learners construct their own knowledge using the new learning skills, exploration experiences, feedback evaluation, and reflection [2]. In the context of active learning, the laboratory practice and computer-oriented exercises become the most important stages of engineering training whereas lecturing goes to the auxiliary side.

This paper focuses on an assessment stage in the scope of active learning. The aim of the assessment is to interpret learners’ personal understanding and their possibilities to design individual examples against the existing theoretical and practical tasks. Being a flexible tool to focus attention on important aspects of knowing, the assessment must help to explore what students are actually learning and how they do it. It should demonstrate what learners see as important concepts and how they relate these concepts. The assessment results can have implications for clarifying the learning objectives, refining instructional strategies, identifying appropriate evaluation tools, and understanding how the learning objectives are being realized by students.

The goal of the reported research is to ground the benefits and to discuss the problems of the new self-assessment methodology introduced in six electrical engineering disciplines: AAR3320 – Electronic Engineering, AAV0020 – Power Electronics, AAV0050 – Advanced Course of Power Electronics, AAV0080 – General Course of Electrical Drives, AAV0040 – Advanced Course of Electrical Drives, and AAV0060 – Electrical Drives and Power Electronics.

The paper describes the solutions of following problems in the field of electrical engineering education: benefits of self-assessment, distinction from the traditional learning evaluation, self-assessment of theoretical knowledge, self-assessment of practical skills, and self-assessment in the computer exercises. Finally all the results are compared and discussed.

II. ASSESSMENT OR SELF-ASSESSMENT: WHEREIN A DIFFERENCE?

Traditionally the grading and evaluation schemes are prescribed by the existing educational system. Every curriculum indicates the number of examinations and practical credits the learners need to pass. As a rule, the students are required to take the theory exams that qualify them for the next semester, and to get some credits as prerequisites for further exams. Typical drawbacks and ineffectiveness of such evaluation were cited frequently [3], [4].

In practice, answering the questions posed to students regarding different aspects of their activity is often liable to the subjective and narrow grading. Such traditional “paper and pencil” evaluations are usually criticised as heavily oriented towards the exams, without other forms of assessment [5]. When the sole evaluation purpose is to measure the students’ ability to respond the questions asked in the form of examinations and credits, it is difficult to understand whether the students can apply their knowledge and use it in the real engineering activity [6]. In this case, the assessment does not represent a part of the learning process, but rather some scheduling events taking place at fixed times during the academic year.

Meanwhile, an assessment is required to give the feedback relatively the students’ progress and achievements. It has to promote learning and to affect on what the students learn, how effectively they spend their time and consequently on the outcomes of their learning. Undoubtedly, both the effectiveness of engineering education and the overall study advancements depend strongly on how well the instructors feel the role of evaluation. If assessment is considered as an integral part of education without which learning is impossible, the students will be stimulated in regular assessment to get the required learning outcomes. Such
assessment as a tool becomes a prerequisite for the professional development [7].

The complexity in the practical application of the theory represents an important feature of traditional engineering training. Knowledge transfer from the class to real-life situations and applications cannot be spontaneous. As a rule, sequential educational interventions are requested in order to increase the ability for such a transition [8]. Therefore, the evaluation methodology must be reformulated and redefined to stimulate a trainee via assessment thus helping him to receive the actual and useful feedbacks.

Self-assessment discussed in this paper can serve as a powerful tool to overpass the barrier between the practical activity and the theoretical knowledge [9]. In contrast to the traditional grading which target is the only evaluation of the learning process without considering this procedure as a tool of improving learning, an effort has to be made to transfer from assessment of learning towards an assessment for learning [7], [10], [11].

By choosing the formative role of mistakes as the major driver for the student motivation, our goal was to arrange the transition from the “one-shot grading process” to “continuous evaluation”. The developed assessment model first published in [12] performs several iterations in the course time span by merging learning and evaluation into the common cycle. Thanks to a quick feedback and learning connection with the student’s interest, in this way assessment does not take place at some fixed times during the term but flows along with other lessons. Such an evaluation built into the lectures, labs, and exercises monitors the students’ progress uninterruptedly and applies it as a guideline of the learners’ achievements. Now it is used as a way of reflection and a feedback for teachers and staff in gauging questionable problems, identifying weak areas, and addressing issues to watch where students are in their learning progress. It is important that the new approach has changed the students’ thinking about the assessment as a learning instrument, and not just in passing examinations. It provides integration of teaching and learning with evaluation, which became meaningful, authentic, and engaging. The basic features of this methodology relate to performance of students as the active participants in the assessment of their own work and in the design of own reflective thinking [13].

III. SELF-ASSESSMENT OF THEORETICAL KNOWLEDGE

Following the cycle of lectures, students have to be assessed in their theoretical knowledge level. At the same time, every our learner has an ability to make evaluation using the self-assessment procedure. He/she can enrol or break this process at any time of the course continuation. To support self-assessment, the rules and problems for the final examination are brought to the students’ attention in the beginning of the semester.

In AAR3320 – Electronic Engineering, AAV0020 – Power Electronics, and AAV0050 – Advanced Course of Power Electronics, an in-class assessment has been arranged as a regular, mandatory event of every lecture. It has a form of individual quizzes with multiple choices. In AAR3320 and AAV0050 the quizzes forms are shared among the students before the lecture. In AAV0020 the quiz questions appear on the screen during or after the lecture. Missed lecture means the lost of the rating scores therefore the students concern about lecture attendance themselves. The drawbacks of such in-class assessment relate to its time costs for the instructor who must examine and evaluate many quizzes. The benefit represents enough flexible scoring system, which can include negative scores for incorrect answers and non-linear grading of the specific and important questions.

In AAV0080 – General Course of Electrical Drives, AAV0040 – Advanced Course of Electrical Drives, and AAV0060 – Electrical Drives and Power Electronics, the personal quizzes are open in the Internet in the prescribed time slots of the lecture day, usually from midnight to midnight thought the number of attempts is unrestricted. In this way, the students visit the lecture with an intention to find the quiz answers or to correct their information obtained before the lecture. At such an approach, the lecture attendance seems optional.

Our experience argues that sharing the personal quiz sheets among the students before the lecture represents a good practice. In this case, the students endeavour to come beforehand, to discuss and clarify their problems, to find the sources of information, to occupy the best places in the classroom, and to ask the lecturer about their problems.

The use of Web, notebooks, textbooks, etc. is not prohibited during the quizzing. Students usually discuss probable solutions with each other or they listen to the lecturer, make abstracts, interrupt him, and ask qualifying questions during the lecture. To support the students’ interest, the solutions of many of the quiz problems are included into the lecture content, evidently or marginally.

Liable quiz answers do not represent the secret. At the end of every lecture, a lecturer reserves a time slot (5 to 10 minutes) for discussion and debates both the students with the instructor and with each other. Here, a lecturer clarifies the quiz problems and makes recommendations. At the same time, multitasking is a good way to prevent from direct answering the quiz questions.

To support learners in their self-assessment performance, an original learning content management system (LCMS) has been designed [14], which represents a segment of the national learning management system built on the basis of the well-known Moodle toolkit [15]. The main components of the developed LCMS are placed in the repository of Estonian National e-Learning Portal. The system includes the Web-textbooks on Electronics, Power Electronics, and Electrical Drives as well as the hypertext tutorial aids, videos supporting the lecture understanding, weekly updated assessment sheets, the examination problems and their rules, and some other e-documents. As well, the LCMS shares self-evaluation recommendations and the rating tables in which information about student’s scores is updated periodically.

All student responses are supported with an instructor’s feedback. The most effective teacher-to-student out-of-school collaboration is arranged with the help of social media, primarily via the Facebook pages. Every course is supported with such an open-access page. Discussions through the Facebook are very fruitful thanks to its powerful tools, such as personal profiles, chats, pictures, videos, etc.
If a student’s self-assessment rating does not exceed ‘3’, it means that at the end of the term he/she needs to take a traditional exam the grade of which depends on the solution of the proposed examination problems.

During the learning, the students follow online their current rating and watch expected examination grade. This information serves them as an instrument for planning, adjusting, and prediction their learning outcomes. One example of an online self-assessment page is shown in Fig. 1.

Our goal in the labs organisation is to approach practice to the theory as close as possible, to effectively employ novel online tools and devices, to face real-world situations, to interact with peers in circumstances that require problem solving skills developed through close collaboration, which is characterised by initiative, creativity, etc. This also emphasises the benefits of experimentation within other learning activities, in part, because these activities permit students to interact in a new fashion.

Following this goal, our main method to increase student’s activity in experimentation and to suppress cheating consists in application of multi-variant multi-choice individual directions and questions and in increasing the number of open problems where students can accomplish their own tasks. Since the tasks and questions as well as the choices within the questions are shuffled randomly, the number of variants is actually equal to the number of students.

At the same time, in all the practical tasks the participants are supported with full access to the course materials that could be printed out prior to the experimentation. Additionally, they can apply any stimulus materials (animations, simulations, and virtual experiments in the form of Java applets or Flash objects) to generate responses or analyse data.

The process of students’ competence evaluation is generally done at every stage of the laboratory session, including pre-work and post-work talks, successful completion of the experiment, and report submission. All these performances and the laboratory report are checked and, once the students complete the laboratory module both his particular weighting scores and the final grade are prepared and displayed. After the report is presented, the following review options help the learner to understand the question solution and to further improve his skills: whether his result is correct, what is the right answer, and what is the teacher’s feedback? The standard Moodle report engine includes a suitable style for the result displaying. Currently the grade sheet is published where all the laboratory users and instructors can easily keep the information for future reference.

Additional benefit is obtained from the self-assessment procedure based on automatically scoring answers on the questions regarding the practical lab preparation. As well, each laboratory work involves both the compulsory and the optional items. Solution of only major problems is mandatory whereas the other ones are optional. Participants will obtain additional scores if the team implements the optional points.

To understand how students perceive the work, we improved the conclusion section of personal lab reports. Here, the reporters are asked about ease of access laboratory modules and their ability to help in concept clarifying. We ask the student’s recommendations regarding stimulation their interest in experimentation and work organisation as well as about mistakes in the circuits, manuals, methodology, etc. Every fruitful advice is graded with additional score and serves for the future work enhancement. It enables evaluating instructional materials and methods and thus helps in improving teaching effectiveness.

One useful feature of an automatic scoring is the deadline and cut-off time scheduling. It is prohibited to start the next
lab without reporting the previous work, to begin work in the case of coming late, as well as to get optional points after deadlines. Also, nothing can be improved in the report after the cut-off date and/or grading. This helps to discipline the learners and increase the responsibility for every step and action.

In this way, the proposed e-assessment system of the laboratory practice opens the possibility to evaluate not just students’ declarative, but also their procedural knowledge (i.e., explaining and applying the skills, answering “why and how” questions, etc) needed for interacting with equipment and colleagues in a variety of paths. This focus on the skill priority is tailored to students’ engaging in development such individual and collaborative aspects like discipline, interdisciplinary context, pragmatic outcomes, and professional preferences for getting the most out of their learning.

V. SELF-ASSESSMENT OF EXERCISES

Objectives of exercises in computer simulation are to prepare experts in the schemas and to develop the trainee’s experiences with major types of electrical devices. The students learn how to identify the circuit functions and determine how they perform. To this aim, they study the signal input stimuli, collect the output data, and compare them with the expected responses defined in the textbooks and manuals. Beside the system design, learners are responsible for appreciation of the diagnosis strategy, which requires them to analyse the circuits and their functional specifications. Students should determine what faults and malfunctions they detect and which tests and inputs the fault propagates at.

Below, a collection of principles is postulated which acts as the prerequisite of successful assessment of computer-aided exercises.

First, multitasking and personalization are the compulsory conditions for the students’ evaluation. Every student should constantly feel his own liability for the learning result.

Second, there is no way to prepare an engineer without calculation tasks. We try to apply in practice every formula given during the lecture in one way or another. Very short verbal calculations, approximate measurements, and preliminary estimations are the important parts of engineering practice.

Third, the student’s ability to ask questions also demonstrates his knowledge level. Specially, it concerns the classroom lessons that should reserve enough time to answer the student’s requests.

Fourth, as repetition is an important part of knowledge appreciation, a part of exercise problems comes from the previous lessons. Also, additional questions in examination cards include the computer tasks.

Assessment during exercises invokes to evaluate:

- understanding of the learning objectives and the methodology used
- quality of the problem solutions under the practical headings
- practical experience and qualification obtained from simulation
- nature and appropriateness of student collaboration and group working potential

The evaluation currently applied consists in a continuous assessment throughout the exercise lessons. As all the exercises involve both the compulsory and the optional items, a learner may obtain additional scores if he/she implements the optional parts. The scoring principle assumes obtaining one score for each solved problem.

The classroom discussions and talks are used regularly as a substantial instrument of learning monitoring and students’ evaluation. To ensure students’ preparedness for a lesson, a teacher asks usually 5 to 10 questions before, during, or after the simulation. Students are asked to search answers to the questions that were preliminarily published. Every correct answer increases the trainee’s personal rating thanks to the simple scoring rule.

Analyses of the in-class evaluations have resulted in the following:

- some learners tend to approach the minimal mandatory level whereas most of them rush the maximal score
- the reason of low scoring lies in the difficulty in the understanding of many physical phenomena that requires additional time and knowledge
- the low-motivated students are more passive during the exercises, therefore special attention to this group is needed
- there was found an evident dependence between the exercise scores and the final examination grades

VI. ANALYSIS AND DISCUSSION

Some self-assessment results are represented in Fig. 2. Here, three categories of engineering students are compared among about 250 learners. The first one (around 100 students of AAR3320) represents three second-year bachelor groups without any preliminary experience in active learning. The second category (35 students of AAV0020 and 75 students of AAV0080) represents four third-year bachelor groups who have enough skill in self-assessment. The third category (15 students of AAV0050 and 12 students of AAV0040) involves two master groups who have both the learning and the professional experiences. The diagram shows the results obtained in 2013/2014 academic year.

![Fig. 2. Analysis of self-assessment.](image)

Lecture attendance • Participation in self-assessment • Final grading without exam

The first important observation concerns the lecture attendance. Traditionally, this index drops with time because lecture visiting is optional in the university. In our case, the attendance in the frame of self-assessment remains
persistently high weakly depending on the quizzing method, whether it is online (AAV0080, AAV0040) or on-lecture (AAR3320, AAV0020 and AAV0050) quiz. It seems especially important for the master study where the students have to attend classes along with their professional work.

At the same time, participation in the self-assessment increases in progress of learning in all forms of lessons, whether it is lectures, labs or exercises. To the end, all the attendants visit the classes for the sake of self-evaluation.

The third columns in Fig. 1 represent the most remarkable result that is the student’s experience in self-assessment also increases in progress of learning. In this way, the targets of learning are reached thanks to the proposed approach.

VII. CONCLUSION

A self-assessment methodology in learning electrical engineering disciplines has resulted in development such useful skills as the problem solution, effective calculations, experimentation performance, practical experience, and acquisition of qualification. Analysis of lesson attendance, participation in self-assessment, and final grades show, that an active approach became beneficial, leading to deep understanding and design of a conceptual knowledge base.

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