Learning process enhancement through self-testing and self-assessment using the TeSLA system

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Learning Process Enhancement Through Self-testing And Self-assessment Using The TeSLA System

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Abstract. The learning process consists in memorizing knowledge, knowledge analysis and organization, knowledge application in practice. Its enhancement is still a challenging issue that provokes a wide variety of approaches. This paper suggests a solution for the enhancement of the learning process in different courses through students' self-testing and self-assessment. Activities for self-assessment are implemented in Moodle, and the TeSLA system is used for e-authentication and authorship verification that is adaptable to various assessment scenarios. The experiment presented follows and verifies the model for self-assessment using the TeSLA system proposed by the authors in their other work. Findings show an improved understanding of knowledge and their application during mathematical and engineering assessment activities.

INTRODUCTION AND MOTIVATION

Students' involvement in educational process is an important factor for their achievement and performance. According to Nash [1], the idea of self-directed learning originated with the response to what is the ideal aim of education in a democracy - it is the creation of self-control that can guide one's personal freedom to choose. Self-directed learning can happens under a number of conditions, such as: 1) teachers act as facilitators rather than as sources of content; 2) learners are involved in selecting learning resources and strategies, and 3) learners are involved in self-assessment of their learning outcomes [2]. The advantages of independence are that it encourages active learning and extends student responsibility for learning. The basis for self-directed learning includes three elements: learners must: (a) perform tasks, (b) assess their task performance, and (c) choose future tasks for improving their performance. Independent learning is a proactive process rather than a reactive event that happens to students due to "impersonal forces" such as teaching. Independent learning in mathematics results from a student's attitude and ability to learn mathematics independently, master a competency and be responsible for completing the task with reduced guidance from others [3]. To improve and maintain mathematics learning outcomes, it is necessary to take into account factors that allow students to learn mathematics independently. When the student's level of independence is high, this will affect learning outcomes of the student in mathematics, the higher the independence of the student, the higher the math learning results.

Regarding the role of tests, they can be classified into four categories [4]: *placement tests*, *formative tests*, *diagnostic tests* and *summative tests*. The placement test is used to determine the student's ability at the beginning of the learning process, the formative test is used to monitor learning outcomes, the diagnostic test is used to diagnose learning difficulties, and the summative test is used to assess achievements. All these types of tests can be used for self-testing and self-assessment.

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This paper aims to show how the learning process can be enhanced by self-testing and self-assessment of students. The TeSLA system is used for students' self-assessment.

THE ROLE OF SELF-TESTING IN HIGHER MATHEMATICS EDUCATION

In [5] is discussed the need to increase by at least 33% the number of successful graduates in natural sciences, technology, engineering and mathematics (so-called STEM education). There are still many myths about learning mathematics, some of which have been overlaid for decades. The most popular of them are (see [6]): "aptitude for math is inborn"; "to be good at math you have to be good at calculating"; "math requires logic, not creativity"; "in math, what's important is getting the right answer". The interest in self-assessment is driven by changing concepts of teaching and learning, because for today's generation, which is very active, dynamic and "born with technology", educators should consider new forms of pedagogy.

One possible solution to the problem of dropping out a large percentage of students in mathematics and engineering is to offer them systems for active learning. Self-testing and self-assessment are an essential part of learning, but the students are not skilled in them. Using self-testing and self-assessment as a formative assessment is a challenge, and it takes time the students to see and understand their importance. Formative assessment includes self-testing that allows students to focus on understanding what they need to learn rather than getting a correct answer. More time needs to be spent on self-testing and an integral part of this process is peer-assessment. Used together, they help to develop the intrinsic value of learning. Students can begin to see that they are in control of their learning and that doing their self-testing is the beginning of responsibility for the learning process.

Here we consider some of the most popular systems for students self-testing.

The **Khan Academy** website [7] aims to provide learner self-training, and the system is based primarily on video tutorials that can be found on YouTube. Practical exercises are also planned and there are tests suitable for self-assessment. To verify mathematical knowledge and skills, the system offers two main ways: practical tasks and challenges. Practical tasks for each level are five, and in the correct answer, the student goes to the next level. In challenging tasks, when the answer is true, the level rises, and in the case of a wrong one can go to a lower level. The disadvantage of Khan Academy is the lack of systematicity in the developed material and the inability of the student to develop self-test tasks.

Another popular system for self-testing of students in the field of mathematics is the **WebAssign** system [8]. It offers students homework assignments and evaluation system. For this purpose, each student has an instructor to assess what he/she needs. The system is designed to give the student immediate feedback, according to the answers he gives to the tasks so that he knows immediately whether he/she is on the right track or is wrong, and he/she is also given the appropriate advice. The system has paid access and in any mathematical discipline students can have online textbooks, as well as individual help. The downside is that the system is more of an intermediary between a teacher (instructor) and a student rather than offering options for self-testing and self-assessment.

A system that tries to overcome the disadvantages of both systems is **Math-XPress** [9]. Each task that a student chooses to solve from the system's suggested material has three levels: *Learning*, *Practice*, *Testing*. During the *Learning* level, the student receives a set of tasks on the topic, each with a different parameter. The student can solve the task on his/her own and note the answer, or can ask for help from the system. Help can be different: more general or more detailed, or the student can see a solution to such tasks. If the *Practice* level is used, the student receives 4 possible answers (one true and 3 wrong) and he/she must choose one. Here the number of attempts is not limited. If the student has chosen a level *Test*, he/she has no right to either help or to more than one attempt. When selecting *Study* or *Practice*, the student can, after completing the assignment, request a new type of task or a task of the same type, but with other parameters. When students have the opportunity to rework test questions, this can help them understand how their work can be improved. The system also gives the user the ability to create new content through the so-called *XPress Problem Generator*, and the fact that the system has a *Task Translator* makes it suitable for use by students who use different languages including Bulgarian (see [10]).

Ten years ago, the course of Linear Algebra at the Mathematics and Computing and Engineering faculties at Ariel University in Israel has been taught using the homework assignment system of Math-Xpress. The results of student's exams have shown essential improvements of about 20% [11]. The students of the faculty Applied Mathematics and Informatics at the Technical University of Sofia used the system Math-Xpress for self-testing in the course "Linear Algebra" during the winter semester of the academic year 2017-2018. The author registered that the average grade of students has increased by about 20% compared with the results of previous exams.

SELF-ASSESSMENT WITH THE HELP OF THE TESLA SYSTEM

The TeSLA system [12] is being developed in conjunction with the three-year project "Adaptive, Trust-based e-Learning Assessment", funded under the European H2020 program. It supports e-testing in courses where blended learning or distance learning courses are applied. TeSLA is now tested for evaluating exams in a formal learning environment, with formative, summative and continuous assessment.

Self-assessment scenarios that are suitable for students educated in Technical Universities are presented in [13]. In the *first scenario*, students have to perform a self-assessment task, for which the tutor has prepared a list of self-assessment criteria. They do their self-assessment taking into account the criteria prepared by the tutor. Then, students may need to explain why they have assessed their knowledge/skills accordingly. Students can be encouraged on execution of their self-assessment, this task being perceived as a percentage of the final grade. They can also be stimulated by performing qualitative self-assessment. In the *second scenario*, self-assessment can be implemented in combination with other forms of assessment. Such self-assessment can be encouraged in different ways. The self-assessment may be a percentage of the final mark or be counted as an average arithmetic value, also taking into account the teacher's assessment. In the *third* scenario, the teacher evaluates the student's self-assessment and use this assessment a percentage of the final grade. In the *fourth* scenario, students' self-assessment is not a percentage of the final grade and is not even evaluated by the lecturer. Students will self-assess according to certain criteria, thus improving their performance, achievements or end results.

Students' Self-assessment in the Course "Electronic Servicing in the Public Administration"

During the summer semester of the academic 2017/2018 year 24 students involved in the course "Electronic Servicing in the Public Administration" participated in the third pilot of the TeSLA project. They had to perform in the TeSLA system two assessment activities. The second one was focused on self-assessment and two instruments were tested: *Face recognition* (FR) and *Forensic analysis* (FA). The instrument FR is used for students' authentication and the instrument FA is applied to confirm the students' writing style. The students had two weeks to prepare explorative papers at home on individually assigned topics. Then, they had to do self-assessment on this task according to well-defined criteria in qualitative and quantitative manner.

1. **Content understanding**. The questions posed by the teacher are: "Did you understand the explored material?", "How much did you understand – all content or part of it?"
2. **Process performance**. The questions posed by the teacher are: "Did you have the required knowledge and skills to perform this task?", "Did you perform it effectively?"
3. **Quality performance**. The question posed by the teacher is: "What was the performance quality?"
4. **Quality of the final product**. The question posed by the teacher is: "What is the quality of the final version of your explorative study?"

Additionally, the students were asked to summarize their self-assessment scores from all criteria in one final score. The obtained quantitative results are presented in Fig. 1.

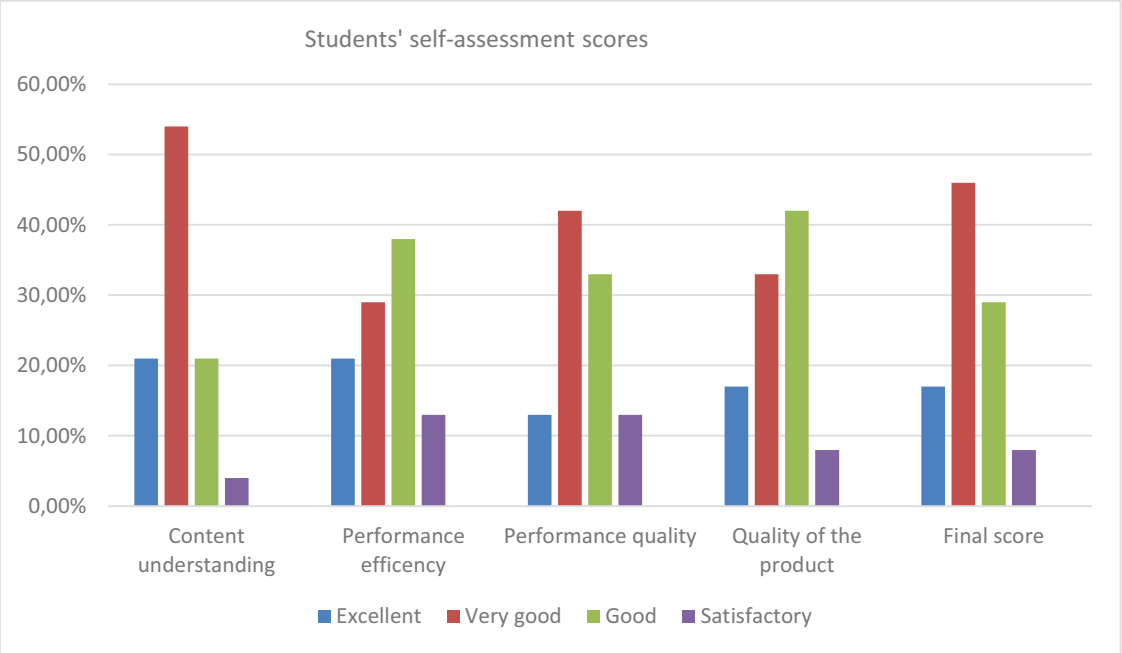

FIGURE 1. Results from students' self-assessment

- According to the first criterion: *Content understanding*, the major part (54%) of the students assessed themselves with score **Very good** and 21% of them with score **Excellent** and **Good**. It means that the biggest part of this study group understands the material topic, but not so deeply. Some terminology and concepts remain non-understandable for them.
- The second criterion: *Process performance* is assessed by 38% of the students with **Good** score, by 29% of students with **Very good** score and by 21% of them with **Excellent** score. The majority of students are not satisfied with their results and consider that they could be improved.
- Concerning the third criterion: *Performance quality*, 42% of the students were self-assessed with **Very good** score, 33% of them with **Good** score and 13% of the students with **Excellent** and **Satisfactory** scores. The major part of students could improve the quality of their achievements if they are more organized.
- With regard to the last criterion: *Quality of the product*, 46% of the students gave answer **Very good**, 29% reply with **Good** score and 17% of them with **Excellent** score. It means that the biggest part of the students' study group classifies their product as qualitative, but thinks that some parts or the product as a whole could be improved.

It can be seen that the student self-assessment scores are critical and realistic, and they are aware of the gaps in their knowledge, skills and competences as well as the need for self-improvement. According to the collected data, the final students' scores are as follows: 17% of them formed for themselves **Excellent** mark, 46% of the students voted for **Very good** mark, 29% of the students evaluated themselves with **Good** mark and 8% of them formed the final mark as **Satisfactory**.

The qualitative analysis of the students' opinion reveals the meaning of their quantitative vote. Regarding the first criterion: *Content understanding*, the students explain their scores in the following manner: one student who self-assessed with **Very good** score wrote *"I did not understand the material content in its entirety. I had difficulties with the terminology";* another student who gave herself an **Excellent** score shared that *"I understand the assessment task, but the topic is out scope of my interests and competences and it led to some difficulties";* third student who formed **Very good** score explained her vote: *"I understood the material content, but I had difficulties with the meaning of*

different words, phrases and terms". The self-assessment scores concerning the second criterion: *Process performance* were explained by the students in the following way: one student with **Very good** self-assessed score wrote *"I possessed the needed skills for this task conductance, but my performance was not effective enough, because I did not have the required knowledge and I had to collect additional information about some terms";* the second student with **Good** self-assessment score declared that *"I did not have the required skills to accomplish the assessment task. I have to put more effort for better result";* the third student with **Very good** score wrote: *"I had very good knowledge about the explored topic that allowed me faster and effective performance of this task".* The vote regarding the third criterion: *Performance quality* was explained as: *"Good quality, because of lack of required competences"*– wrote a student with **Good** self-assessed score; *"Very good quality, because some explanations could be improved"* – declared a student with **Very good** self-assessed score; *"Excellent quality, because of the required knowledge and invested effort"* – explained a student with **Excellent** self-assessed score; The forth criterion: *Quality of the product* is presented as: *"Excellent quality, because the task was difficult for me and gave all my power"* – explained a student with **Excellent** self-assessment score; *"Good quality, because the task was so time consuming and I had to take care about the content structure and organization, as well as for the process performance"* – shared a student who evaluated himself with **Good** score; *"Very good quality, because I did not finish the whole task for the given time"* – wrote a student with **Very good** self-assessment score.

The comparison of the final students' self-assessment marks and the teacher marks are presented in Fig. 2. It can be seen that the teacher's marks are higher than students' self-assessment scores. It proves the students' engagement to the task performance and critical analysis of the accomplished work.

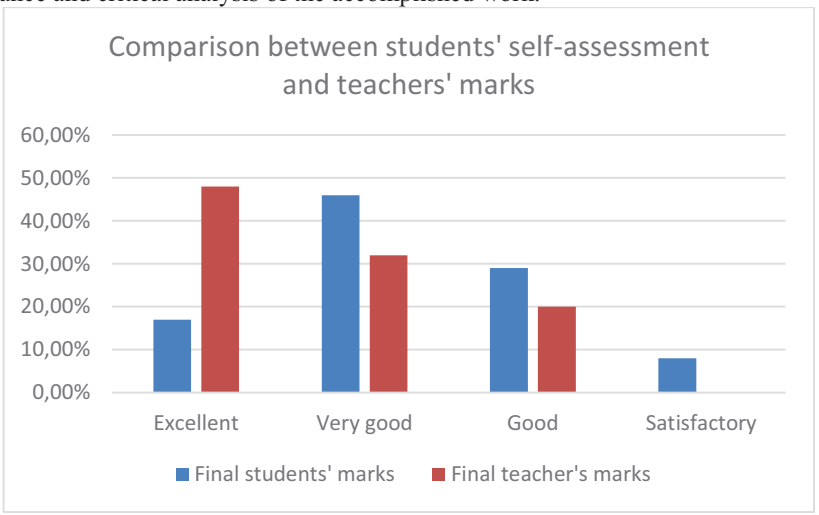

FIGURE 2. Comparison of the final students' self-assessment marks and the teacher marks

The analysis made in this section points out that the TeSLA system is very friendly and suitable for a self-assessment scenario. Different instruments could be used in support of this task. In this study, a combination of two instruments is involved: *Face recognition* (FR) and *Forensic analysis* (FA) that allows the student to be authenticated and her/his work to be checked for originality.

Students' Self-assessment in the Course "Discrete Mathematics"

During the summer semester of the academic 2017/2018 year 22 students of the specialty "Applied Mathematics and Informatics" involved in the course "Discrete Mathematics" participated in the third pilot of the TeSLA project. They had to perform in the TeSLA system one enrollment and two assessment activities. The involved TeSLA instruments were: *Face recognition* (FR) and *Keystroke dynamics* (KD). Both of them are used for students' authentication. For the enrollment purposes for KD the students are asked to write an essay on the role of information security. The students had three weeks to prepare their essays. Then they had to make a self-assessment of this task according to the criterion: originality and expression of their own opinions. They had to assess their works with points between 0 and 1. Self-assessment is implemented in combination with other forms of assessment. Such self-assessment is motivated by the teacher as a small percent of the final grades. It is interesting, that none of the students

are self-assessing with less than 0.5 points. The results of students' self-assessment and the teacher's assessment can be seen in the Table 1.

TABLE 1. *Results of students' self-assessment and the teacher's assessment*

Student's Points	Teacher's Points	Number of students
0.5	0.2	1
0.5	0.5	3
0.6	0.6	2
0.6	0.8	2
0.7	0.5	1
0.7	0.8	2
0.7	1	1
0.8	1	1
0.8	0.6	2
0.9	1	1
1	0.8	1
1	1	3

From the results obtained, it can be concluded that the students' self-assessment points are very realistic and even some of them are very self-critical (in yellow are shown the points of the students who have self-assessed higher and in green - those who have self-assessed lower). Most of the students have a real idea of the work they had put in, as well as about the knowledge and skills they have. They also recognized the need to make more efforts into self-development. The students shared that after the self-assessment they were more interested in the subject they had to learn and had begun to read much more about it.

CONCLUSION

Nowadays all people who are engaged in student education are looking for new forms of pedagogy. The main goal – to drive quality enhancement learning processes in the universities, could be reached in different ways. We believe that one of the ways to achieve this is through more active participation of students in the learning process, attracting and inspiring students' motivation and increasing students' engagement. There are different approaches to achieving this goal. In this paper we shared our opinion and experience in this direction: we introduced some systems for student's self-testing in the in math courses, and the use of the TeSLA system for self-assessment of students. Our experiments with student's self-testing and self-assessment are presented and analyzed. We observed that self-testing and self-assessment influence the engagement and interest of students in the subject. In addition, both approaches improve students' outcomes.

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