Abstract: This article deals with e-learning course of computer graphics that was created for distance, “face to face” and blended learning at the Department of Informatics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Slovak republic. The subject Computer Graphics is the part of bachelor study program of discipline Applied Informatics and is determined for students of master study programs in specialization Informatics too. The content of this subject includes 2D and 3D transformations, algorithms for drawing basic graphical elements in raster graphics, fractal theory, animation, colour-processing, modelling and drawing 3D objects. Because communication between the students and the teachers is complicated we decided to base it on information and communication technologies. In paper we try to describe this e-learning course of computer graphics and at the end we also want to present outcomes of survey about electronic testing.

Key-Words: Computer graphics, Teaching, E-learning, Course, LMS Moodle, Testing, Automated assessment

1 Introduction

In Slovak and Czech education region some universities have chosen the path of creating of their own learning and management environment (Technical University of Liberec, and Masaryk University in Brno). But most universities combine form of learning using one of a number of commercial or free LMS. They decided to use products such as Claroline, Fle3, ILIAS, MS Class Server, WebCT, Eden, Enterprise Knowledge Platform, LearningSpace, eAmos, eDoceo, Uniforms, uLern, Aspen, Oracle iLearnin, NETOPIL School and Moodle [1]. As the best “investment” to the future seems to be an LMS Moodle (good price, continuously development and active community). Moodle is increasingly appearing also in secondary school. At our university we use LMS Moodle as central environment for five faculties and all departments. In last few years were created many courses for supporting teaching and also for testing process. The article describes one of these courses and also presents outcomes of survey about electronically testing.

2 Subject Computer Graphics

Subject Computer Graphics is determined for the second class students of bachelor study program of discipline Applied Informatics in full-time and part-time study and for the first class students of master study programs in specialization Informatics in full-time study too. This subject is taught at the Department of Informatics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra as compulsory subject.

2.1 Content and Objective

Students of enumerated study branches have one lesson of lecture and two lessons of practice per week (this is a typical weekly hour allowance for subjects which ends with final grade examination). The Computer Graphics subject objective is to understand that graphic program systems serve for graphical output creation; to understand fundamental methods used in computer graphics; to understand fundamental computer graphics algorithms and comprehend join the theory with the practice and to know practical applications of a theory. Every student is required to be enrolled in the online course because it
provides students with electronic study materials, tests, questions and tasks.

Content of the subject is identical for all study forms and includes following themes:
1. Introduction to computer graphics: history, fields of its using, fundamental terms and definitions, bitmap and vector graphics.
2. Color processing: color intensity, saturation, lightness, brightness, hue, color mixture, color models RGB, CMY, HSV, HLS.
3. 2D transformations: homogenous coordinates translation, rotation, scaling, symmetry, skewness, composition of transformations.
4. Line rasterization: analytical representation of line, DDA algorithm, Bresenham algorithm, antialiasing
5. Circle rasterization: Cartesian and polar coordinates, Bresenham algorithm.
7. Plane areas filling: area types, recursive and nonrecursive algorithms, scan algorithm.
8. Curve modelling: approximation and interpolation curves, cubic Bezier curve, cubic Ferguson curve and Coons cubic, Bezier curve, B-spline, rational Bezier curve, NURBS
10. Animation: animation systems classification, calculation of motion interphases, motion trajectory.
11. Introduction to 3D graphics: 3D transformations, translation, rotation, scaling, symmetry, skewness, clipping in 3D.
12. 3D modelling and projection: parallel, axonometric and perspective projection, sweeping, constructive solid geometry tree, boundary representation and filled parts of space calculation. Appel’s algorithm (which is described in detail in [7]).

3 Computer Graphics E-learning Course
The Computer Graphics e-learning course (Fig. 1) was created in LMS Moodle. The course is divided into 12 lessons. Each of the lessons corresponds to one theme from content of subject and provides study materials in form of texts, pictures, presentations, animations and interactive teaching support which add much more clearness into the teaching process in comparison to common computer graphics textbooks provided to students.

3.1 Teaching texts and presentations
Teaching text in pdf format is compulsory part of each lesson. It contains study materials parts of which were presented during the lecture. In some lessons presentation from the lecture to help students understand some important terms using their graphic demonstration is added, for example in lesson covering curve modeling [3].

3.2 Applications
Each lesson provides students with animations and interactive teaching aid mostly created in Adobe Flash. They are available in swf format and contain animations and interactive animations according to what object or transformation property should be presented. For example in lessons 3, 7 and 8 are used animations to explain how transformations and algorithms works (Fig.2), and in lessons 3, 4, 5, 7 is interactive teaching support available with the purpose to better understanding of computer graphics algorithms and methods. This type of teaching aid enables the students to test algorithms in practice using whatever inputs.
These applications are determined to the full-time students to working with them mainly during their lessons, and they and the part-time students too may use them during their individual studying and preparing for the computer graphics exam.

3.3 Questions and tasks
The students besides the teaching texts, the presentations, the animations and the interactive teaching aid have possibilities to solve Questions and Tasks. Their single items are ordered logically from simple to more complicated. Students during solving gradually construct their own partial solutions. It leads to solving of partial problems solutions and their complex represents of origin problem solution.

4 Electronically enhanced testing using LMS
Computer-assisted teaching (Computer Based Learning), significantly increase students’ knowledge, as well as create an incentive to learn. This is confirmed by research conducted in England and Australia on a sample of 139 students [5]. Effort of the automated evaluation increased in the last two decades, particularly with the development of distance education. Some studies have even confirmed the weak difference between the results of students educated in a traditional way with teachers and students using online system with automatic feedback [4]. Based on the analysis, we found that the some of the universities have own electronically testing systems e.g. Quiz (Chemware Ltd, New Zealand) WBPES (Web-Based Public Examination System, Dhaka University, Bangladesh [2]) or ASSYST (Assessment SYSTEM, University of Liverpool), WOES (The Web based Online Examination System [8]), TRAKLA2 (Helsinki University of Technology), PILOT (Platform-independent Online Tools, Johns Hopkins and Brown University). Last two mentioned systems work on visual principle in the interaction with the user (learning by doing, the same principle like flash application in Computer Graphics course). Due to visualization of the right solution they are suitable as support for self-study. None of the mentioned system was suitable for our purpose so we decided realized the final theoretical examination electronically also in Moodle Quiz (but in the controlled environment of the classroom). It makes the monitoring of students’ learning activities and learning outcomes more effective. Improvement of LMS system implied significant shift to the active using of electronic tests.

Question bank consists of nine categories which includes almost hundred questions. Students have to attempt all nine tests, generated randomly from the prepared database, according to sets for specific category. Questions in the database have been elaborated and most of the course’s curriculum can be tested this way. Final examination from subject Computer Graphics is realized face-to-face and consists of written and oral parts.

We are using testing only during lessons and their results partly influence subject Computer Graphics evaluation. The most important role of testing we can see in feedback during lessons because we have possibilities to consult students’ answers correctness.

4.1 Quizzes in Computer Graphics Course

Moodle offer a wide base of question type. We can divide them into two areas [6]:
1. Standard types of questions (strictly defined) – questions are formed filling out simple forms, have a fixed structure. The role of the creator is only specification of content. Among the commonly used types of this types includes:
   a. Multiple choice
   b. True/False
   c. Short answer
   d. Matching
2. Non-standard types of questions (freely definable) – Embedded answers questions are very flexible type of questions comprising a snippet of text in which questions are embedded with different types of responses (multiple choice, short answer, numerical task etc.)

In computer graphics course we use only the typical type of question for electronically testing, multiple choice (Fig. 4).
Fig. 4 Question from category 2D transformations

Every test has a time limit and is displayed in full screen pop-up window with JavaScript security (e.g. ban on copy&paste). Immediately after the attempt students get response, answer, feedback and score. By using only multiple choice answers there are no way to get a mistyped character, therefore there is any need to check the test assessment after. Fig. 5 shows how results of test for chosen student group can look.

Fig. 5 Results of test for chosen student group

4.2 Survey about electronically testing

The main research took place during three years among the students of the Department of Informatics after the end of the semester. In the last phase we realized national research among the selected group of secondary and university teachers of Informatics.

Students sensed testing in Moodle as good designed, intuitive and modern. The biggest complaint from the students and partially from teachers are directed to display the remaining time, which make rise of the nervousness. Students appeared to prefer view of each question separately before view of all the test questions at once, where they have to scroll the screen.

The survey responses exposed that despite the significant positive relationship to the electronic testing still dominates partial distrust of computerized assessment tests (due to open answers, but not used in Computer Graphics course). The concept of electronic testing is perceived more positively than the concept of traditional paper tests. Figure 6 shows the result of scaling, in which student compared the traditional paper and electronic testing. They reflect on concepts using the nine seven-point bipolar scales.

For example, if student choose for term classical testing point one in S1, it means that he perceived it to be completely objective, in contrary point seven means to be completely subjective. The middle point (4) refers to the neutral perception.

We used following scales:
(S1) objectivity vs. subjectivity, (S2) effective vs. inefficient, (S3) modern vs. outdated, (S4) suitable for all vs. suitable for small group of students (S5) difficult vs. easy (S6) convenient vs. inconvenient (S7) examines theoretical knowledge vs. examines the practical knowledge (S8) interesting vs. boring, (S9) giving rise to fear and stress vs. does not fear and stress.

Fig. 6 Comparison of traditional paper and electronic testing (scale are describe above)

5 Conclusion

We have been using the Computer Graphics online course since 2006 (5 academic years, about 100 students per semester). During this years, the course was improved until today’s version. By using of them we gained greater insight into the students’ activities.

We analyzed the possibilities of systems suitable for testing and enabling simple archiving of results and we finally chose LMS Moodle as the most accessible alternative for educational organizations. One of the findings of the survey was that students not clearly prefer computer testing and evaluation to teacher’s assessment.

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