DiLibS Platform for a Virtual Education Space

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Abstract

The Distributed eLearning Centre (DeLC) developed at the Faculty of Mathematics and Informatics aims at the delivery of electronic education services and teaching content, personalized and customized for each individual user. In this paper are presented some general characteristics and the architecture of VES (Virtual Education Space), a successor to DeLC. In addition, the core of a space called DiLibS platform is considered.

Keywords

eLearning, Virtual Education Space, DeLC, eLearning Platform, Intelligent Agents.

1. Introduction

In recent years the interest towards electronic education has been growing stronger. Higher education is facing a renaissance in terms of its approaches to teaching and learning and the use of physical and virtual spaces. Universities are no longer defined by the physical boundaries of their traditional campus but are closely connected to virtual environments [1]. It is expected that a virtual education space, integrating physical and virtual worlds and supporting various learning approaches, styles and forms will contribute to the achievement of any-time, any-where and any-how education. One of the first projects, called Virtual Education Space (VES), belongs to the Massachusetts University. It is an educational intranet for educators and students which provides a secure and personalized portal with a set of online tools and resources designed to support preK-12 standards-based education [2]. The primary objective of the system is to improve student learning by collaboratively designing and implementing an educational information management system that provides for the effective use and exchange of information among educators and school systems. In accordance with [3] learning spaces are: physical, blended or virtual learning environments that enhance as opposed to constrain learning; physical, blended or virtual 'areas' that motivate a user to participate for learning benefits; spaces where both teachers and students optimize the perceived and actual affordances of the space; spaces that promote authentic learning interactions.

As a result, many universities have developed and implemented their own systems for electronic and long-distance education. In line with this trend, a Distributed eLearning Centre (DeLC) project was implemented at the Faculty of Mathematics and Informatics at the University of Plovdiv, Bulgaria, aiming at the development of an infrastructure for context-aware delivery of electronic education services and teaching content, personalized and customized for each individual user [4,5]. DeLC is a reference architecture, supporting a reactive, proactive and personalized provision of education

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services and electronic content. The DeLC architecture is modeled as a network which consists of separate nodes, called eLearning Nodes. Nodes model real units (laboratories, departments, faculties, colleges, and universities), which offer a complete or partial educational cycle. Each eLearning Node is an autonomous host of a set of electronic services. The configuration of the network edges is such as to enable the access, incorporation, use and integration of electronic services located on the different eLearning Nodes. The eLearning Nodes can be isolated or integrated in more complex virtual structures, called clusters. Remote eService activation and integration is possible only within a cluster. In the network model we can easily create new clusters, reorganize or remove existing clusters (the reorganization is done on a virtual level, it does not affect the real organization). For example, the reorganization of an existing cluster can be made not by removing a node but by denying access to the services offered by it. The reorganization does not disturb the function of other nodes (as nodes are autonomous self-sufficient educational units providing one or more integral educational services). Wired and wireless access to the eLearning services and teaching content has been implemented in DeLC. The current DeLC infrastructure consists of two separate education clusters [6]. The first one, known as MyDeLC, delivers educational services and teaching content through an educational portal. The second one provides mobile access to services and content over an extended local network called InfoStations.

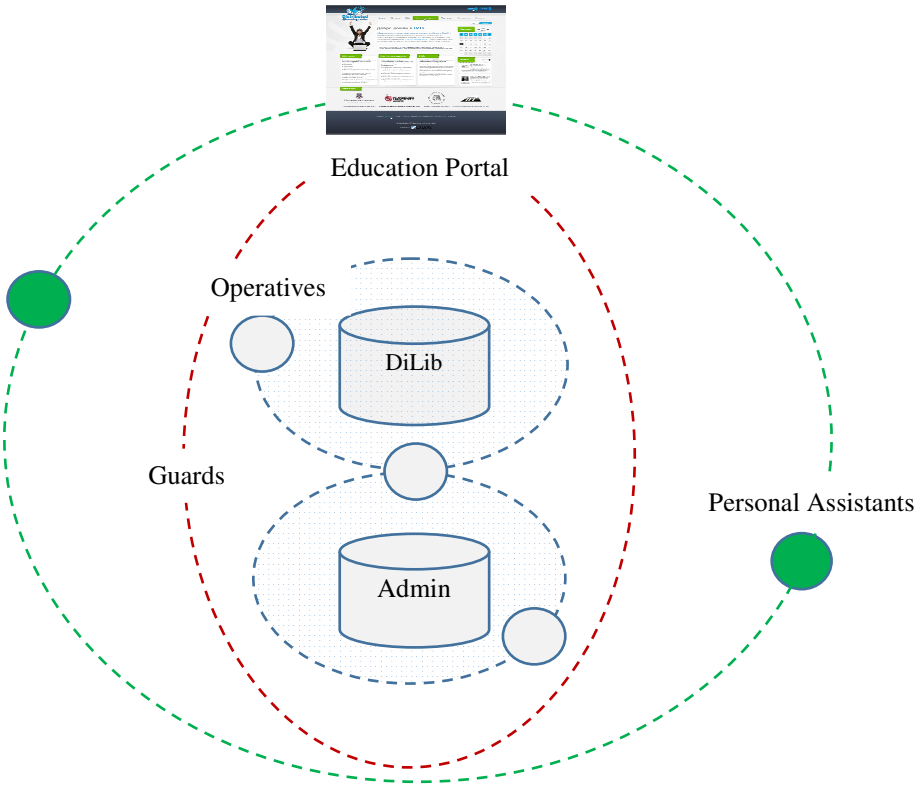

Figure 1. Virtual Education Space

The Virtual Education Space (VES) is developing as a successor to DeLC and it accounts for two important tendencies in the development of the Internet and the Web. The first tendency is the transformation of the Internet into Internet of Things [7] stimulating the origin of cyber-physical social systems which will lead to essential technological,

economical and sociological consequences in the following years. This type of systems can introduce new approaches and scenarios for solving complex problems in the field of electronic education. The second tendency is the rise and growth of the Semantic Web [8, 9]. Some ideas for the usage of the semantic web in electronic education are presented in [10]. At the current moment using the capabilities of the Semantic Web in electronic education is the subject of strong scientific interest.

In the first section, a general overview of the VES architecture is presented. The second section examines the core of the virtual education space, known as the DiLibS platform. Two use cases are discussed in the third section.

2. VES Architecture

Our goal is to develop the virtual space with the following features:

- Intelligent – it can continuously monitor what is happening in it, can communicate with its inhabitants and neighbourhoods, can make related inferences and decisions and act on these decisions [11, 12];
- Context-aware – the ability to find, identify and interpret the changes (events) in the space [13] and, depending on their nature, to undertake compensating actions. The main compensating actions (attributes for context-dependency) are personalization and adaptation;
- Scenario-oriented – from a user's point of view, the space is a set of separate e-learning services and educational scenarios provided for use through the education portal DeLC or personal assistants. Scenarios are implemented by corresponding workflows rendering an account of the environment's state. Thus it is possible to take into account various temporal characteristics (duration, repetition, frequency, start, or end) of the educational process or events (planned or accidental) which can impede or alter the running of the current educational scenario. To deal with emergencies (such as an earthquake, flood, or fire) there are defined emergency scenarios which are executed with the highest priority;
- Controlled infrastructure – access to the space's information resources is only possible through the so-called "entry points." The personal assistants operate as typical entry points while the education portal of DeLC is a specialized entry point; a user has to be in possession of a personal assistant or to use the portal to be able to work in the space.

The VES architecture contains different types of components. Assistants play an important role in the space. Three types of assistants are supported in the space (Figure 1.). The *personal assistants* have to perform two main functions providing the needed "entry points" of the space. Firstly, they operate as an interface between their owners and the space and, if necessary, carry out activities related to personalization and adaptation. Secondly, they interact with other assistants in the space in order to start and control the execution of the generated plans. In certain cases they operate as an intermediary for the activation of scenarios or services. The personal assistants will usually be deployed over the users' mobile devices. The specialized assistants are usually located on the server nodes of the VES, known as *operatives*. They support the execution of the plans generated by the personal assistants; therefore they implement suitable interfaces to the available electronic services and data repositories. Operatives serve two subspaces, known as DiLibs-Subspace and Admin-Subspace respectively. *Guards* are special assistants which are responsible for the safety and efficient execution of the plans in the space. These are usually intelligent devices that react to various physical quantities in the environment, e.g. smoke, temperature, humidity. The guards act as an interface between the physical and the virtual world in the space.

VES is "populated" only by active components known as assistants. Each assistant has to play a role in accordance with its delegated responsibilities. The responsibilities (tasks) are implemented or delivered by electronic services. The electronic services themselves cannot be separate operational components of the space because they are suitable for the implementation of business functionality but are static without having the properties to be context-aware and intelligent. The assistants themselves implemented as bounded rational agents are active context-aware intelligent components that support the planning, organization and implementation of the educational process.

Two subspaces are maintained in the VES:

- Digital Library Subspace (DiLibS) – the digital libraries are specialized repositories where mainly educational content is stored. Furthermore, the operatives of that subspace realize interfaces to three components supplied to the space by DeLC – SCORM 2004 Engine, Test Engine (QTI 2.1. compliant) and Event Engine.
- Admin-Subspace – it supports all activities related to the organization, control and documentation of the education process. In the administrated database is stored all the necessary useful information for planning, organizing, protocoling and documenting the educational process such as school plans, programs and schedules, protocols of examinations, and gradebooks.

The two subspaces are supported by a common platform known as DiLibS platform briefly presented in the next section.

3. DiLibS Platform

The platform is built as a dynamic web application distributed in two main areas – an education portal operating as a specialized user interface and server side (Figure 2.). Both areas communicate by using pure HTTP requests, RESTful services and Web Sockets. An application in the browser consists of a pure HTML 5 and CSS 3 implementation combined with dynamics provided by JQuery and responsiveness delivered by Bootstrap.

At the server side, the core services provided by the platform include the minimal functionality needed for the majority of the current web applications:

- Security – it implements the security mechanism with per roles, per groups and per users' rules;
- Web Content – it allows a definition of static web content;
- Control Panel – the management of the above services, the plugins, and so on.

There are also two additional services that are provided by the platform at a lower level:

- Message Queue – it is used by all the plugins and core services as a message bus for asynchronous communication between the different components;
- ORM Layer – an object-relational transformation layer that is used by all components for communication with the database.

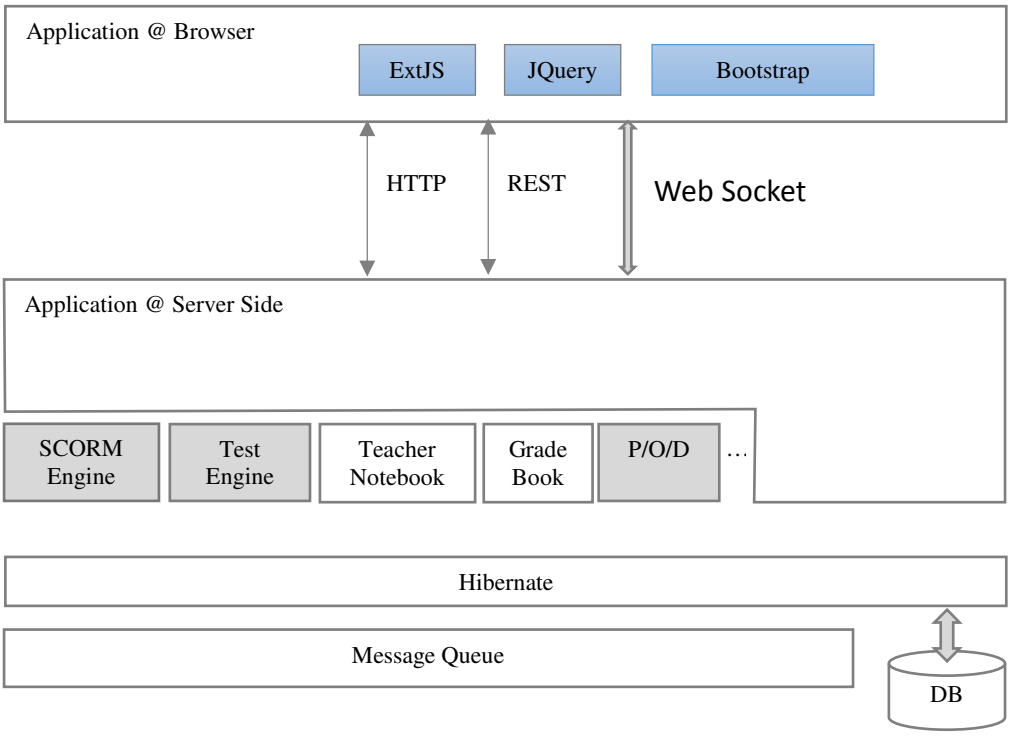

Figure 2. DiLibS Platform

That platform is open for extension by using the so-called plugins. Each plugin provides unique functionality which is integrated in the portal seamlessly. Currently, several plugins in a different state of completion are supported by the platform.

The core of the platform is Digital Library which stores educational content. Basically, the content is prepared in accordance with the SCORM 2004 standard, but storage in other formats is also possible (.pdf, .ppt, .doc).

The data model (Figure 3) allows storage of static and dynamic content in the library. The static content is actually references to real files in the file system. In this way the database is not affected by the size of the static files. The dynamic content consists of the SCORM packages deployed in the system and the QTI content, which is related to the assessment subsystem.

The content of the current version of the Digital Library is organized in a hierarchical structure

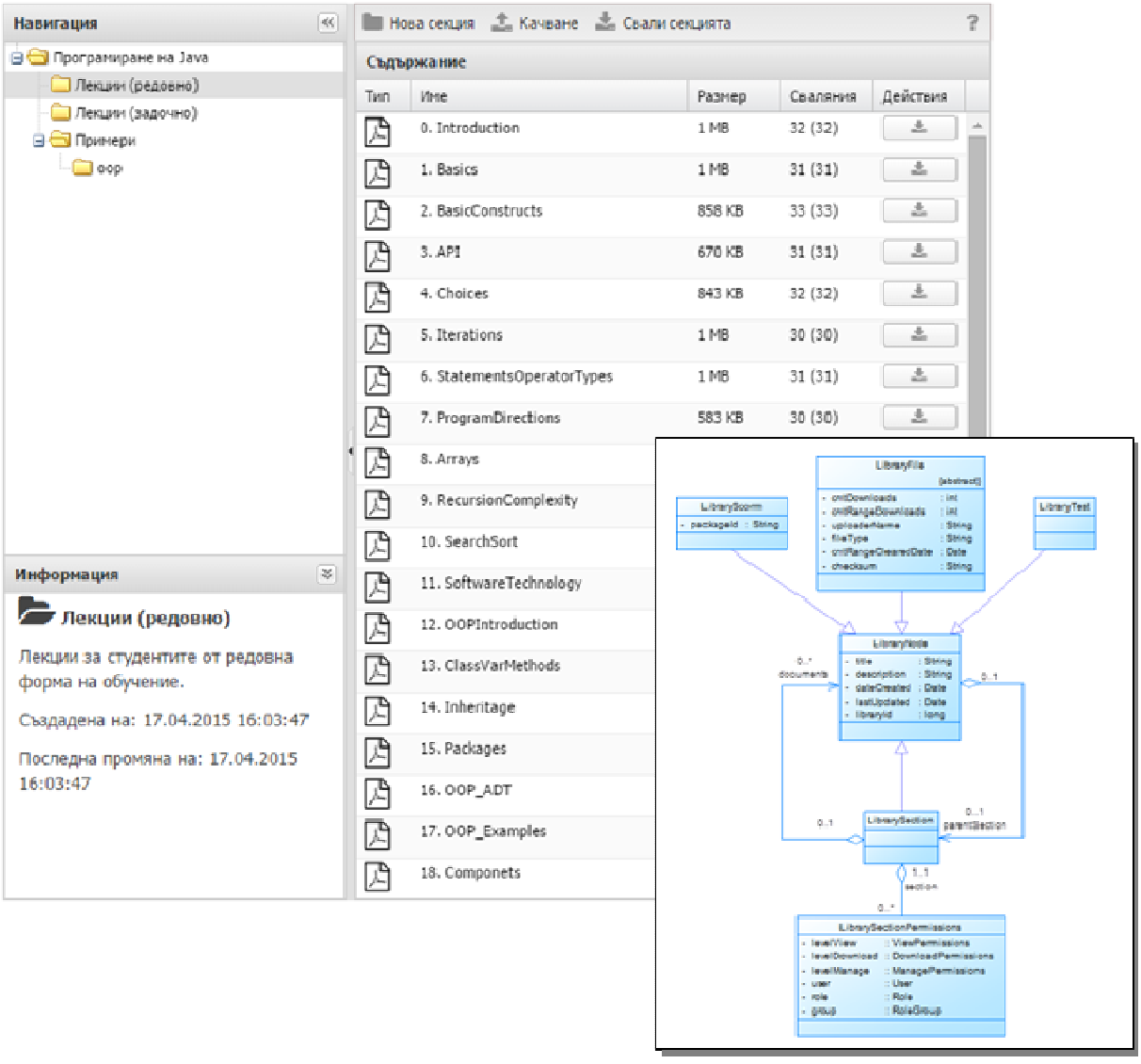

Figure 3. Digital Library UI & Data Model

composed by sections. Each section can have mixed content – other sections (subsections) and/or resources (static and dynamic). In addition, the Digital Library provides a flexible security mechanism. It allows the definition of cascading access rules per users, roles and/or role groups. There are three different access rights: view, download and manage, each of which with several access levels. The access rules can be defined for a section and cascade down to all subsections in the subtree of that section. The final set of access rules for a section is composed by a union of the cascaded rules, set by its supersection, with its own rules (if any). This model allows providing the users only with the resources that are relevant for them (based on roles, role groups or a person) and swipe the rest of the content, which is part of the personalization concept.

4. DiLibS in Practice

The whole education of students in the Master's degree program of Software Engineering is planned and conducted in accordance with DiLibS. The platform is used partially in the teaching at the undergraduate programs in Informatics at FMI at Plovdiv University, in the Master program of Business Informatics and English, and the Master's degree program of Software Engineering at the Free University in Burgas. At present, more than 2100 students and 18 teachers are using the platform. DiLibS provides educational content in 13 subjects of the Master program and 7 subjects of the Bachelor's degree program.

The basic educational services supported by the platform are the following:

- Self-Paced Learning – This service delivers educational content for self-study of students, usually in the form of SCORM 2004 electronic packages. The SCORM Engine, consisting of SCORM Player, SCORM Manager and SCORM Statistics modules, is implemented according to the ADL's SCORM 2004 R4 specification [14]. SCORM was developed to support the creation and portable delivery of reusable

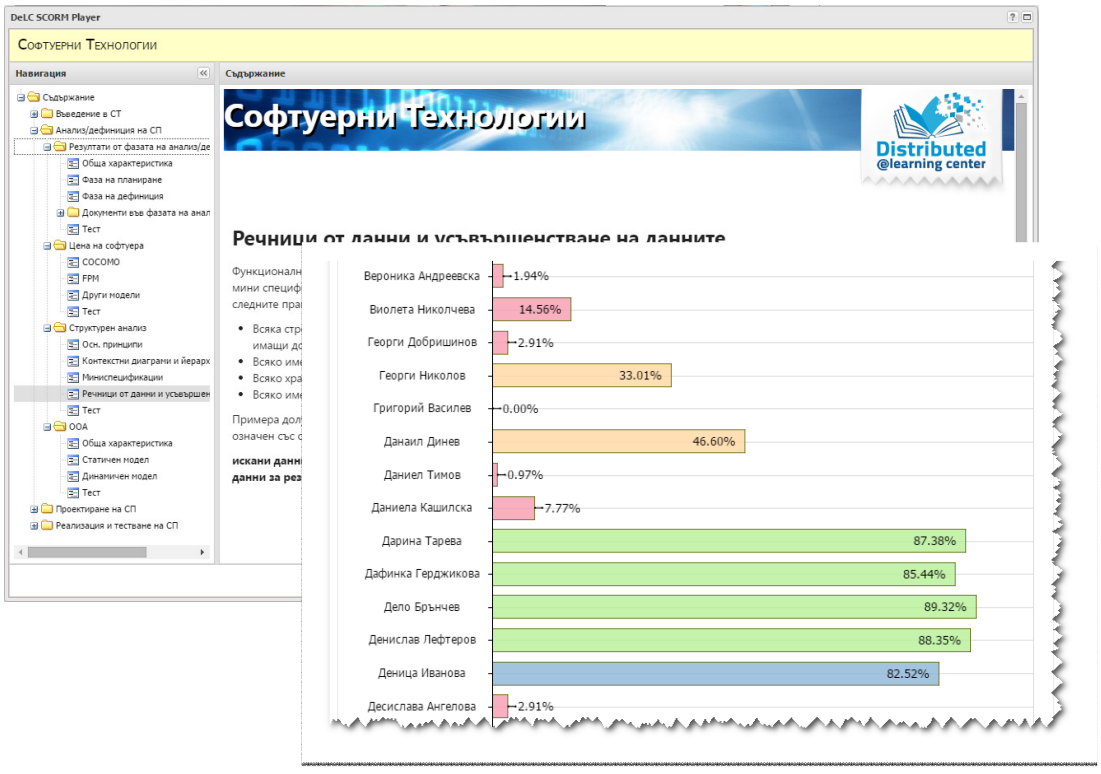

Figure 4. Course in Software Technology

teaching content for self-spaced computer-based training. In our case, the teaching material is stored in a digital library that can be accessed by the students during their self-study. The SCORM Engine traces the progress of the students actually working with the content. The collected information is delivered to the teacher for analysis and evaluation of the students' performance.

- E-testing – The Test Engine is the most commonly used service in the real teaching process at the Faculty of Mathematics and Informatics at Plovdiv University. The access to the functionalities of the engine is provided by web services for managing, assessing and analyzing digital assessment content. These services are in direct communication with multi-agent content and an assessment management system that is responsible for providing the digital information resources requested by users via the web services from the service layer of the Test Engine. The Assessment Agent System manages the digital content by using the provided REST web services for
- database access to acquire it and cooperative work between the existing agents for its processing. The digital assessment content that the engine manages is designed as a final specification fully compliant with the QTI 2.1 [15]. Defining in such a way the architecture and its provided services facilitates a wide range of opportunities for integrating the proposed Test Engine in the space.
- Grade book – the student's grade-book stores and analyzes information on the success rate of students in all the studied courses. It is currently being developed in accordance with the Grade Book specification, which is included in the Common Cartridge standard [16].
- Teacher's notebook – it is designed for the analysis of the success rate of students in a particular course of studies. In addition, it helps the teacher to organize his/her duties during the current education period (it is being developed at present);
- Services for planning, organizing and documenting the learning process, including different registration services, etc.

We will demonstrate the practical use of the system with two examples – the Software Engineering course and the English language course.

One of the SCORM e-learning content packages is in Software engineering (Figure 4). This package is organised in different sections that cover a specific pedagogical model. After each part of the e-learning content students have to pass a test. When the students have passed the specific test, the next section of the package is opened. This structure is realized by sequencing and navigation technology in the SCORM standard. Based on the students' results some statistics are collected – how many students have passed the package, what percentage of the content has been covered, etc.

Figure 5. An example of open and closed questions on a self-study test

DeLC is integrated in the English language education at the Faculty of Mathematics and Informatics at Plovdiv University by means of the E-testing system. This system is used both for summative assessment in the classroom during the term and at the end of the course, and for formative assessment in the foreign language outside the classroom. The medium of self-study tests allows for acquisition and reinforcement of knowledge and skills in a relaxed atmosphere in the students' own homes. Self-study tests are administered online – they are published on the DeLC website to help learners to practice what they have learned in the classroom within a validity framework and a time limit set by the teacher. Their content is relevant to the most recent study materials and activities performed during the academic classes. In order to gain maximum benefit from the self-study tests and achieve best results, students are allowed to redo them as many times as needed, in case they are not happy with their performance. The E-testing system makes use of multiple-choice questions (MCQs) with one correct answer, MCQs with more than one correct answer,

strict matching (where the number of questions corresponds exactly to the number of answers), non-strict matching (the number of questions does not correspond to the number of answers), and open questions (Figure 5.).

All self-study tests have the same structure and method of scoring. The grades that students are given (from the lowest grade of Poor 2 to the highest of Excellent 6) correspond to the number of points that they obtain from all test questions (Figure 6.). Closed questions are graded automatically while long-answer open questions are evaluated by the teacher and those points are added later to form the student's final grade. Self-study tests are activated on a regular weekly basis in immediate succession of the academic classes at university which allows students to become well acquainted with the types of activities used for their final course assessment. They provide educators with essential information which can be used to make decisions about instruction and student grades.

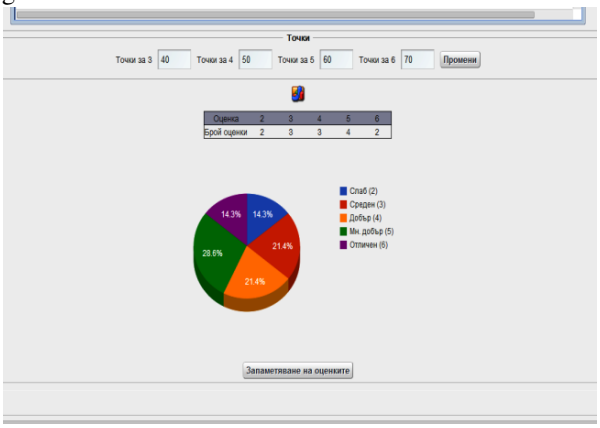

Figure 6. An illustration of the scoring system and the test results obtained from a group of students on a self-study test

Below are some of the advantages of using the Distributed E-Learning Centre as a medium for self-study tests:

- It is very user-friendly. It allows for various types of tasks including the upload of pictures and graphics and makes use of metadata which facilitates the compilation of tests on the basis of different criteria.
- The preview option helps teachers to try out the test and make changes before its actual administration to students.
- DeLC offers the option to set a time limit and different validity periods for every test.
- Self-study tests are done online from the comfort of students' homes at a convenient time within the framework of the test validity.
- All questions are placed on one and the same page which facilitates scrolling through the various tasks to review, edit and correct items.
- Students obtain their test results immediately except for the open question scores which are added after the teacher has evaluated the texts.
- Students can check the grades they have obtained on previous tests from their accounts.

5. Conclusion

In this paper is presented an intelligent, context-aware, scenario-oriented and controlled infrastructure known as Virtual Education Space. The kernel of the space, the DiLibS platform, is implemented for the provision of teaching material and eLearning services according to the SCORM 2004 and Common Cartridge (QTI 2.1., Grade Book) standards. The DiLibS platform is created through re-engineering of the existing environment DeLC. Currently, our effort is focused on expanding and strengthening the platform with intelligent assistants. In addition, a workplace for teachers is developed providing specialized editors for the preparation of teaching material and electronic tests.

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