"Dunarea de Jos" University of Galati

Doctoral School of Fundamental Sciences and Engineering

THESIS

Contributions on the analysis and design of computer-aided education systems

SUMMARY

DOCTORAND:

BUMBEA (căs. SAVIN) NUȚI

PHD SUPERVISOR:Prof. Univ. Dr. Ing. LUMINIȚA DUMITRIU

Series I2: Computers and information technology Nr.8

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BUMBEA (câs. SAVIN) NUȚI

Chairman:	**Prof. Dr. Eng.Marian BARBU**
	"Dunarea de Jos" University of Galati
PhD supervisor:	**Prof. Univ. Dr. Eng. LUMINIȚA DUMITRIU**
	"Dunarea de Jos" University of Galati
Official reference:	**Prof. Dr. Eng. Ștefan TRĂUȘAN-MATU**
	POLITEHNICA University of Bucharest
Official reference:	**Prof. Dr. Eng. Costin BĂDICĂ**
	Craiova University
Official reference:	**Prof. Dr. Eng. Emilia PECHEANU**
	"Dunarea de Jos" University of Galati

Series I2: Computers and information technology Nr.8

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Chapter 1. E-learning systems. Current status

1.1. The evolution of computer-assisted training in Romania

The first forms of Computer Assisted Training (C.A.T.) in our country appeared at the beginning of the 60s, when "learning machines" were in full swing. A landmark moment in the dynamics of Romanian pedagogical programming was the establishment of fundamental directions related to the use of computers in the field of education [2].

The education system around the world has been strongly influenced and also marked by the development of information and communication technology. The computer is present in the entire training process, starting with the presentation of knowledge, continuing with its acquisition by the student (learner) and finally, with its evaluation.

Studies show that the computer system, with all its variants (computer, laptop, or gadget) cannot replace the teacher in the classroom and the direct interaction of students with him and with colleagues, a situation confirmed by the online education during the COVID-19 pandemic.

The development of Web applications on educational platforms has been a standardized way of designing educational software for any operating system [96].

Creating a didactic application using web design is relatively easy, has interactive content, provides instant feedback to students and can facilitate the immediate evaluation of the activities carried out [4],[3].

1.2. Architecture of e-learning platforms

1.2.1. E-learning platforms. Generalities..

Choosing an e-learning platform is difficult, implicitly also choosing a certain architecture appropriate to the needs of the respective institution. New technologies [60], [78] promising especially for video-interactive facilities, networking, virtual collaboration software and hardware tools, could reduce costs and increase the possibility of access to information.

Therefore, such a choice is not exactly easy, but it must respect several criteria [75]. The design [35], [57] of the architecture of an e-learning platform is a complex process due to the heterogeneity of the technologies used, with performance, scalability and security as objectives. If we also mention the elements related to time and available human resources, the cost of the developed solution and the software used to develop it, we can conclude that the design of an e-learning platform should be based on the following criteria:

Functional requirements:

1. Management of access/roles/users; 2. Activity planning; 3. Assignment and follow-up of tasks 4. Collaboration; 5. Internal/external information; 6. Elaboration of reports; 7. Activity performance evaluation; 8. Content creation; 9. Evaluation/self-evaluation of knowledge; 10. Roles with specific attributions; 11. Educational management.

Design requirements:

1. To constitute a solution suitable for the needs of the institution; 2. The cost of the solution should be minimal, by using free software: MySql database, Apache server, Php programming language; 3. To be characterized by flexibility in order to allow the integration of new functionalities, within the already existing architecture.

1.2.2. Communication tools in e-learning

- Blog, Wikipedia, Forum, Chat, Audio-video conference, Aggregator, Podcasting.

1.2.3. Advantages and disadvantages of e-learning

Regardless of the form that e-learning takes, it generally has advantages [30], [31], [112], but in addition to the benefits brought by e-learning, there are also a number of disadvantages that can appear, the most important of which are described in the thesis [30], [31].

1.3. Classification of e-learning platforms

1.3.1. General description

An e-learning platform is a support for learning, which ensures the distribution of all the necessary tools to support training activities through courses, self-assessment or collaboration. E-learning platforms are centered on students (learners) and allow them greater autonomy.

Under these conditions, students can reproduce and retain information better [22]. The environments in which the training takes place follow several principles, namely:

1. Modality Principle;
2. Multimedia Principle (Multimedia Principle);
3. The principle of coherence (Coherence Principle);
4. Signaling Principle (Signaling Principle);
5. The principle of continuity (Spatial and Temporal Contignuity Principle);
6. Segmentation Principle (Segmenting Principle).

The learning environment in an e-learning system is centered on the student. The student structures his own knowledge and uses his experiences within the training process, under the guidance of a teacher, who has the role of coordinator. The courses made available can be stored in many formats, their content being distributed over the Internet and displayed through a browser. Accessing instructional materials by students is usually done on their own computers using a browser approved by the platform. The student has access to these online courses, being free to train on his own, at any time and at his own pace.

Imposing his own pace, his retention rate is higher, because the level of understanding of the instructional material also increases.

1.3.2. CMS – Content Management Systems

Any content management system has a database in which the content that is created, stored and distributed via the Web is registered, providing wide-scale access to the development of the e-learning field.

In a CMS system [18], [93], [CMS-77], used in computer-assisted education, the instructional content can take the form of text, graphics, animation, sound, video, images, but also other forms of its embodiement. It is created with the help of a tool provided and is stored in a database (created when installing the content management system) as an individual element. Any changes to the content are reflected very little in the database, being managed and distributed through it.

For content management systems, the developer community experienced a real explosion by offering the source code for free, under the GNU (General Public License), which makes the vast majority of content management systems free. This has expanded the communities that develop templates, make projects and components for content management systems. In a CMS system, complete articles are assembled from content components that have the advantage of providing a personalized experience.

The objective of a content management system is to simplify the creation and administration of instructional content made available online (the same principle as in publications) through articles, images, films, etc., used with the aim of bringing more knowledge to those who they train. Content management is achieved by separating content from presentation and imposing process flow.

A separate category of content management systems is represented by Web content management systems - WCMS (Web Content Management System), which allow the creation, management and distribution of content via the Web.

Another category of content management systems are integrated document management systems - IDMS (Integrated Document Management Systems). They have the same functions as a content management system, but in addition, they can interface with multiple types of authoring tools to manage many types of content, content that must be

converted to a common format to be reused. The IDMS system can distribute content in its source format or converted to other formats.

Published content management systems - PCMS (Publication Content Management Systems), are used for the needs of technical publications and books published in the industry. Content can be distributed at the paragraph level or smaller and target multiple types of multimedia elements. In other words, reuse is done at the paragraph level, being supported in systems based on XML (eXtensible Markup Language). Unfortunately, such a system does not support web content management for a long time, for various reasons, one being the required storage capacity.

Knowledge management systems - KMS (Knowledge Management Systems), are systems that manage structured and unstructured knowledge, focusing on discovering and synthesizing information, but also on collecting all knowledge and indexing it [21].

1.3.3. LMS – Learning Management Systems

A learning management system (LMS) [83], is a system that provides planning, distribution of educational content and learning management, which can also be used for virtual training. Starting from this idea, we can conclude that the activities offered by a training management system are e-learning activities, but also activities that do not involve e-learning. At the base of such a system is a content management system, [89] which allows the storage of learning objects represented by text documents, graphics, multimedia documents for their integration in Web environments or courses, but unlike a management system of content, a learning management system allows tracking and reporting of the use of these objects.

The development of content for e-learning initiatives and for personalized learning directly from the use of standards-based learning objects, [81], [82], [41] led to the unification of concepts and systems that appeared and developed in an overwhelming number, but in a chaotic way.

It has been argued that a learning management system can comprise or be based on a content management system as both are designed to store course components at the object level in a central database. This means that content management can be done everywhere. And a LMS, just like a CMS, allows the constant updating of the content, which makes the management of the site much easier. Unlike a CMS, in an LMS the issue of security must be looked at from other aspects, in the sense of ensuring the mechanisms much more sophisticated protection. An LMS must have additional security measures in place to prevent unauthorized access.

1.3.4. LCMS – Learning Content Management Systems

A learning content management system or LCMS [86] is a system characterized by the following functions:

1. Offers the possibility of creating and editing content;
2. Content storage and archiving;
3. The possibility of structuring the content, distribution and communication of the content;
4. Ensures interoperability;
5. It offers the possibility of a competent administration of teachers and students.

We will approach the learning content management systems through the prism of the previously described systems, the similarities and differences between them.

We will start from the premise that, to be complete, an LCMS should certainly contain an LMS, enhanced with a CMS. A CMS system is built into an LCMS system and will work together with an LMS system. Thus, an LCMS system will be implemented as a package that combines a CMS system and an LMS system and will have the role of tracking, creating, storing and reusing content, whenever needed.

Many LCMS systems have LMS capabilities, which can be confusing at first glance. However, the differences are clear according to the objectives that each one proposes, the first

objective of a learning management system being the administration of users, keeping their performance and progress during all types of training activities, while a learning content management system (LCMS) administers the content or objects of learning, which are offered by right to the learner at the right time.

An LCMS system does not manage blended learning but does manage content at a much higher level of granularity. This makes content reuse much more accessible. An LCMS system can build learning objects based on the user's profile and learning style. One therefore manages the processes of the training environment, and the other manages all the processes related to the creation, distribution and reuse of the content.

Also, an LCMS system manages easy-to-reuse dynamic content, manages the personalized distribution of learning content and ensures interactivity between them and the content. And from a technological point of view, an LMS system and an LCMS differ, as follows: an LMS system manages communities of users, an LCMS not having this purpose. An LMS system can use this function to allow users to load objects stored and managed by an LCMS system.

1.3.5. Characteristics of LMS and LCMS systems

The main characteristics of LMS and LCMS e-learning platforms are highlighted in table 1.1

Table 1.1. Features of LMS LCMS

Caracteristici	LMS	LCMS
Target group	Students, teachers, administrators.	Content developers, instructional content designers, project managers.
Objective	Management of learners, courses, instructional materials and authentication	Management of educational instructional content, providing appropriate tools for content creation.
Making reports on learner performance	Is a fundamental objective	No
Collaboration	Enables collaboration for learners	Enables collaboration for authors of instructional content
Learner Profile	Maintaining the learner profile is a fundamental goal	No
Share learner information with other systems	YES	No
Event planning	YES	YES
Analysis of student performance	YES	YES
Content Creation	YES	is a fundamental objective
Organizing content for reuse	No	Is a fundamental objective
Test creation and question administration	YES	It offers such facilities
Adaptive learning	No	It offers such facilities
Content management and creation tools	No	It is a fundamental objective

Providing content by providing navigation control	YES	YES

1.4. General notions of mobile learning

With the emergence of m-learning, which represents the philosophy of the four "A" (anywhere-anytime-anything-and quantity) of the information society, the young generation's "appetite" for these IT technologies has grown considerably. There are many e-learning platforms in the world that offer or host mobile learning applications precisely to make training more flexible and more attractive. In the context of the COVID19 pandemic, this approach has become almost mandatory.

1.4.1.Mobile learning [34]

Advantages of students using portable devices:

1. Spontaneity - learning activities take place when the student feels ready, or can be used to fill "dead time";

2. Immediacy - learning becomes possible from the perspective of need, regardless of location.

3. Increasing access - learning resources can be accessed from the workplace, during trips, during courses and lectures;

4. Portability - communication with teachers and students, as well as capturing, storing and retrieving information in multimedia format, are possible from a device in any place.

Due to the increasing use of mobile technologies in society by the younger generation, students will demand that course materials be delivered on mobile devices (tablets, mobile phones, smartphones) to be accessed anywhere and anytime.

Mobile training must take into account the diversity of mobile devices that currently support m-learnig platforms, currently available: iPhone, iPod Touch, and iPad devices (OS 4.x+) smartphones based on Android (OS 2.1 +).

1.4.2. Learning system management

The FRAME model (Framework for Rational Analysis of Mobile Education) was the first comprehensive theoretical model that described Mobile Learning as a process resulting from the convergence of mobile technologies, human learning capabilities and social interactions [19]. The model addresses contemporary pedagogical issues of information transmission, knowledge sharing, and collaborative learning. It was considered that this model helps in the development of mobile learning devices, learning materials for m-learning and in specifying instructional and learning strategies for mobile education.

In a definition given by O'Malley (2003) – Mobile Learning is "any way of learning, which the student uses when he is in a predetermined fixed position, or in a classroom, taking advantage of the opportunities offered by mobile learning technologies", and researcher Geddes (2004) adds: "acquiring knowledge and skills through the use of mobile technologies, anywhere and anytime, which leads to behavior change". A hierarchical architecture of mobile applications based on modules, is illustrated in figure 1.1.

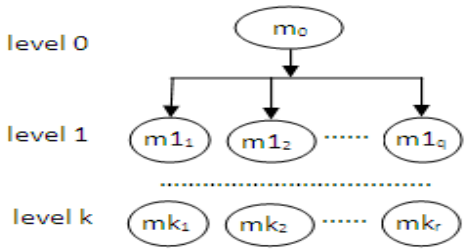

Fig. 1.1. The hierarchical structure of mobile learning applications

According to this architecture, the applications are scalable, the new modules are more easily attached to the already existing application. For users who do not want all the modules

within the application, the modules they do not want can be easily removed and thus the application becomes exactly what each user wants.

Mobile applications can be divided into the following categories:

1.General information applications; 2. Virtual identity verification applications; 3. Communication applications; 4. Economic applications; 5. Games.

1.5. Conclusions

Research trends in the field of educational technologies have been influenced by two main factors, namely:

- the evolution of learning theories from behaviorism [20] to cognitivism and further towards constructivism;
- technological changes, from machine learning to virtual reality technologies.

The evolution of the use of educational technologies in learning has been influenced by the dominant scientific paradigm and the advantages of IT tools. A clear transition between the design of training and the design of learning can be observed, not only in the fact that the content is oriented towards the learner and training, but also from the recognition learning outcomes that are owned by learners. Technology should enable them to achieve idiosyncratic learning goals. It should be emphasized that learning is much more dependent on the student's activity than on the amount of information and the processing of opportunities offered by the environment. Expanding the type of online education will enable students to assume greater responsibility in terms of organizing and identifying the object of study. M-learning must be perceived as a tool of the learning activity. M-learning is a complementary form that enriches and varies conventional lessons or courses, which appeared as a result of the evolution of technology and the change of our way of life and which has the role of helping us in the learning process through solutions adaptable to our resources of time.

E-learning is a type of computer-assisted education that allows access to new information and knowledge through effective learning methods. Innovative e-learning technologies allow the simulation of the traditional class but also the adoption of a set of useful tools in preparation such as: online counseling; library of interactive courses; and so on In the terminology of e-learning, the word "virtual" is increasingly used in order to highlight the way of communication and face-to-face interaction for participants.

According to the latest publications in the field [76] "Learning Management Systems (LMS)and Virtual Learning Environments (VLE) have become increasingly common in education".

There are a number of other environments for designing web applications, each with its own advantages and disadvantages, but with one goal: to create interactive, secure, responsive web applications that also provide a nice graphical interface

.

Chapter 2. E-learning platforms used in pre-university education in Romania

2.1. Introduction. Analysis of e-learning platforms in pre-university education in Romania

The new ICT technologies [23], [24], [25], [53], related to the development of the Internet, have revolutionized pedagogical methods leading to the emergence of e-learning. There are several forms of e-learning: 100% distance training, mixed training or blended learning, synchronous training (real-time platforms and virtual classroom systems), asynchronous training.

By the generic name of e-learning platforms [80], a wide range of products are designated that support the learning process in different ways using electronic support. The platforms that are described in the thesis were originally developed with different purposes. Some platforms are just CMS with a focus on teaching or testing, some are just LMS, some are LCMS.

An in-depth analysis of the platforms used in pre-university education is carried out, namely: Moodle, AeL, eSchool, INSAM, Google Classroom, ASQ, 24Edu and Adservio.

The first analysis considers the technical characteristics of these platforms: Moodle, AeL, Insam, eScoala, ASQ, 24Edu, Google Classroom and Adservio. It is noted that the vast majority of features are common with small exceptions (license type and IT technologies used). In the case of the technologies used in the design of the platform, they are not a determining factor in the beneficiary's choice of a platform.

Instead, they differ in a point that is critical for pre-university education in Romania, namely the type of license (free or for a fee!).

The second analysis investigates the communication tools of the platforms: Moodle, AeL, Insam, eScoala, ASQ, 24Edu, Google Classroom and Adservio.

It is noted that the AeL platform does not have chat, blog and podcasting but instead has videoconferencing, unlike Moodle which has these functionalities but with extension for podcasting and videoconferencing.

In the case of data and access information, the eight platforms have similar characteristics except for access permission and communication language.

The third analysis studies data and access information in: Moodle, AeL, Insam, eScoala, ASQ, 24Edu, Google Classroom and Adservio.

From the point of view of the activity the eight platforms differ in the existence of lesson model, lesson date planning and import/expert operation over tests of different forms.

The fourth analysis looks at the activities of the platforms comparatively.

The fifth analysis investigates evaluation items of educational platforms.

The sixth analysis takes into account the main evaluation functions: resource planning, practical activities, access to the database, upgrading the operating system, feedback, lessons implemented and last but not least, statistical reports.

If we refer to the design aspects and especially to the implementation of e-learning platforms, several technological features can be highlighted. These platforms have been qualitatively evaluated.

The seventh analysis studies the technological characteristics of the Google Classroom, ASQ, 24Edu, Moodle, Adservio, Ael, eScoala, INSAM platforms.

With regard to the analyzed platforms, we found, also on these platforms, that the classical design principles of software systems in general are followed and respected.

An important criterion in evaluating the quality of a software system and therefore of an e-learning platform is data security. This should be considered starting with the system analysis phase, establishing requirements, and continuing with the design implementation, and testing phases of procedures to protect system and user data from unauthorized access or loss

In the case of the e-learning platforms analyzed and used in pre-university education in Constanța county, Romania, we used the SWOT analysis to better reflect and compare data security.

2.2. Conclusions

In general, online platforms qualitatively improve the educational process and lead to increased performance in training and student training by developing new formal and non-formal, individual and group learning environments.

The analysis carried out aimed to highlight the main functional and constructive characteristics of the analyzed platforms and certain facilities offered to users were presented.

It cannot be said that one platform is "better" or "less good" than another (that would be a vague assessment!) but only that there are priority or preference criteria.

For an objective assessment, quality criteria must be established that apply to all e-learning platforms.

Chapter 3. Educational software for pre-university education

3.1. Criteria for evaluating the quality of educational software from the perspective of analysis and design

According to Jones et al., "There is no one design, process, or method that can predict outcomes or prevent all problems a learner may have. So the design process must be interactive: the material must be tried on learners and refined, and then tried again, and the cycle will continue for as long as necessary. Some common quality assessment criteria include: quality of feedback, coverage of content relevance, use of appropriate language, visual appearance, and a variety of forms of interaction [9]. Software compatibility with different computers is of considerable importance to teachers who have valuable software libraries, but facing the problem of moral wear and tear on hardware, or for those who simply want to choose the best from a diverse range of equipment. Teachers are still central, but computers add a powerful motivational factor. Consequently, students cannot all use the same programs or in the same ways

Criteria for choosing e-learning software

Table 3.1 presents some characteristics that we considered relevant for choosing an educational software in pre-university education for the Informatics discipline

Considering the target audience, the most attractive educational software are game-type ones.

Table **3.1.** Criteria for choosing an educational software for Informatics lessons

Crt.no	Characteristics	Comments
1	The quality of software program	It is important to attract students' attention.
2	Moving from one level to another.	Students will take the games seriously.
3	Easy to use	Students will work harder.
4	Interactive learning	Keep students' attention.
5	Competitive games	Many students will be incited.
6	Levels of difficulty	For students from different years of study
7	Clear objectives	The best expression.
8	Exercises and tests	Checking students' learning ability.
9	Availability for group work.	Students can work in groups of two or three.
10	Quality of interface graphic design.	Providing clear figures.
11	Encouraging creativity	The original solutions.
12	Feedback and written work	The students know what they have done
13	Curriculum relevance.	This part is essential for effective learning.
14	Good design	How can the program effectively engage students.
15	Problem Solving.	Designing games to enhance creativity.
16	Fun.	The package is nice, fun to use.
17	Critical Thinking	Attracting students' attention

Some of the characteristics in the table are related to the educational content such as:

Passing from one level to another; Interactive learning; racing games; Clear objectives;

Exercises and tests; Encouraging creativity; Suitability to the curriculum; Critical thinking skills.

Features related to the platform are:

- Software program quality; Easy to use; Difficulty levels; Availability for group work; The quality of the graphic design of the interface; Feedback and written work; Good design; Solving problems; Fun.

3.2. Quality assessment in e-learning systems

Quality represents the totality of an entity's characteristics that affect its ability to satisfy or exceed the explicit and implicit needs of the beneficiaries/users.

The concept of quality can be viewed and approached by considering different aspects. Thus the SunTrust Equitable Report [37] illustrates what the authors perceive as the value chain in e-learning, in the form of a pyramid. Content is the most critical factor in e-learning, as it forms the base of the value pyramid. In a more detailed approach from 2010, the bottom of the pyramid is user reaction and the next level up is content.

The effectiveness of the e-learning system is represented in three fundamental dimensions: quality, technology, access. Moreover, quality is an important term with broad expressions that cannot be expressed and established by a simple definition, because quality is a complex and eminently conceptual notion.

It is important to recognize that in the case of the quality of a learning process, quality is not something that is delivered to a learner by an e-learning provider, but rather is a co-production process between the learner and the learning environment. This means that the product/result of an educational process is not exclusively the result of the production process of an educational institution. According to the Information System Success Model, system quality is a critical success factor that influences user satisfaction and the intention to use the system. Petter and McLean (2009) conducted a meta-analysis of studies using the IS(Information System) success model to investigate the strengths of various relationships in the model. They found that both perceived system quality and user satisfaction have strong relationships

3.3. Evaluation model of the quality of e-learning platforms in pre-university education in Romania

Based on what was presented and established in paragraphs 3.1 and 3.2, we retained five characteristics for evaluating the quality of e-learning systems in pre-university education in Romania. These are:

1. Accessibility. It refers to the way to access the platform and the technical conditions that the user must meet (computer, tablet, mobile phone, internet speed). It is evaluated with 5 qualifications: I don't know, unsatisfactory, satisfactory, good, very good.

2. Stability. This feature takes into account interruptions during operation, total shutdowns, restarts. It is evaluated with 5 qualifications: I don't know, unsatisfactory, satisfactory, good, very good.

3. Friendly interface. It is the feature known as "user frendly" in computer applications. It is evaluated in 5 grades: I don't know, unsatisfactory, satisfactory, good, very good.

4. Feedback with the user. The feature refers to what feedback the platform provides to the student, teacher user. It is evaluated using 5 qualifications: I don't know, unsatisfactory, satisfactory, good, very good.

5. Ease of working with material uploading. The difficulty of uploading documents for both the teacher and the student is appreciated. It is evaluated in 5 grades: I don't know, unsatisfactory, satisfactory, good, very good.

6. Effectiveness. A relationship between quality and effectiveness appears in the model in figure 3.2. According to the explanatory dictionary of the English language, "effective - successful in producing a desired or intended result ", and effectiveness is defined as: " the degree to which something is successful in producing a desired result ". In the case of platforms, it is primarily about effective learning, which is defined in specialist works as follows: "Effective learning has three important characteristics: it is active, it is goal-oriented, it leads to measurable results". We have also introduced into the study the Score given by the user, which we will use in assessing the effectiveness of the platform, as a transitive relationship that we assume to be between the five characteristics, quality and effectiveness. It is a grade from 1 to 5 given by the user (students and teachers).

Modeling and evaluation of online courses indicates the statistical inference method as appropriate, which is why we designed a model and formulated working hypotheses.

We propose to verify two hypotheses:

● I1: There is a positive relationship between accessibility, interface, stability, ease of loading documents and platform feedback with system quality in the e-learning system.

● I2: There is a positive relationship between system quality and e-learning effectiveness.

The study assumes that the effectiveness of e-learning systems is affected by the quality of the system through five dimensions (accessibility, stability, interface, ease of loading and feedback), Each evaluation characteristic was evaluated from the perspective of student users and teachers. The relationships between the evaluation variables are shown in Fig. 3.1.

The study was carried out using the questionnaire method and the results can be found in annexes of the fulltext of the thesis. The 40 questionnaires were addressed to both teachers and students from 5 units in Constanța county. All the interviewed groups were formed either by high school students (grades IX-XII) or by the teachers of these students.

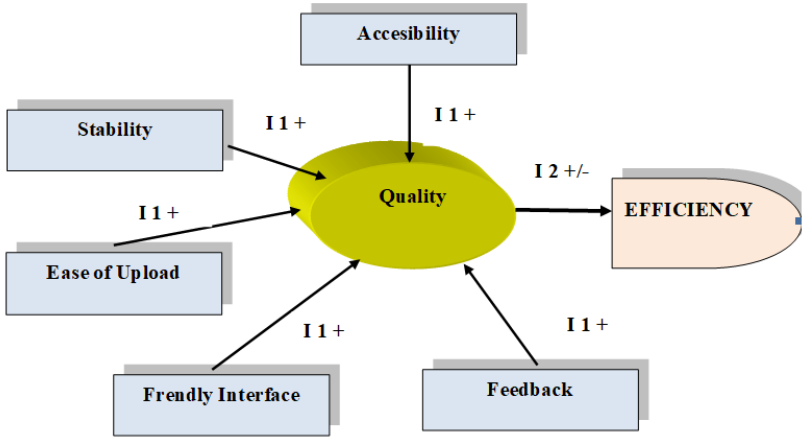

Fig. 3.1. Evaluation model of the quality and effectiveness of e-learning platforms

Study results

1.The Moodle platform

Regarding the 5 features, the majority of teachers answered that the interface and ease of loading are good and about 20% that it is very good.

All five criteria are in the satisfactory area (approx. 25%) (fig. 3.2a).

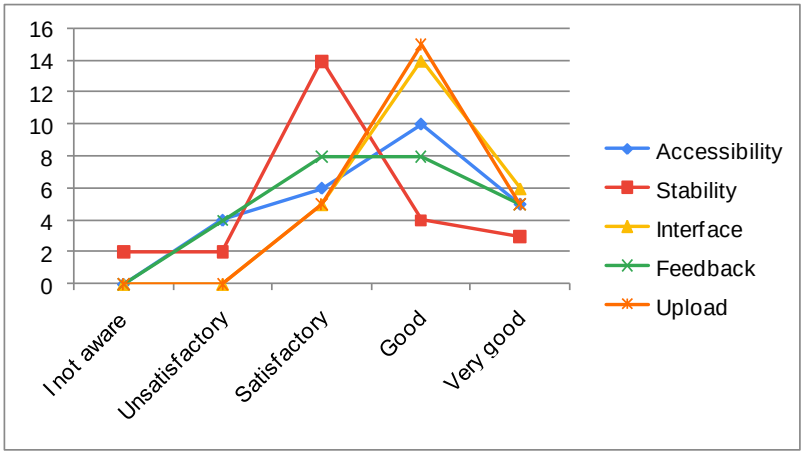

Fig.3.2.a Features for the Moodle platform - teacher responses

In the case of student users, most place the five characteristics in the satisfactory area (fig. 3.2b)

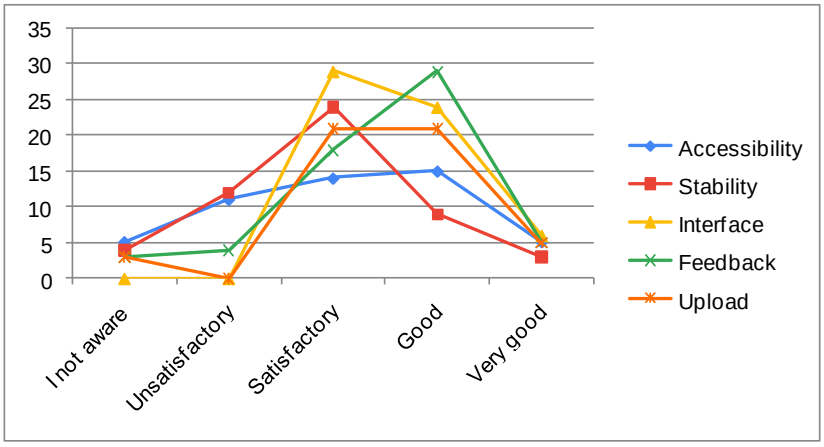

Fig.3.2.b. Features for the Moodle student responses

As a general rating, 80% of teacher users rated the platform 3 out of 4, and 40% of students rated it 4.

2.The 24Edu platform

Regarding the 5 features, teachers mostly answered that the interface and ease of loading are good and about 66% that it is very good. All five criteria are in the satisfactory area (approx. 25%).

As a general grade, 55% of teacher users rated the platform 4 out of 5, and 35% of students rated it 5.

3.The Google Classroom platform

For the 5 features, teachers mostly answered that the interface and ease of loading are good and about 50% that it is very good. All five criteria are in the satisfactory area (approx. 25%).

4.Adservio platform

Regarding the five characteristics, the majority of teachers answered that the interface and ease of loading are good, and only about 20% that it is very good

In the case of students, the five characteristics are in the good-very good area.

As a general grade, 53% of teacher users gave the platform a grade of 4 and 61% of students graded it with a grade of 5.

Comparative study of Moodle, 24Edu, Google Classroom and Adservio platforms

The results of teacher and student user evaluations obtained from the processing of questionnaires for the four platforms are presented in tables 3.3-3.10 of the thesis

The data obtained from the questionnaires according to tables 3.3-3.10 were processed and a score was calculated for each characteristic in the model as follows

$$scor = \frac{\sum_{i=1}^{5} w_i * n_i}{nr} \quad (1)$$ uhere:

1 = don't know, 2 = unsatisfactory, 3 = satisfactory, 4 = good, 5 = very good;

ni = number of responses for each category

nr = total number of respondents in each category.

Applying formula (1), the results from Tables 3.11 and 3.12 were obtained.

Table 3.2. User scores-Teachers

Scores Teachers	Moodle	24Edu	Classroom	Adservio
Accessibility	3,64	4,12	4,71	4,47
Stability	3,16	3,98	4,29	4,13
Interface	4,26	4,05	4,57	4,33
Feedback	3,56	3,97	4,14	4,33
Ease of work	4	4,16	4,45	4,27
Mark	3,8	4,01	4,45	4,33

Table 3.3 User scores – Students

Scores Students	Moodle	24Edu	Classroom	Adservio
Accessibility	2,52	3,79	3,88	4
Stability	2,8	3,4	2,96	4,04
Interface	3,4	3,72	3,5	4,47
Feedback	3,24	3,7	3,47	4,48
Ease of work	3	3,78	3,6	4,57
Mark	3,4	3,99	3,7	4,52

Fig. 3.3 and 3.4 assemble all the criteria for each user category.

It is found that Teacher users rated all features higher compared to students who gave scores below 4 on almost all features except for one platform: Adservio

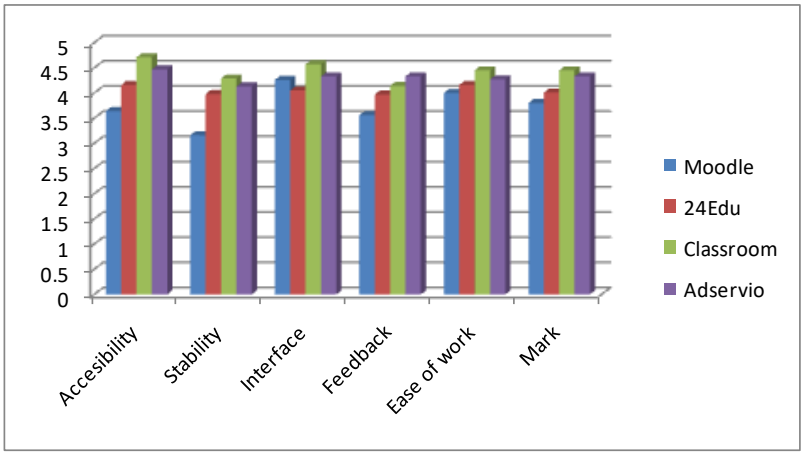

Fig. 3.3. Users Teachers

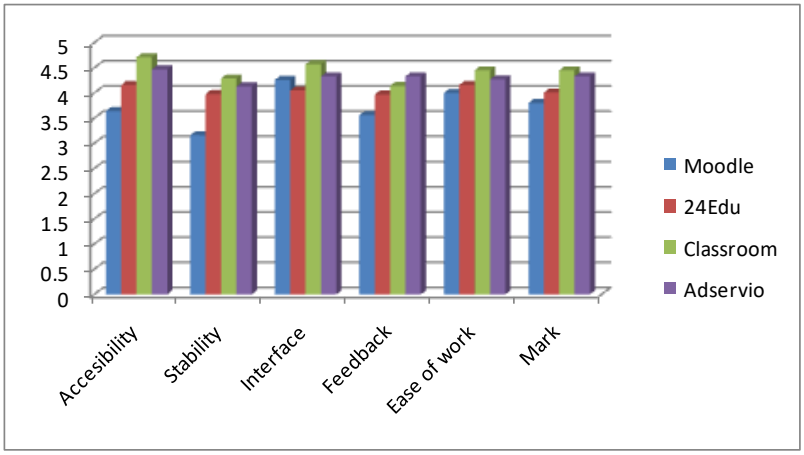

Fig. 3.4. Student user

Correlations

Analyzing the diagrams in Figures 3.3 and 3.4, it can be seen that there is a relationship between the sizes of the features and the marks given by the users.

However, in order to establish more precisely to what extent each characteristic influences the effectiveness of the platform, we checked whether each of the five characteristics is a determining factor in the grade given to each individual platform.

The results obtained are presented in Tables 3.13-3.15

Moodle Platform – Correlations

The data, samples and groups constituted for the statistical analysis are presented in tables 3.15-3.18.

Since the coefficient of determination is 1.337>0.5, the feature Accessibility is a determining factor in Notes.

The coefficient of determination is 1.458>0.5, so the feature Interface is the determining factor in Notes.

The coefficient of determination is 1.224>0.5=> The Feedback feature is determining in Notes.

Adservio platform

Similarly, the coefficients of determination were calculated for all the characteristics in the model and for each individual platform.

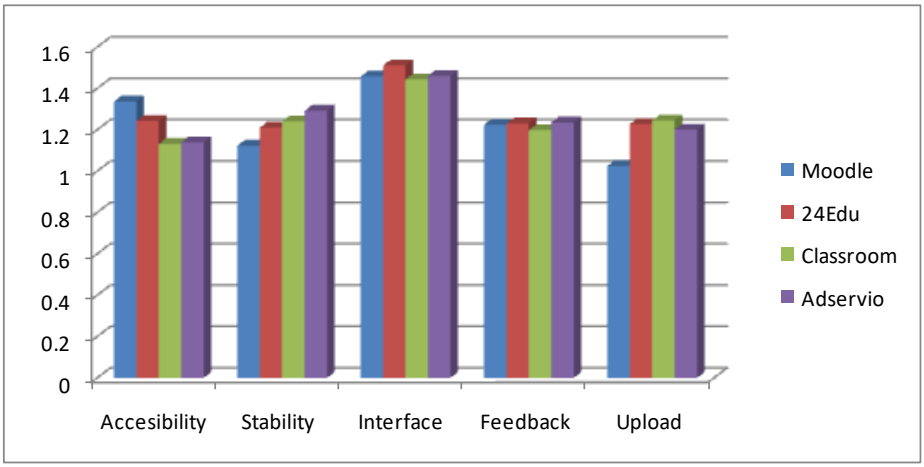

Fig. 3.5 Coefficients of the determining factors for the 4 platforms

It was found that all the values of the coefficients are greater than 0.5, so it can be stated that all the quality characteristics in the model positively or negatively influence the grade given by the users of the platform, a grade that can be a measure of learning effectiveness.

The conclusions of the study

It can be stated that both working hypotheses from the study model were confirmed as follows

- Hypothesis 1- All five characteristics have a positive influence on the quality of the platforms;
- Hypothesis 2 - The quality of the platform influences both positively and negatively the effectiveness, see the score given by each individual user

The study demonstrates that the effectiveness of the e-learning system cannot be achieved without a high level of system quality to attract students to use the system.

Also, the quality of the system is the main factor that increases or decreases the effectiveness of the e-learning system, and therefore the developers of the e-learning systems should consider the dimensions of the system quality

3.4. Studying correlations between features using Overview Mathlab

In order to have as complete a picture as possible regarding the IT quality characteristics of the studied platforms, the correlations between the studied characteristics and the final grade given by the two categories of users (students and teachers) on the one hand, and the correlations between all pairs of characteristics were calculated . The obtained results are summarized in tables 3.24-3.31 in fulltext of the thesis.

3.5. The conclusions of the study regarding statistical processing with Overview Mathlab

From the analysis of the tables that calculate the statistical correlation (between the quality characteristics and the final grade given by the users of the platforms) and the p-value, the following conclusions result:

The 24 Edu platform

Between the characteristics of Stability, User-Friendly Interface, Feedback and Ease of Upload there is a highly significant statistical relationship with the overall grade ($p< 0.001$, Confidence S = 99.9%) in both student and teacher users. On the other hand, Accessibility has no statistically significant relationship with the overall grade ($p>0.05$) for both teachers and students

Regarding the correlation between the characteristics, all the characteristics are statistically correlated with each other with a confidence level of 99.9% ($p< 0.001$), both in students and teachers. Stability correlates very well with the interface but less so with the overall score.

If we analyze the correlation values on various criteria, we find the following:

students vs. teachers: the general perception is quite close (approx. 4) with a greater variation of values for students than for teachers (0.98 compared to 0.78). From the answers of the students, it is not possible to draw a clear conclusion which characteristic is more relevant (the correlation values are quite small, the order of the first 3 being A, U and I, while for teachers the first 3 are all A U and I) and they have clear correlations with the overall grade , these seem more important to teachers, and S correlates well with I but less so with overall grade, so does F with U but less with overall grade

Adservio platform

In the case of students Accessibility, Stability, Interface, Feedback and Ease of work have a statistically significant relationship with the overall grade ($p< 0.05$) and therefore 95% confidence. For teachers, Accessibility, Interface, Feedback and Ease of Work have a statistically significant relationship with the overall grade ($p< 0.05$) but not with Stability!

Analyzing the correlation on various criteria in the case of this platform, the general perception students vs. teachers is close (approx. 3) with an almost equal variance between students and teachers (0.65 vs. 0.6). From the students' answers, the most relevant characteristics are: Stability and Ease of work correlated with overall grade (0.77 and 0.72

respectively.) while for teachers first place is User-friendly interface followed by Accessibility and then Ease of work. So Ease of work is well correlated with overall grade both in the case of students and teachers.

As for the pairs of characteristics, they are weakly correlated in all cases among students, with one exception, namely Interface-Ease of work (0.73). In teachers, the pairs of correlated characteristics are S-I (0.82), F-U (0.81), S-U (0.77) and I-F (0.7). The other paired characteristics are weakly correlated

The Google Classroom platform

- In teachers, Accessibility, Stability and Ease of work have a highly significant statistical relationship with the overall grade ($p< 0.001$) and therefore 99.9% confidence. Interface and Feedback have statistically significant correlation with overall grade ($p< 0.05$), 95% confidence. In the case of students, all characteristics are statistically highly correlated with the overall grade (($p< 0.001$, confidence = 99.9%). Based on the correlation values, the following conclusions can be drawn:

- students vs. teachers: the general perception is that all characteristic values are not correlated with the overall grade with only one exception in the case of students regarding Accessibility (0.7). In the case of pairs, the same situation is repeated, i.e. the correlations on pairs of characteristics are very small, hence the conclusion that the Google Classroom platform is not well liked by users

The Moodle platform

On this platform, the results show that in both categories of users (teachers and students) all the characteristics are not correlated with the overall grade ($p>0.05$), perhaps also because it is little used in pre-university education and the number of respondents was small

Comparatively, the general perception of students is better than that of teacher values of correlations of characteristics vs. general grade are higher than in the case of teachers.

And in the case of feature pairs the results are similar.

It can be said that the Moodle platform is not well appreciated in the pre-university environment.

Conclusions

The 24Edu platform

The 24 Edu platform is a complex platform with a large number of users and is continuously being improved. Connecting teachers to the platform is done on the web. A contract is concluded for the use of the 24 Edu platform, thus ensuring the number of licenses that corresponds to the number of teachers in the school unit.

The 24 Edu application can also be used on mobile (Android), connecting to the platform being very difficult (space, phone model, internet, etc.).

Adservio platform

To use this platform, the school concludes a payment contract that includes: database backup, maintenance, etc.

To connect to these platforms, teachers use the web.

It is a platform with quite a large number of users nationwide

The Google Classroom platform

The Classroom platform is a free, closed platform. There is no maintenance, back-up, etc. User login to this platform is done on the web. It is a closed platform. Schools use this platform because there are no usage costs.

The Moodle platform

The Moodle platform is little used in pre-university education. It is an open-source platform that needs many improvements to meet the needs of pre-university education. Users of this platform use the web part.

The user fee has been waived for using this platform. The rating and reports for this platform are very low

The maintenance part is not provided and an improvement of the platform is expected, hence the very low number of users.

In addition, it is found that the platforms used in pre-university education in Romania can be divided into two categories, namely:

1. Platforms used on a small scale (Adservio, Moodle);
2. Widely used platforms (24Edu, Google Classroom).

In the case of platforms used on a small scale, Adserio is better rated than Moodle by both students and teachers, but students rate Adservio more than teachers, and teachers rate Moodle more than students.

For widely used platforms (24Edu, Google Classroom) - Google Classroom is well appreciated by teachers but less so by students, and 24Edu is similarly appreciated by both categories of users.

It can be concluded that these platforms were developed with more attention for one of the target groups (Adservio for students, Moodle and Google Classroom for teachers) only at 24Edu the attention was equally distributed between the two target groups (students and teachers

Chapter 4. Aspects regarding e-learning systems for pre-university education

4.1. Types of C.A.E (Computer Assisted Education) systems for pre-university education

Computer-assisted education systems have, along with the hardware components that are substantial, software modules that coordinate them and give them the character of an educational system. Precisely because we are referring to an educational system, even if it is a software system, we cannot fail to consider pedagogical aspects in its analysis.

From a didactic-pedagogical point of view, assisted education systems [1] fall into the following categories: 1. Tutorials; 2. Exercises/practical work; 3. Virtual experiments; 4. Verification tests

4.2. Educational software

Educational software [94] represents an IT product, designed specifically for solving didactic or educational problems, by capitalizing on technologies that ensure:

1. Data Retention; 2. File management; Simulation of learning; 4. Assessment of learning; 5. Control of education.

At the level of didactic activities, the hierarchization of teaching-learning-evaluation actions is allowed, which involves dividing the pedagogical content of the training.

The software structure of an e-learning platform

The development of mobile computing system devices and the organization of the educational process allowed the definition of new actors derived from the trainer category, who were added as participants in the study programs.

The main participants in the e-learning process are the administrator, the teacher and the students.

- The administrator – has the role of permanently assisting the students in using the e-learning platform, guiding them towards the directions and capabilities offered by the study programs;

- The teacher - has the role and the right to create training materials, to import them on the platform, to plan the activity of the course (online or offline) that must be completed by the student in a period of time in order to complete the course by groups of students training participants;

- Students – the direct beneficiaries of the platform's services, are the ones who provide information on the quality of the course and the degree of coverage of their needs through procedures and services.

The main categories of information and procedures in a platform are: resources, beneficiary data, calendar of activities, data on the quality of the educational process and procedures

4.3. Unitary design of subject content on an e-learning platform for pre-university education

4.3.1. Training streams

In parallel with the actual design of the software, we believe that the design of the content of the lessons should be done, of lesson patterns that all teacher users can then apply.

Obviously, there will be several types of patterns suitable for exact, socio-human, vocational, etc. disciplines. For this, training flows and/or Bloom's taxonomy as presented in the thesis can be used

There is no definition of the training flow in specialized publications until now.

There is only the flow of the training process as part of the management of a course (ISO 9001:2018 training process diagram).

Learning streams "can be described as a series of tasks that result in a specific part of the broad learning process." [67].

Analogous to learning flows, we will introduce the notion of training flow, which we will describe below.

In the case of our system, the user is the specialist teacher, and the training flows will allow a unitary approach to lesson design for all subjects and teachers. Based on them, the lesson templates and then the evaluations will be designed.

An instruction flow diagram (Fig.4.1), inspired by the functional model graphics from the OMT (object modelling technique) methodology, will contain processes, knowledge flows, information, actors and information storage structures.

The training processes will be:

1. To present the content of a lesson (new information);
2. To exemplify;
3. Learning and problem solving;
4. Evaluation.

In the diagram, the process is represented by a blue ellipse.

Knowledge and information flows were represented by arrows.

Actors (teachers, students) are generators/consumers of information and are represented by a rectangle.

Storage structures are represented by a rectangle with rounded corners

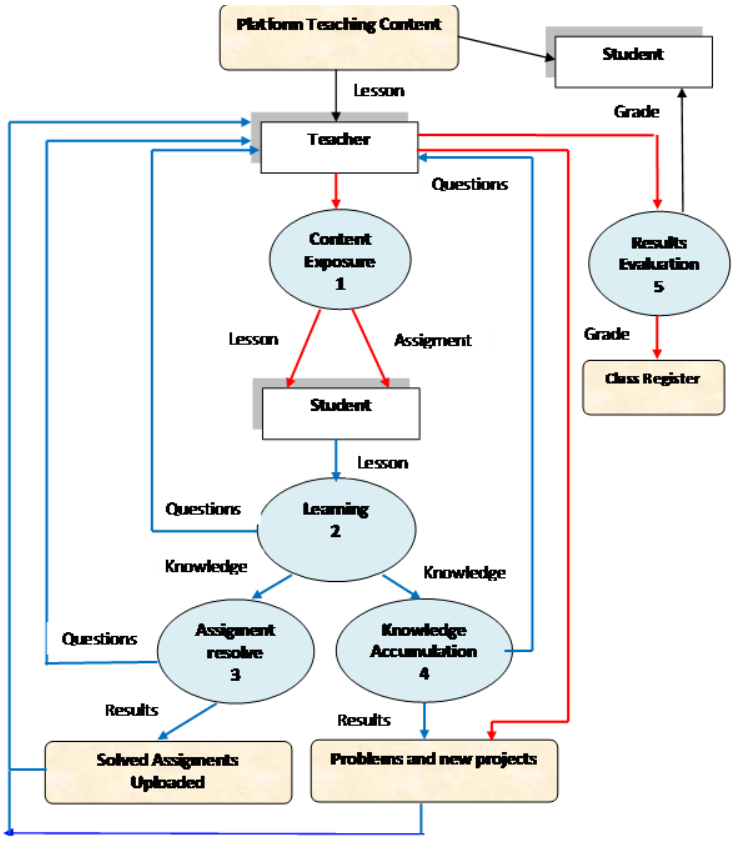

Fig. 4.1. Training flow diagram

Legend : → Teacher
→ Student
→ Results

As can be seen from fig. 4.1. the instructional flow goes through all the stages of a lesson, namely: exposition (teaching the lesson), assimilation of knowledge by students, solving the proposed tasks and then evaluating the assimilated knowledge, carried out by the teacher.

In all these stages there can be teacher-student interactions.

The instructional flow can be used for each type of lesson and for any discipline thus ensuring a unitary design of student instruction

4.3.2. Prototyping lessons based on Bloom's taxonomy

The American psychologist Benjamin Bloom created in 1956, together with the collaborators of Max Englehart, Edward Furst, Walter Hill and David Krathwohl, an architecture for the classification of educational goals, namely the "Taxonomy of educational goals". This has been applied by generations of teachers and is known as Bloom's Taxonomy [5].

In a study published in 2016 by researchers A. Eșanu and C. Hatu from the Educational Evaluation and Analysis Center in Romania, the three models of competences that must be taken into account when creating school programs are highlighted.

These are: Bloom's Taxonomy, Webb's Depth of Knowledge and the Hess Matrix.

We applied the six levels of Bloom's taxometry, their definition and behavior for the ICT discipline (Information and Communication Technology) 9th grade technological high school.

The application of Bloom's taxonomy for the ICT discipline - 9th grade for the six levels (Remembering, Understanding, Applying, Analyzing, Evaluating and Creating) can be found in the doctoral thesis

Using this taxonomy, a uniform pattern can be designed for all lessons on an e-learning platform, from most subjects of a year of study in pre-university education.

4.3.3. Network learning

An e-learning system can be defined in the following programming state.

This status is based on the priority for entering the availability level. In this state, each user can use network documents according to their activity level. Users who are active can take more documents for their educational goals than inactive users. The growth rate of this network depends on user activity. We can define a pre-growth rate (PGR) for these e-learning networks as

$$PGR = KnT \qquad (2)$$

where K is a coefficient showing the activity rate in the time period T.

Educational feedback in this state is a value based on user activity. We may tag users based on their activity. The level of uploading/downloading of documents by users can be defined by the growth rate.

This method can encourage all users to use educational documents faster. This is one of the best ways to apply the "quick learning" methodology. We can also control the availability level of users by measuring their growth rate

4.4. Conclusions

As a conclusion of what e-learning is we can say that it represents activities of storage, design, query, use of electronic documents composed of video, audio, image or text presentations. In the virtual classroom, students communicate in real time, regardless of where they are located

Designing teaching content and lessons using instructional flows and Bloom's taxonomy can lead to a unified development of teaching material for all teachers, from all disciplines, users of the same platform.

As we have already stated, online education has many advantages over traditional education, but we can say that e-learning methods are not always the most effective. It is obvious that the number of users of web resources is on the rise and with it the quality of education can also increase.

E-learning is gaining ground in front of the traditional one and students almost associate the Internet with a real teacher. The educational environment must be modern, in which the information is as attractive as possible, well done, interesting, interactive and well supported. By

using the presented hardware and software architectures, any computer system is scalable and any other software component can be added to the system

Referring to the 2020 experience of the COVID-19 pandemic, when the entire Romanian education was online, it must be emphasized that the main gaps and at the same time difficulties encountered by students and teachers were primarily related to the online teaching and examination methodology, the lack of of experience and knowledge of the vast majority of teachers in organizing and designing online lessons.

That is why there is a need for a unified methodology, at least at the level of a platform, for designing lessons and why not, for the collaboration of teachers who teach the same discipline in order to develop the most appropriate didactic materials to be put on the platform.

Chapter 5. Designing e-learning systems for pre-university education

5.1. Model design software

The software model for such a system is called the Client /Server model. This is a solution where presentation, presentation logic, application logic, data manipulation, and data tiers are distributed between client computers and one or more servers. In the Client/Server model there are two other types of models known as Distributed Data (also called Two-Tier Architecture) and Multi-Tier Distributed Architecture – Data and Application (called Three Tier Architecture Design or n-Tier Architecture Design).

The most widely used methodology for developing new instructional systems is called InstructionalSystems Design (ISD). It is also known as Instructional Systems Design and Development (ISDD), Systems Approach to Training (SAT) or just Instructional Design (ID).

One of the most used design models is the ADDIE model

5.2. MySchool software system

5.2.1. MySchool App Requirements

The MySchool application that we propose can be connected to the Moodle platform through APIs and will have access to the platform's database. The user (student) will be able to download it on their mobile device

The functional requirements of the system are as follows:

- To allow users to navigate through the application using tabs and screens;
- On each tab, allow logging in, registering a new account or recovering the password by email in case of no connection;
- To be able to share the application with friends by means of messages posted on the Facebook and Twitter networks, but also by email;
- To be able to download teaching materials (video and text);
- Be notified (SMS or WhatsApp) when the teacher posts something.
- Data security.
- Data confidentiality.

Non-functional requirements may be more critical than functional requirements. If they are not met, the system may no longer be useful for the purpose for which it was developed.

- The performance of an application is reflected by the user's requirements. The proposed system will be quite fast for an application intended for mobile phones, with a short response time, which is why users will have a positive reaction in this regard. Problems can only occur in the case of a bad internet connection, which can slow down the loading of data from the server. A standard Internet connection allows the entire application to run interactively, without waiting problems to irritate the user.
- Storage space requirements. The system will have an acceptable size for an average phone from the range of those using the Android operating system, falling under the size of 1Mb, so it will not create problems occupying the phone's internal space. However, if the device will have an external storage space,the user will be given the option to choose this one for app storage, thus also getting rid of the small inconvenience related to the size of the app.
- Reliability. Reliability is the probability that a software system will function without errors for a specified period of time, in a given environment. In the present case the application will be relatively simple, tested in detail.
- Scalability. Scalability is the property of a system to successfully support its development as an application or increase in the number of users. The present application is organized by modules, which is why it can be scaled very easily by adding new modules and linking to existing ones.
- Usability. Usability is the ease with which a user can use the application. Even though it is a subjective measure that depends on the type of user, the present application can be used very easily by anyone who can use a mobile device. It will have a very interactive interface and a

division into tabs with names suggestive of each one's functionality, which is why the present application can be categorized as an application with a high degree of usability.

- Robustness. Robustness is represented by the probability of data corruption upon failure, as well as the restart time after the occurrence of failure. In the girl's case, in the worst case, when an error occurs, the application will throw an unhandled exception that will require its forced closing, but upon restarting, which will be done immediately, everything will work within normal parameters. So robustness can also be seen as a feature of the present application.
- The cost. Cost is the price paid for the system compared to the cost of other similar systems.
- Simultaneous access is measured in the maximum number of users that can be connected simultaneously without affecting the correct operation of the system.
- The response time represents the time between the formulation of a request and system response.
- Easy maintenance. Maintenance activities that can be done at low cost and with minimum of specialized personnel and system interruptions

5.2.2. System architecture.

The proposed MySchool system is organized according to the Client-Server model. It is based on the division of tasks between the service provider called the server and the one who requested the services, namely the client. Communication between the two components is usually done via a communication network, but there are cases where this is not necessary, as both the server and the client will be located on the same system.

The client-server architecture uses intelligent terminals in that the processing is divided between the two components, the client and the server.

Thus, the mobile device client that has the Android operating system installed will connect to the server via the HTTP protocol. On the server side, PHP scripts will be used that will make the connection with the MySQL database, and will query one table at a time.

The system has two major components namely: one is the platform and the other is the Android mobile component.

An application will run on the server through which the user authenticated as a teacher will be able to add, modify or delete lessons, exercises, proposed problems, tests. It will also manage the students of its classes. In the case of a website, the system architecture could be that of figure 5.1

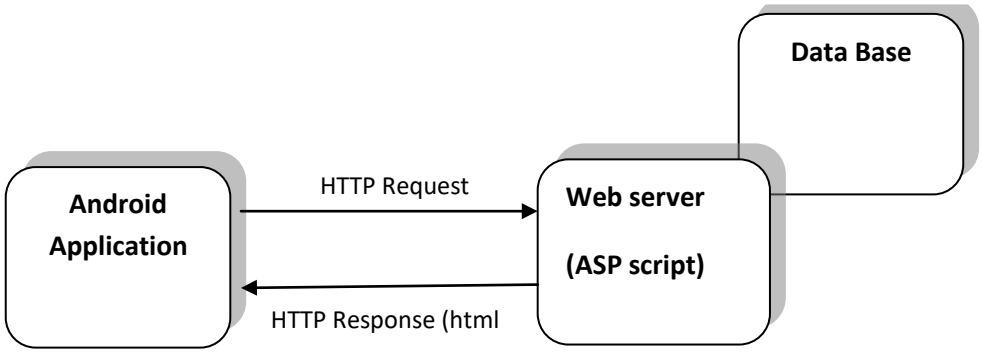

Fig.5.1. Website architecture in the MySchool system

5.3. Design pattern for the MySchool system

The system propose has 2 major components. One of them is the one developed on the mobile device with Android operating system, and the other on the server.

Thus the client (the mobile device that has the Android operating system installed) will connect to the server via the HTTP protocol. On the server side, PHP scripts will be used that will connect to the MySQL database, query one table at a time, and the obtained result will be encoded in the JSON language, which will finally be decoded by the client and be used further

As can be seen, the user acts on the client side. The operation of a request in which content from the database is needed will be processed as follows:

- on the Client side, the process will be initialized by an event triggered on the user interface side. It will be processed by the respective screen manager, after which a request will be sent to a binding class with certain parameters.

- This will make an HTTP POST or HTTP GET request requesting information from the server.

- on the Server side, there will be a PHP script that manages the request and queries the database, returning a result that it encrypts in JSON format and uploads to a web page. From here the result can be retrieved and returned to the client who manages and uses it.

The function will be used by the model to extract and update the data, after which the new information will be sent to the view, which will then display it via predefined objects.

The classes that deal with authentication and posting messages on online social networks, namely Twitter and Facebook, can also be included in the controller part.

The model represents the logical part of the application, the hard-programming. He is responsible for actions and operations on data, user authentication, integration of various classes that allow processing information from the database.

In the case of the present application, in this component the classes for object modeling will be defined, namely Course, CoursesList, Location, LocationsList, User, UsersList, CourseContent

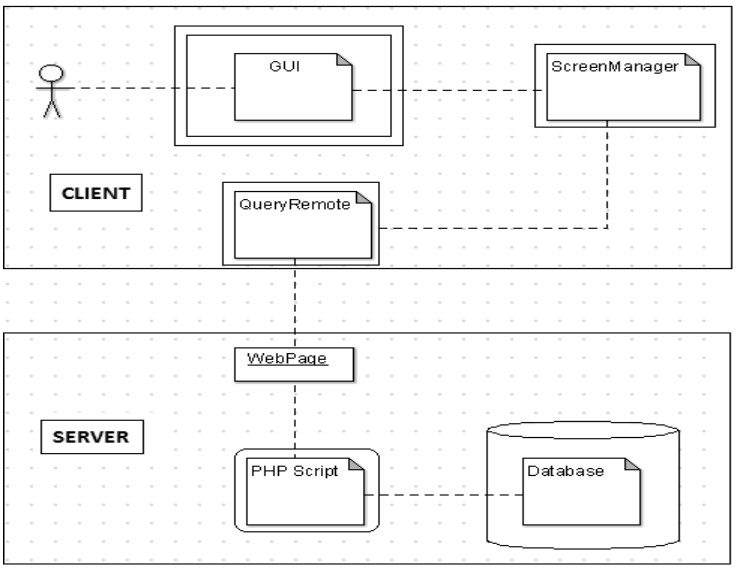

Fig. 5.2. MySchool Client-server system architecture

The View displays the data, basically this part of the program deals with viewing the information processed by the controller. As the functions are executed by the model, the view is given the results, and it will redraw them in the application.

5.3.1. The modular conceptual solution of the MySchool system

The proposed system will be organized on three access levels and will have 4 modules as shown in fig. 5.3:

Level 0

It will contain only the Main Module – Authentication, which will allow the student access to the system.

Level 1

It will have two modules: the Student Module and the Lesson Module. The Student module will manage each student through the Android application that they will download on their phone. It will also allow access to any lesson from the subjects taught in his class, interact with the teacher and be able to access the discussion forum.

Level 2

It will only contain the Forum Module. The Forum module will have attributes according to its name and will be accessible to all users.

The software solution described above represents version 0 (a prototype) and does not claim to be definitive, it may undergo changes and adaptations when it is implemented and tested.

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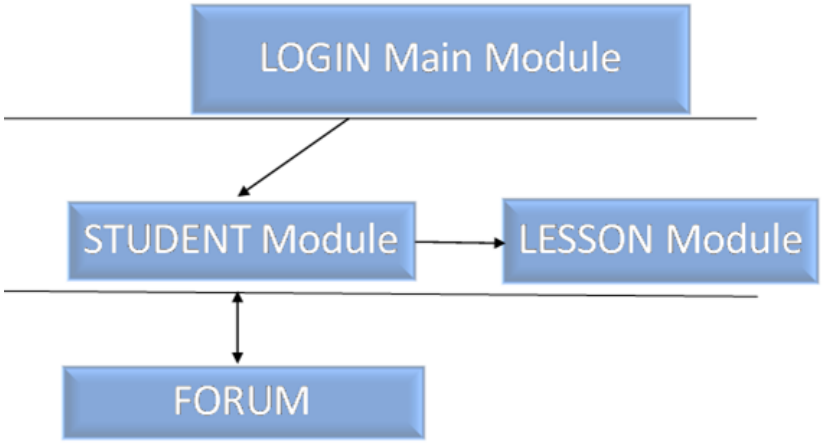

Fig. 5.3. The modular conceptual architecture of the MySchool system

UML diagrams will be created for the design of the MySchool system. Diagram of use cases for student user login to the MySchool system.

5.4. Conclusions

The m-learning technology requires a distance education system, which should include an access to training materials and services from various mobile devices, as well as the availability of web-access. The objective is to create flexible teaching solutions that will allow access to information with all kinds of devices, as well as to produce flexible material in a variety of situations. Mobile technology is just the beginning to take the first steps in teaching and learning

The present chapter contains the main directions and objectives that were pursued in the research. The aspects that in one way or another contribute to the achievement of the objective proposed for the doctoral thesis have been highlighted.

The m-learning technology vis-a-vis e-learning and the particularities of mobile learning systems are presented. The advantages and disadvantages of such systems (contributions) were identified

The paragraph "Proposed software system" mostly contains own contributions as follows:

- The proposed software solution;
- General architecture of the system;
- The conceptual modular architecture of the MySchool system;

All this represents an approach and a conception of its own and is not similar to other systems of this kind studied.

CHAPTER 6. Conclusions - Contributions - Future directions

6.1. Conclusions

In computer-assisted training, interactivity is generalized and provides the learner with permanent feedback, thanks to the visible and immediate effects produced on the computer screen

This involves a monitoring of the student supervised and guided by the teacher, who helps him in carrying out technical and documentation operations and in identifying the links between information, which will lead him to new knowledge

As a conclusion of what multimedia is we can say that it requires activities of storage, design, query, use of electronic documents composed of video, audio, image or text presentations. In the virtual classroom, students communicate in real time, regardless of where they are located

Although online education has many advantages over traditional education, it can be said that e-learning methods are not always the most effective. Unfortunately, this came true with the outbreak of the COVID19 pandemic and the transition of education in Romania from November 2020 to February 2021, exclusively online.

1. In the present work in **chapter 1**, entitled "**E-learning systems. Current status.”** we presented the architecture of e-learning systems, highlighting the main characteristics of e-learning platforms. we also dealt with the taxonomy of e-learning platforms and the current status of the three types of e-learning systems CMS, LMS and LCMS, highlighting comparatively the main characteristics of LMS and LCMS platforms (table 1.1)

2. Chapter 2, entitled "E-learning platforms used in pre-university education in Romania" presents the most used platforms in pre-university education, namely: Moodle, AeL, eȘcoala, INSAM, Google Clasroom, ASQ, 24Edu and Adservio.

We also analyzed comparatively according to the following criteria: evaluation, resource planning, creativity, practical activities, access to the database, upgrade, feedback, lessons implemented, security, statistics and SWOT analysis, the platforms: Moodle, AeL, eScoala, INSAM, ASQ, 24Edu, Google Classroom, Adservio.

Chapter 3 entitled "Analysis and evaluation of the quality of educational software for pre-university education", represents 90% of the author's personal contributions. Some criteria have been established for choosing an educational software with examples for Computer Science Lessons (Table 3.1).

Some evaluation criteria of an e-learning software were also established in order to choose the best solution for a school unit.

In this chapter we studied the quality of the e-learning platforms Moodle, 24Edu, Google Classroom and Adservio.

To evaluate the quality of the four platforms, we designed and implemented an analysis-contribution model. The study was carried out on the basis of a survey carried out through a questionnaire addressed to the users, teachers and students. The questionnaires, answers and graphs can be found in the full version of the thesis.

We made the feature correlations using Overview Mathlab for the 4 platforms.

4. In **chapter 4** entitled **"Aspects regarding e-learning systems for pre-university education"** the types of CAE are analyzed (Computer Assisted Education) systems from the content point of view and presented the fundamental structure of a tutorial and the structure of a practical exercise. We also structured the tests and student assessment tools and introduced the notion of instructional flow that can be applied in prototyping lessons (fig. 4.1). We also proposed a prototype also for the design lessons but based on Bloom's taxonomy and we applied it for the 9th grade ICT discipline. We have designed networked learning that can be used in the design of an e-learning system.

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In **chapter 5** entitled **"Design of e-learning systems for pre-university education"** it deals with considerations and principles regarding the design of e-learning systems and mostly represents the author's contributions.

We analyzed and compared with each other, from the point of view of design and software features, five of the e-learning platforms in the country. We found, not only on these platforms, that the classical design principles of software systems in general are followed and respected. They are not innovations in terms of design, but only the addition of new functions, facilities and/or ways of presenting didactic materials.

With this statement, it should obviously be taken into account that certain technical details of the projects are not made public! We also found that, among the five platforms (Google Classroom, ASQ, 24Edu, Moodle and Adservio), the ones that best correspond to the requirements of the pre-university educational system are: 24Edu and Adservio. They are complex platforms with all the elements necessary to carry out the educational process for both teachers, students and parents. Technical support is provided permanently.

In paragraph 5.1 we analyzed a design software model (ADDIE) and rapid prototyping in order to apply this model to the system we proposed to design and which we named **MySchool.** This will be a mobile learning system coupled with an e-learning platform. We established the android application requirements, system architecture, conceptual solution, UML diagram of use cases for the MySchool system (contributions).

6.2. Contributions

Chapter 1

- Comparative study of LMS and LCMS platforms (table 1.1).

Chapter 2

- Comparative analysis according to various technical criteria of the platforms: Moodle, AeL, eScoala, ASQ, INSAM, 24 Edu, Google Classroom, Adservio;
- Comparative analysis of the AeL, eSchoola, INSAM, ASQ, Moodle, 24 Edu, Google Classroom, Adservio platforms according to 6 criteria;
- SWOT analysis for data security;

Chapter 3

- Criteria for choosing an educational software with examples for IT Lessons (Table 3.1);
- Development of a quality assessment model for e-learning platforms;
- Development of a questionnaire to evaluate the quality of the studied platforms (Moodle, 24Edu, Google Classroom and Adservio);
- Processing the obtained data, interpreting the results (40 graphs) and validating the quality assessment model.
- Correlations between features using Overview Mathlab for the 4 platforms

Chapter 4

- The fundamental structure of a tutorial;
- The structure of a practical exercise;
- Structure of a test and student assessment tools;
- Introducing the notion of training flow and developing the training flow diagram (figure 4.1);
- Creating the prototype for lessons based on Bloom's Taxonomy;
- Designing networked learning.

Chapter 5

- Software design model;
- Android application design – MySchool

6.3. Future research directions

In conclusion, it can be stated that the analysis and design of an e-learning system must take into account all quality characteristics if the system is to be used efficiently in the educational process. Moreover, there is a need for standardized models for evaluating the quality of e-learning systems, and in this regard a consensus of specialists has not been reached.

The realization and optimization of assessment and quality assurance models in the current context of the COVID19 pandemic, which has practically generalized online education, involves several clear directions, namely:

- Establishing metrics for quality criteria, which reflect the impact of new technologies and devices used in e-learning and m-learning;
- Developing/updating e-learning and m-learning standards;
- Introducing new occupational standards in e-learning and m-learning to cover the necessary expertise in the context of e-learning and m-learning trends from the year 2022

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