

## Using IT to Enhance the Educational Achievement of Students

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### Abstract

*This article presents the use of information technology (IT) in the education of students in Software Engineering and in English at the Faculty of Mathematics and Informatics at Plovdiv University. The teaching process incorporates traditional methods with applications based on the E-learning standards QTI and SCORM. The use of IT has been applied to the education of full-time and part-time Bachelor degree students from the 1st to the 4th year of studies. Based on the statistics from the teaching some conclusions have been drawn regarding the students' performance and possible ways of enhancing their educational achievement.*

**Key words:** *IT, educational achievement, QTI and SCORM standards.*

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### INTRODUCTION

In modern education e-learning is spreading rapidly at all educational levels. Nowadays a large number of academic institutions offer training materials in an electronic format along with traditional forms of teaching. An environment, which provides various services for e-learning, is the Distributed e-Learning Center (DeLC) (Stoyanov *et al.*, 2010). In this article we will consider the e-content and e-tests as a

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way to improve the educational achievement of students. To guarantee the quality of e-learning materials we use two standards in DeLC – SCORM 2004 R4<sup>2</sup> and QTI<sup>3</sup>.

The Sharable Content Object Reference Model (SCORM) is developed by ADL and it is a set of technical standards for e-learning software products. SCORM is the industry standard for e-learning interoperability and more specifically it governs how online learning content and Learning Management Systems (LMSs) communicate with each other. In DeLC is developed the SCORM Player (Doychev, 2013), which is used to play to students e-learning content developed in the SCORM format. The goal is to reuse e-learning objects which have already been created as we save them in digital libraries. According to the SCORM standard these objects are named SCO (Sharable Content Object). They represent small and reusable components that can contain text, images, animations, and others (assets), and the organization of SCOs in bigger components is named Aggregations. Another concept of SCORM is to define the sequence of execution of the different components and the navigation that determine a pedagogical education model.

The IMS Question and Test Interoperability specification (QTI) defines a standard format for the representation of assessment content and results, supporting the exchange of this material between authoring and delivery systems, repositories and other learning management systems. It allows assessment materials to be authored and delivered on multiple systems interchangeably. It is, therefore, designed to facilitate interoperability between systems. We have developed a test environment (Gramatova *et al.*, 2014) in DeLC that implements the QTI specification.

In this article we discuss how we use these educational services of DeLC to improve the knowledge of students in Software Engineering and in English at the Faculty of Mathematics and Informatics at Plovdiv University.

## **CREATING AND USING E-LEARNING CONTENT IN SCORM FORMAT**

To enhance the educational achievement of students in Software Engineering we have developed an e-textbook in SCORM format. This e-textbook is available in DeLC2<sup>4</sup>. First we will focus on the development of this e-textbook that has been implemented in several steps:

- Designing an e-textbook in SCORM format;

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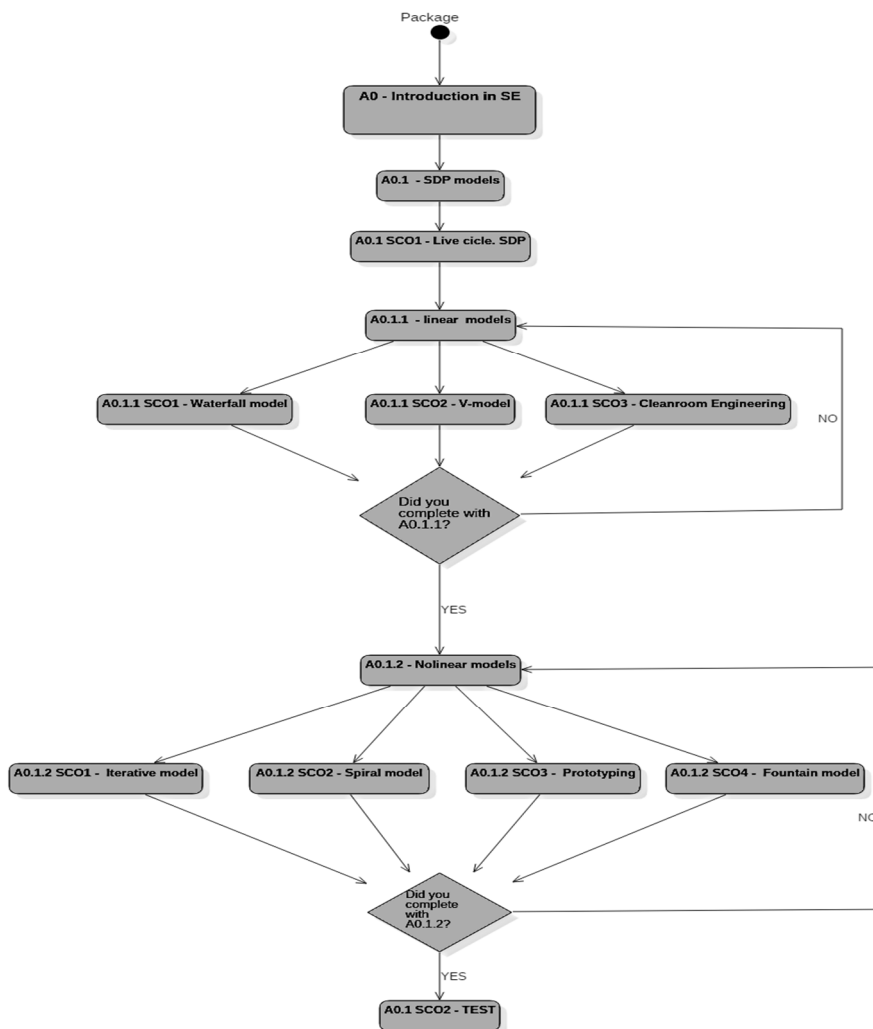
<sup>2</sup> SCORM: <http://scorm.com>

<sup>3</sup> QTI: <http://www.imsglobal.org/question/index.html>

<sup>4</sup> DeLC2: <http://delc2.fmi.uni-plovdiv.net/courses/show/1>

- Designing and realization of the e-textbook in the SCORM editor;
- Implementation of the control tests;
- Testing the e-textbook in our SCORM player in DeLC.

Designing the e-textbook in SCORM is the most time-consuming step in the development process. To create the structure of the SE e-textbook we used activity diagrams (Figure 1). On the activity diagram we defined the components that build the lesson. The activity states correspond to aggregations, and states correspond to SCOs. Transitions between components present the order of the component execution, and decisions serve as go-ahead conditions. Figure 1 shows the structure of the first lecture in the SE e-textbook.



**Fig. 1.** SCORM structure of the first lecture in the SE e-textbook

In this structure we defined different components, the sequence, and the navigation between them. Each lecture ends with a control test that determines the navigation scheme in this e-content.

## Тест 1

### Въведение в СТ и разработка на СП

1. С какво се занимава дисциплината СТ?
  - С разработка на софтуер
  - с разработка на качествен софтуер
  - с определяне качеството на софтуера
2. Кои са фазите на жизнения цикъл на разработката на софтуер?
  - анализ, проектиране, разработка, тестване, поддръжка
  - анализ на домейна, разработка, тестване, поддръжка
  - анализ и дефиниция, разработка, тестване, поддръжка
3. Какви недостатъци има водопадния модел?
  - Грешките в проектирането или анализа се откриват късно
  - Не могат да се провеждат тестове
  - Клиентите не участват в процеса
4. V-модела се нарича още:
  - модел за тестване на софтуер
  - модел за сигурност
  - модел на функционалните точки
5. Колко типа прототипиране има?
  - Два - хоризонтално и вертикално
  - Един
  - Няма верен отговор
6. Итеративният модел на процеса се характеризира с:
  - разработване на софтуера на версии
  - разработване на софтуера на малки части
  - и двата отговора са верни
  - няма верен отговор

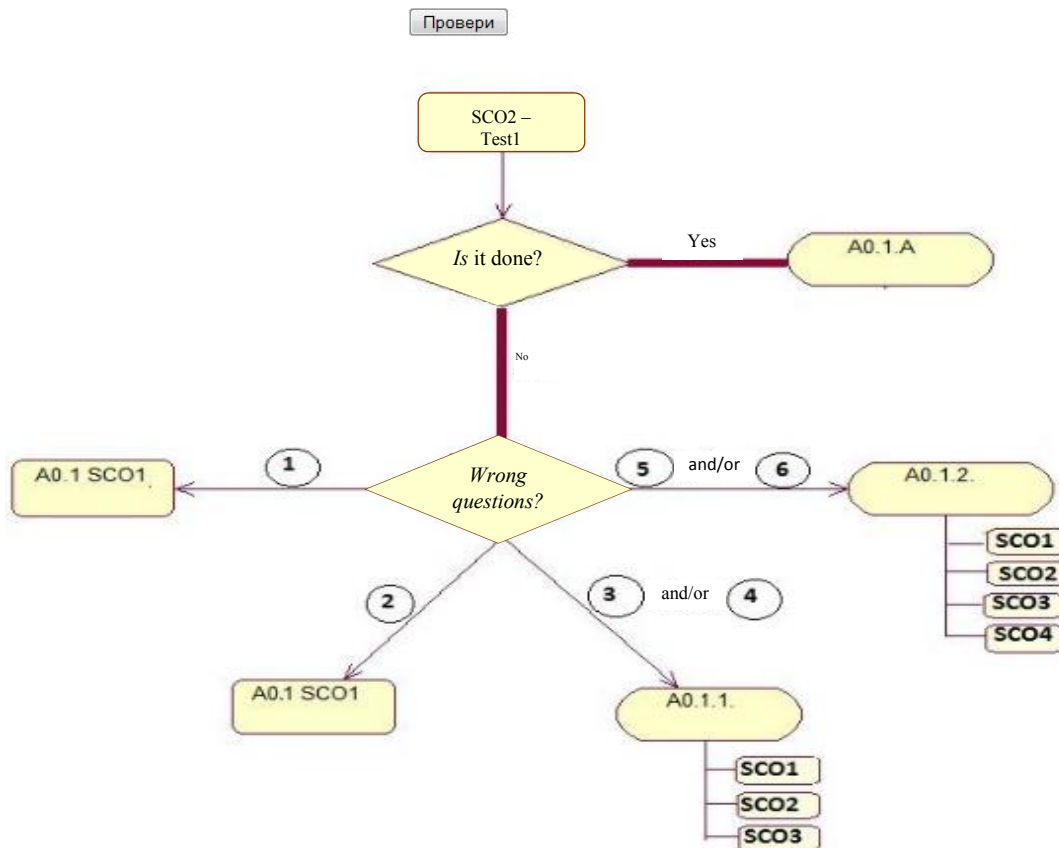
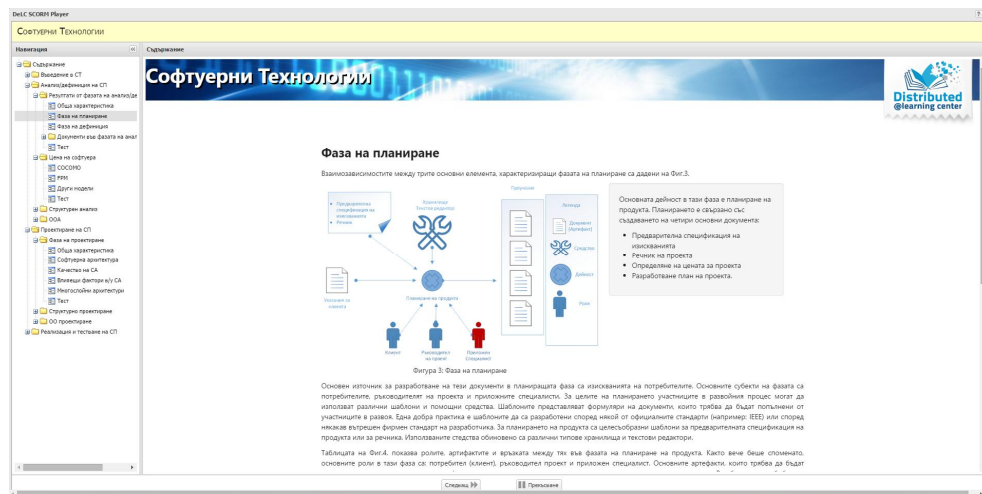


Fig. 2. A control test and a relevant navigation scheme

Figure 2 shows the first test based on the first lecture in Software Engineering and the navigation scheme for it. This navigation scheme shows what happens when the obtained answers of the different questions are wrong. Let us give an example from the first test: when the answer to question one is wrong the SCORM player will return the student to A0.1 SCO1. This navigation makes the e-learning process adaptive and each student will make his/her own track in the lecture.

The design and realization of the SE e-textbook are made in the SCORM editor Trident 2.0<sup>5</sup>. It creates a manifest file of the e-textbook that consists of all e-learning components, the execution order of the components and all resource files associated with the e-learning components.

Figure 3 presents a screenshot of the real SE e-textbook. On the right-hand side is the navigation tree of the textbook including different topics with subthemes. There are SCORM restrictions that we define in a sequence and a navigation of the e-content. Each topic concludes with a test. If the test has been passed, the SCORM player will unlock the next topic in the tree. In case the test has been failed, the SCORM Player returns the student to the e-content where the content regarding the wrong question or questions is located.



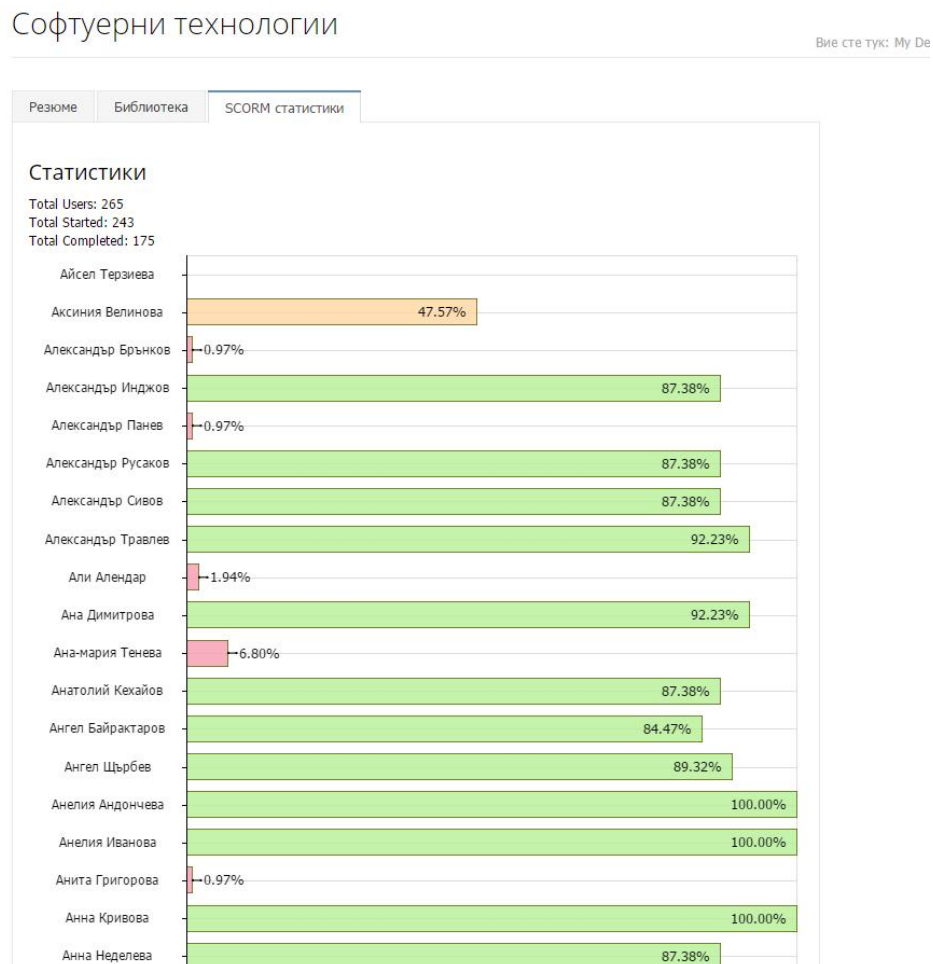
**Fig. 3.** Software Engineering e-textbook

We use the E-textbook in Software Engineering in our classes with Computer Science students at the Faculty of Mathematics and Informatics at Plovdiv University. Below we explain how exactly we do that.

<sup>5</sup> IDE Trident <http://www.scormsoft.com/trident>

According to the curriculum bachelors have 30 academic hours of lectures, 20 academic hours of lab exercises and 100 academic hours dedicated to self-study. Besides different resources students are obliged to read the e-textbook. In this way we have feedback about the learning process of each student both from the students and from the SCORM Player. We collect information which allows us to draw some conclusions about each student’s knowledge in this discipline.

The first statistic that we collect as we use some of the parameters of SCORM refers to the personal progress of each individual student in the e-textbook. On Figure 4 is shown some common information – how many students have managed to start the e-textbook, how many students have started reading the e-textbook and how many have finished it, as well as the progress of each student – what percentage of the content has been covered by each student.



**Fig. 4.** SCORM statistic

Another kind of statistic that is collected by SCORM is shown in figure 5. It is a statistic for different SCO components. We can see how many attempts have been made for each SCO by students. It helps a lecturer to make some conclusions about the level of knowledge of the students, which part of the book is the easiest/the most difficult for them and about the quality of the e-content. It is possible that certain material is difficult for students to understand and the lecturer may wish to explain it further.

activity_id	title	attempts	users	attempts_for_success	parent
ACT-405926	Многослойни архитектури	188	150	1,4462	Фаза на проектиране
ACT-319886	Въведение	292	199	1,4673	Осн.концепции на ориентирания към състояния изглед
ACT-53607	Системни тестове	176	119	1,479	Стратегия за тестване на софтуер
ACT-80387	Влияещи фактори в/у СА	199	128	1,5547	Фаза на проектиране
ACT-470479	Activity диаграми	236	150	1,5733	Осн.концепции на ориентирания към състояния изглед
ACT-307755	Интерп. тестове	188	119	1,5798	Стратегия за тестване на софтуер
ACT-509617	Валид. тестове	178	112	1,5893	Стратегия за тестване на софтуер
ACT-979258	Sequence диаграми	237	148	1,6014	Осн.концепции на ориентирания към сценарии изглед
ACT-156169	Валидационни тестове	182	112	1,625	Тестване на OO софтуер
ACT-763070	Динамичен модел	231	132	1,75	OOA
ACT-431728	Статичен модел	256	145	1,7655	OOA
ACT-241207	Дърво на решенията	271	152	1,7829	Осн.концепции на ориентирания към правила изглед
ACT-673369	Общ преглед	330	185	1,7838	Структурно проектиране
ACT-186866	Пример за спецификация на изискванията	228	127	1,7953	Документи във фазата на анализ/дефиниция
ACT-130755	Use case	279	155	1,8	Осн.концепции на функц.изглед
ACT-487185	Таблица на решенията	270	150	1,8	Осн.концепции на ориентирания към правила изглед
ACT-687593	Въведение	377	202	1,8663	Осн.концепции на ориентирания към правила изглед
ACT-808281	Крайни автомати(State transition)	282	151	1,8675	Осн.концепции на ориентирания към състояния изглед
ACT-259305	Въведение	379	202	1,8762	Осн.концепции на ориентирания към данни изглед на с-ма
ACT-519927	Обща характеристика	342	182	1,8791	OO проектиране
ACT-867276	Правила	312	166	1,8795	Осн.концепции на ориентирания към правила изглед
ACT-50435	Структурни диаграми	267	139	1,9209	Структурно проектиране
ACT-613241	Проект на разработката	263	135	1,9481	OO проектиране
ACT-411436	Проект на архитектурата	267	137	1,9489	OO проектиране
ACT-828976	Collaboration диаграми	294	150	1,96	Осн.концепции на ориентирания към сценарии изглед
ACT-90810	Обща характеристика	373	190	1,9632	OOA
ACT-291771	Модел на продукта	249	125	1,992	Документи във фазата на анализ/дефиниция
ACT-590636	Качество на СА	269	135	1,9926	Фаза на проектиране
ACT-732699	Софтуерна архитектура	285	143	1,993	Фаза на проектиране
ACT-614991	Речник	265	132	2,0076	Документи във фазата на анализ/дефиниция
ACT-701674	FRM	300	149	2,0134	Цена на софтуера
ACT-86344	Миниспецификации	292	145	2,0138	Структурен анализ
ACT-594438	Обща характеристика	380	188	2,0213	Фаза на проектиране
ACT-256247	Други модели	300	145	2,069	Цена на софтуера
ACT-398061	Предварителна спецификация на изискванията	274	131	2,0916	Документи във фазата на анализ/дефиниция
ACT-450472	Въведение	385	181	2,1271	Стратегия за тестване на софтуер
ACT-952942	Тест	404	185	2,1838	Структурно проектиране

**Fig. 5.** SCORM statistic about each SCO

The introduction to the SE e-textbook in the educational process in Software Engineering is useful both for students and lecturers. It motivates students to read the study materials because these consist of control tests, which are examples of the final exam. The materials give learners additional knowledge, they can read them anytime and anywhere and the lecturer can track the progress of each individual student during the semester.

The SCORM statistics that the lecturer receives from the SCORM Player assists the tracking of the students' progress and the evaluating the quality of the educational e-materials.

The use of the e-textbook improves the quality and personalization of the educational process.

## **USING SELF-PRACTICE ELECTRONIC TESTS TO ENHANCE THE EDUCATIONAL ACHIEVEMENT OF STUDENTS**

Self-testing is considered one of the most efficient methods of study (Dunlosky *et al.*, 2013). Long-term memory is increased when some of the learning period is devoted to retrieving the information that needs to be remembered, which is known as the testing effect. At the Faculty of Mathematics and Informatics we use e-tests in the education in English to consolidate the course content and practice the students' language skills. These online tests are created by the teacher on the basis of the study material that is covered during the seminars in English. These tests are administered every week as self-study practice in a place and time which is convenient to each and every student.

### **Content of e-tests**

When constructing self-study tests one of the most important questions to consider is which study material to include in them. For this purpose we have developed five criteria for evaluating the learning outcomes based on Bloom's taxonomy (Ivanova *et al.*, 2015). For each criterion we have proposed several types of test questions with varying degrees of difficulty.

### **Criteria for evaluating the learning outcomes**

1. Reproduction of information.
2. Understanding the meaning of a word, expression or a phraseological unit and finding a match.
3. Detection and correction of errors in various contexts.
4. Analysis of the use of words or expressions and selection of an appropriate grammatical form of verbs in a context.
5. Text creation.

### **Form of e-tests**

All self-study tests have the same format – they include open and closed types of questions with equivalent maximum total scores. To ensure higher reliability of e-tests, the DeLC environment can impose some restrictions on test-takers, for example the test validity authorizes only selected students to do the test in a specific period of time, and the time limit determines the time allowance to complete the tasks. (Figure 6) The short-answer open questions as well as the closed type of test tasks



such as True or False, Multiple choice questions, Strict and non-strict matching, etc., are graded automatically, while the long-answer open questions are evaluated manually by the teacher. As soon as students have submitted their tests, they can see their current scores, and the points from the essay-type questions are added subsequently (Figure 7).

The screenshot shows the 'Валиден' (Valid) configuration window in the DeLC system. It includes the following elements:

- Разписание на теста** (Test Scheduling):
  - Начална дата и час** (Start date and time): 2015.11.23 12:37:01
  - Крайна дата и час** (End date and time): 2015.12.01 12:37:01
- Автоматично активиране** (Automatically activate): Checked checkbox.
- Продължителност** (Duration): 0:60 часа (0:60 hours).
- Парола** (Password): A text input field.
- Отворен за** (Open for): A section with a table for 'Факултетен номер' (Faculty number) and 'Име' (Name).
- Добавяне на студенти** (Add students): A pop-up window with a list of subjects and courses, each with a checkbox:
  - математика и информатика рб (4 курс 2 гр)
  - математика и информатика рб (4 курс 3 гр)
  - математика и информатика рб (4 курс)
  - математика рб
  - математика рб (3 курс 1 група)
  - математика рб (3 курс)
  - математика рб (4 курс 1 група)
  - математика рб (4 курс)
  - медицинска биология
  - медицинска биология (1 курс 1 група)
  - медицинска биология (1 курс)
  - международни икономически отношения
  - международни икономически отношения
  - международни икономически отношения
  - молекулярна биология
  - молекулярна биология (1 курс 2 група)
  - молекулярна биология (1 курс)

**Fig. 6.** Example of setting test validity and a time limit in DeLC

### Administration of e-tests

Self-study tests are administered every week in the students' own place and time. Learners simply need a device connected to the Internet. In case they are not satisfied with their scores students are allowed to complete the test again as many times as they wish within the week of the particular test administration. As only the highest grades obtained by the test-takers are considered for their final evaluation, learners feel motivated to spend more time on e-tests and achieve better results.

✓ Точки: 1 от 1

*Peter ..... a car last year but since then it ..... only trouble to him.*

- bought/ has brought
- has bought/ brought
- bought/ brought
- has bought/ has brought

✓ Точки: 1 от 1

*Plans ..... to start producing only silent machines.*

- are made
- make
- are making
- have made

✓ Точки: 1 от 1

*If the driver ..... the steering wheel tightly the car may crash.*

- doesn't hold
- don't hold
- didn't hold
- hasn't held

✗ Точки: 0 от 1

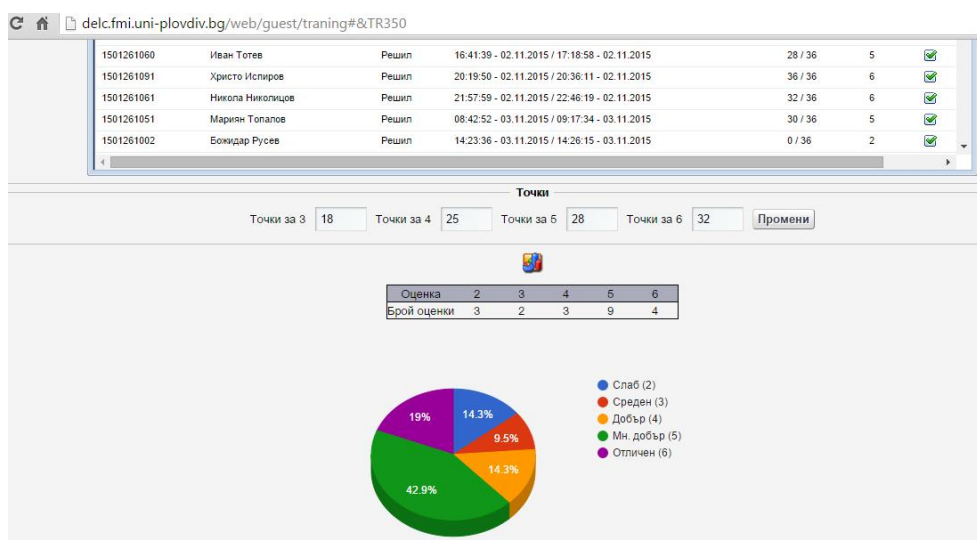
*Choose the sentence below which explains the meaning of the given one.  
Many people have strong feelings about the value of violent films.*

- Lots of people either love or hate films with violent scenes.
- Many people are indifferent to films with violent scenes.
- Many people do not care if the films they watch contain violent scenes or not.
- Lots of people think that watching violent films is probably not a good idea.

**Fig. 7. Example of administered test questions**

### Use of e-tests

Practice tests can be used both for formative and for summative assessment. In other words, e-tests can be used not only to assign grades to students for their performance but also to adapt teaching in order to realize certain educational purposes. Test statistics allow teachers to evaluate their own work as well as the learners' progress (Figure 8).



**Fig. 8. Example of test grading**

## CONCLUSIONS

The use of SCORM e-content and e-tests in the educational process motivates students to improve their knowledge and makes learning more interesting and rewarding for them. In the future we plan to create more SCORM materials and tests and make use of some additional educational services of DeLC, for example educational games, intelligent services, and others. Also, we plan to integrate other language skills in the e-tests such as listening comprehension tasks and speaking instead of typing the answers to open questions.

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