Designing M-Learning Applications for Collaborative Virtual Environments

Cristian Ciurea and Paul Pocatilu

Abstract **—** In this paper are presented specific quality characteristics of m-learning applications designed for assisting the collaborative learning process inside virtual environments. There are analyzed the features of virtual organizations and their collaborative character is presented. The advantages of virtual organizations are revealed compared with the classical organizations. Specific features of m-learning applications that run on smart-phones are described and also the advantages of integration with social network platforms are presented. The paper describes the m-learning applications and the mobile learning processes inside a virtual campus. Also the paper presents an existing mobile learning application, still under development. Metrics are built in order to evaluate the performance of mobile learning processes in collaborative virtual organizations.

Keywords **—** Mobile Learning, Virtual Organization, Collaborative, Application, Virtual Campus, Social Network.

I. Introduction

The virtual organization represents a collaborative system where components have more capabilities and more power than individually. The working context of virtual organization is built on four elements, namely connectivity, purpose, technology and separation.

The virtual organizations are collaborative systems used in economy, in which people share resources and develop complementary activities in different locations, in order to achieve a common goal.

There are many implementations of collaborative systems in the economy, in different areas of interest and in both environments: real and virtual.

In the real environment, there are many types of collaborative systems, the most important being the collaborative educational systems, collaborative banking systems and collaborative systems in production.

In the virtual environment, the collaborative systems implemented are represented by the virtual campus, the virtual bank, the virtual enterprise for software development and the virtual enterprise for production processes [15].

It is considered that the virtual organization has also the interdependence characteristic in addition to flexibility, in the sense of cooperation between departments and authorized individuals within one single organization.

The characteristic of virtual organizations is that they have many virtual offices in different locations from the world. Their employees must relocate from an office to another, in order to fulfill the organization needs. In order to access resources from different locations, they are using mobile applications.

The mobile technologies and applications offer a lot of new opportunities for virtual organizations, they also presenting development and implementation challenges [1].

The market of mobile application is searching for solutions to empower mobile devices with web services integration while minimizing the existing performance issues [2].

The paper is structured as follows [13]:

Collaborative Virtual Organization section presents the characteristics of virtual organizations that that run in a collaborative way.

In *M-Learning Applications* section are presented the main characteristics of mobile learning applications and theirs role in virtual organizations.

In the section *Designing M-Learning Applications for Smartphones*, specific features of m-learning applications that run on smart-phones are described and also the advantages of integration with social network platforms are presented. Also, an existing mobile learning application developed within the Bucharest University of Economic Studies is presented.

The development and implementation of m-learning applications are analyzed in *Development of Mobile Learning Applications for the Virtual Campus*.

The section *Using M-Learning Applications in the University Virtual Campus* presents an m-learning solution adapted for a university.

The last section, *Metrics for Evaluation of Mobile Learning Processes in Collaborative Virtual Organizations*, analyze several metrics built in order to measure the performance of m-learning processes.

The paper ends with *Conclusions and Future Work*.

II. Collaborative Virtual Organizations

In [16] is considered that the use of virtual environments is

Manuscript received December 17, 2011.

This work was supported by CNCSIS –UEFISCSU, project number PNII – IDEI 2637/2008, project title: *Project management methodologies for the development of mobile applications in the educational system*. A preliminary draft was presented at The Applied Computing Conference 2011 (ACC '11), Angers, France.

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growing every day in different activity fields, such as: entertainment, e-education, professional training, health, robotics and others. The great advantage of virtual environments is that these environments make users feel like they inhabit inside them.

The virtual organization features that distinguish it from the classical organization are:

- semi-permanent structural units, geographically dispersed;
- performance level based on a common understanding of the business;
- continuous adjustment of organizational forms;
- intensive use of information technologies;
- information flows and allocation of resources in real time.

Figure 1 shows the position of virtual and classical organizations in space-time coordinates [3].

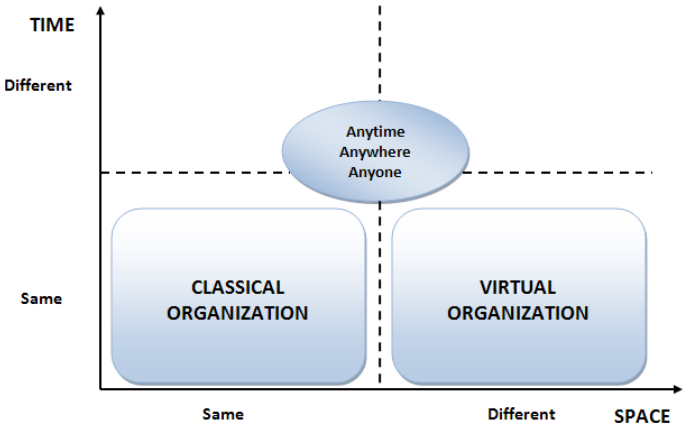

Fig. 1. The classical and virtual organization in space-time coordinates

In a classical organization, the activities are conducted in real time and from the same physical locations. In the case of virtual organizations, cooperation takes place in real time, but in different locations, which allow analyzing virtual organizations systems in terms of collaborative systems.

The anytime, anywhere and anyone characteristics are placed at the intersection between classical and virtual organization, on the space axis. These characteristics are valid both for virtual and classical organizations, but is very difficult to be placed in the middle of space and time axis to achieve them.

In the case of a virtual enterprise for software development, the virtual organization requires a very good coordination between its members, being oriented towards teamwork. The work from different locations and the lack of physical interaction between employees are compensated by the appropriate tasks sharing by managers, so that each employee knows exactly what to do.

The virtual enterprise for software development enables better risk management and effective cost control, compared to the traditional enterprise. The software products supplied are checked in terms of the insertion of open source code.

If the virtual organization is represented by an enterprise for goods production, unlike the traditional enterprise the virtual enterprise enables lower production costs, reduces production cycles and requires very large databases containing different types of resources and raw materials.

The objective of virtual enterprise for goods production is to maximize the profit obtained by automating production processes and reducing costs with personnel and locations.

If the organization is represented by a university, then the comparison between classical education and online education reveal that the assimilation of knowledge is made more efficient in the case of online education, due to the process of collaborative learning within the teams.

III. M-Learning Applications

In the last years, all classical learning techniques were revised and new other techniques were introduced. The e-learning and m-learning applications were the revolutionary new ways through which the students got the necessary needed knowledge and skills [4].

The development of m-learning applications is different by the one of a normal application, because m-learning applications are designed starting from the mobile devices on which are used.

M-learning applications are designed to be used on mobile devices in order to provide anytime and anywhere access to educational content. This is done in a virtual environment when is difficult to train the employees or the students face to face in a classical systems.

M-learning applications are integrated in a mobile learning system to assure an efficient functionality. A mobile learning system consists at least of the three components:

- Mobile devices;
- Mobile learning software;
- Mobile learning content.

Figure 2 depicts the interactions among these components.

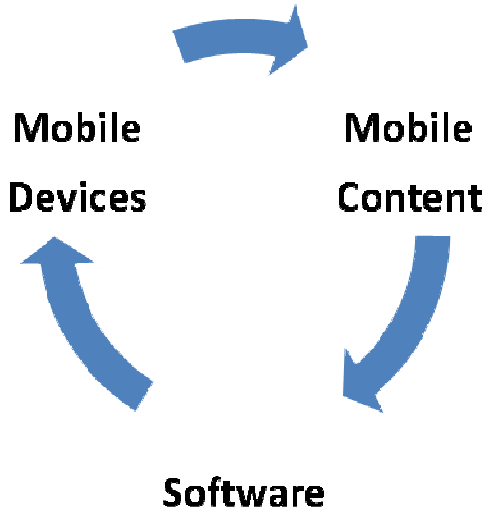

Fig. 2. Mobile learning system components

Mobile devices could be mobile phones, PDAs, tablets. Their size, input capabilities, display capabilities vary, and that is a major issue in developing m-learning applications.

Also, there are several mobile operating systems and platforms upon the m-learning software can be developed.

The software required for mobile learning process could be a simple mobile Web browser or a dedicated application, that can be standalone or a client application in a distributed environment.

The mobile learning content is accessed from mobile device storage or from a server, depending on the architecture of the m-learning system. In either way, the mobile learning content has to be compatible with the mobile device capabilities, keeping in mind its limitations.

A complex m-learning application includes the following modules:

- Courses
- Tests and quizzes
- Homework and Projects
- Marks
- Personal profile administration
- Payments
- History
- Communication and feedback

Every implementation depends on the organization needs.

An important process during the development of mobile learning applications is the quality assurance. Beside this, the analysis of existing m-learning applications has to take place, as is stated in [5].

In any virtual organization that uses m-learning systems, there are four types of users: learners, trainers, content providers and administrators. The roles can overlap (the trainer could be also the content provider and/or administrator etc.). The users interact in this collaborative environment using the mobile learning system infrastructure, Figure 3.

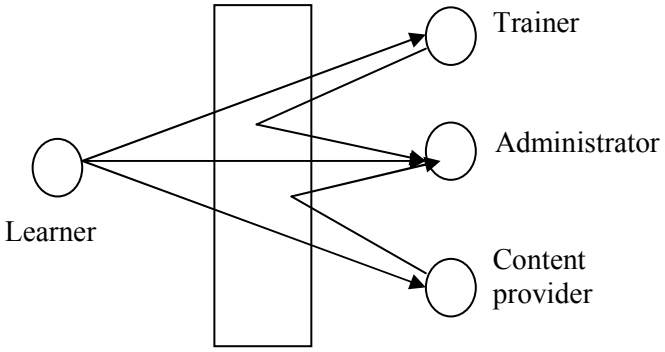

Fig. 3. Interactions between users

The learners interact very often with the trainers (feedback, answers, questions etc.), rarely with administrator and could provide some feedback to content providers.

Content providers interact often with the administrator for educational content. These interactions take place in a collaborative manner in this virtual environment due to the m-learning system capabilities.

Collaborative virtual environments have the great potential to enable innovative and effective distance learning techniques, involving for example debate, simulation, discussion groups, and project-based group work. The emphasis can be placed on the human-human interactions as common understandings are negotiated and developed across differences of knowledge, skills and attitudes [6].

IV. Designing M-Learning Applications for Smartphones

As smartphones become very popular through mobile devices and many users prefer the touch-screen interface, the mobile applications must be developed according to users' preferences. For a multiple choice test integrated in a mobile application running on a smart-phone with touch screen, the answers must be placed on the screen so that the user to correct selects the right answer.

Another characteristic of m-learning applications designed for smartphones is the degree of integration with other applications, especial with social network applications. The m-learning application can be developed to automatically collect personal information of students from Facebook and other social platforms. This feature is useful when creating the user accounts for students in the m-learning application, because students will have the possibility to automatically connect with their Facebook accounts.

In Figure 4 is presented the example of an m-learning application integrated with Facebook and Twitter.

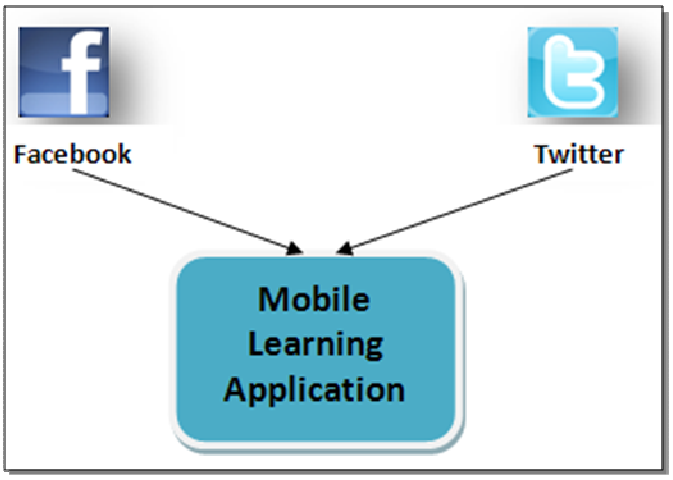

Fig. 4. M-learning application integrated with Facebook and Twitter

Another important feature, offered this time by Twitter, is given by the possibility to post questions or give answers to different problems using directly the "tweet" option offered by this social network application. Some big smart-phones producers, like Apple, have integrated Twitter directly in the operating system, so that users can "tweet" using the menu options of their smart-phones.

Excepting the facilities offered by these social network applications in order to use the same credentials for authentication in the m-learning application, the most important feature is represented by collaboration. The student can collaborate with his friends from Facebook when learning or solving a problem, so that the collaborative learning concept to be successfully implemented also in a mobile

learning environment.

The Figure 5 below shows the interface of Moodle platform used at Bucharest University of Economic Studies, where students and teachers can access to their courses and learning content on a variety of mobile devices, such as iPhone, iPad or BlackBerry.

Fig. 5. Moodle platform accessed on an iPhone browser

Taking into consideration that the m-learning application is used on a smart-phone, it can use the software and hardware facilities offered by this device. The m-learning application can identify the student location using the GPS or can collect student photos using the phone camera. This information will be useful for teachers and application administrators to know more details about their students/users in order to adapt the learning content according to students' preferences.

In [17] is considered that the integration of learning platforms with different software is not without problems, particularly since two more or less independent systems can be used to provide learning material and to grade students work. But, only this variety of possibilities provides a good opportunity to make exactly that kind of information available to the learning person, which best fits to his or her learning type.

Another important aspect that must be considered when designing an m-learning application is given by the people with disabilities, for which partnership is vital to the development of ability training for students with disabilities. For this reason, partners, such as college, universities, and organizations, must work together to offer ability training for students with disabilities [19].

In house solutions are also developed. For example, in [20] is presented a mobile learning distributed application for Android devices developed within a research project in Bucharest University of Economic Studies. The interface is in Romanian language, and future developments will include multiple languages as the strings as stored as text resources and they are not hard-coded.

The application is based on Web services, the available tests, questions and answers are sent over the network using Web service's methods.

The interface is simple and intuitive, without any graphics and drawings. That reduces the amount of memory required by the application and reduces the time of development. Current implementation focuses on testing. The first screen from testing module shows a list of available tests. When the current user selects a test from the list, the screen associated to the first question will be shown. That is illustrated in Figure 6.

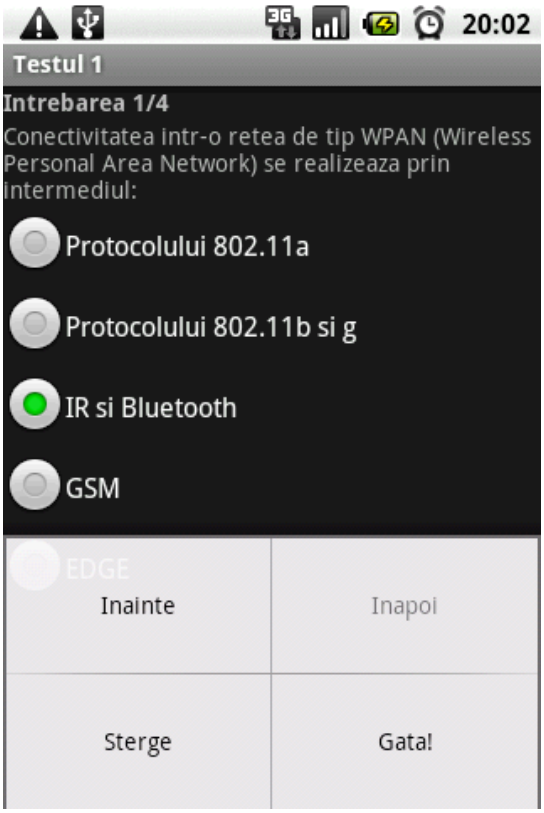

Fig. 6. Question screen as shown on a real device

The questions have only one correct answer. The student can navigate sequentially from one question to another. At the end, the student can review the answers and send them to the server in order to monitor the progress. Figure 7 depicts the answers screen where the students can review the questions and check the correct answers.

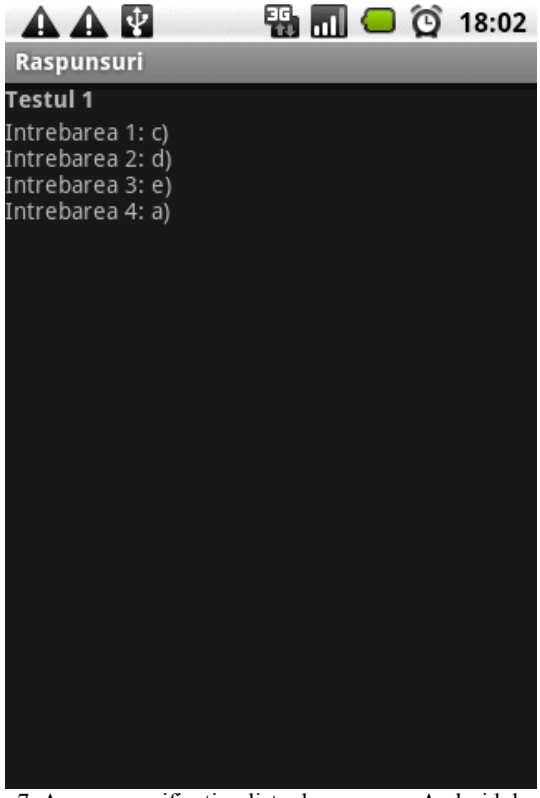

Fig. 7. Answers verification lists shown on an Android device

The student has the possibility to review the answers and to calculate her or his score.

The application is still under development, working on content presentation and content management on the server side.

V. Development of Mobile Learning Applications for the Virtual Campus

The virtual campus is the virtual organization designed for the development of online educational processes at all training levels.

The evolution of knowledge-based society involves the development of virtual campus through a collaborative learning environment. Collaboration is an important dimension when it comes to sharing and integrating the experiences and training courses of different groups of learners. Supervisors, teachers, and learners from the virtual campus play different roles in the learning process. They need to work in the same environment, collaboratively instead of individually, to perform an adaptive learning strategy [7].

The applications from the virtual campus of a university are divided into modules, subsystems and applications covering the full range of university teaching and non teaching activities.

Developing m-learning applications is the situation where software developers and teachers come in contact. Solid mobile development is required in order to obtain high quality software in this specific environment [8].

The development of mobile learning applications is different by the development of the normal e-learning applications, because mobile applications are designed starting from the mobile devices on which they are used.

In [9] is considered that the development of mobile learning applications can be simplified by appealing to the open-source market, where can find some solutions for sustaining on-demand collaboration anytime and anywhere.

The first page of the MLE Moodle platform, seen from the Opera Mini browser, is available in Figure 8.

Fig. 8. MLE Moodle platform

Even if specialists consider that Moodle platform is still under construction and never had a real course to demonstrate its feasibility, many universities use it in different bachelor and master programs, because it is free and open-source and offer the advantage to be customized.

In the case of e-learning platforms which are adapted for mobile access, special views must be created in order to be supported by a mobile internet browser.

In the virtual campus must be taken into consideration the rigorous elements related to schedule and calendar, especially those periods in which each resource is available. A course is posted on the platform in a certain period of time. Before and after this period, the course is not available. Also, uploading homework and projects can be done by students until a certain date and time. The projects uploaded onto the platform after the closing date and time are not evaluated [14].

The applications used in the virtual campus are very different and aims to extend online secretarial services, with the possibility of filling in forms and request directly from the personal page, but also setting up online payment opportunity of university fees.

In a virtual campus, the use of mobile learning can develop

higher level thinking skills, social interaction skills, and responsibility for each other and even promote higher achievement [10].

Interaction between learners is very important for mobile learning, and learners need to do real work together in which they promote each other's success by sharing resources, discussing, helping, and congratulating each other's efforts to achieve [11].

VI. Using M-Learning Applications in the University Virtual Campus

The virtual campus of Bucharest University of Economic Studies contains three departments:

- the Public Relations and Online Education Service;
- the Internet Service and Digital Library;
- the TV Studio Service.

Each service is managed by a chief of service, which is subordinated to the department manager. The virtual campus department ensures the development of virtual education services and research.

The structure of an m-learning testing application from the virtual campus, used for the evaluation of students' knowledge, is shown in the Figure 9.

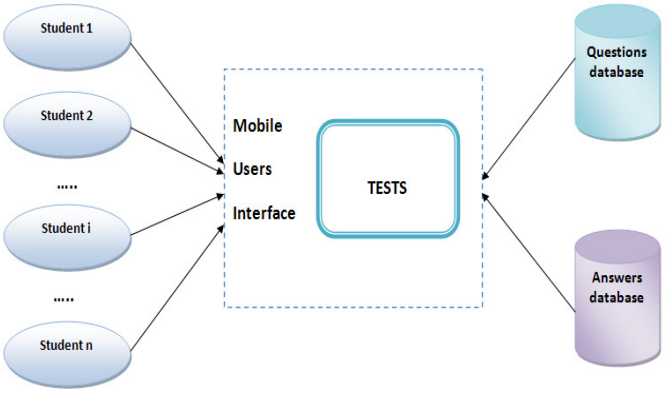

Fig. 9. The structure of the m-learning testing application

Every test contains many questions. For any question in the test, there are many possible answers, like a), b), c), d) or e). If the tests are right formulated, the results of the students evaluation have a normal distribution: 15% results are between 9 points and 10 points, 15% are between 3 and 4, and 70% results are between 5 and 9.

In this case, for a question in the test, the followings situations are possible:

- all the students have submitted the answer a) and the correct answer was b); the conclusion is that the question was very difficult;
- all the students have submitted the answer b) and the correct answer is b); in this situation, the question was very simple.

The databases of tests are different for each lesson or course, the total number of tests available in the virtual campus being integrated in a virtual database. In Figure 10, the virtual database of tests is presented.

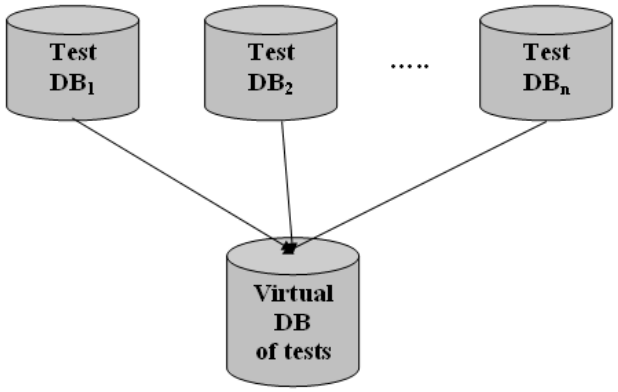

Fig. 10. The virtual database of tests

When estimating the volume of the virtual database of tests, it is necessary to consider as more elements so that whatever changes will occur to the virtual database, its structure remains stable.

An m-learning testing application has a database that stores information about user behavior: when they enter in the application, the options that they access, when they exit. The application contains a number of counters for the information analysis on user behavior. The values are *0* for all counters when a user enters into the application. As the user accesses certain features of the application, the counters associated with these options are activated and takes the value *1*. Introduction of these counters is to develop an automatic restructuring of the application, according to the most frequently options accessed by users [12].

VII. Metrics for Evaluation of Mobile Learning Processes in Collaborative Virtual Organizations

In order to measure the performance level of mobile learning processes in a virtual campus, it is considered a students collectivity that participate to a test in an m-learning testing application.

For the questions from the test taken into consideration, the *performance level* of one student, *PL*, is calculated as follows:

$$PL = \frac{\sum_{i=1}^{n} p_i}{n},$$

where:

- p_i – the points received by the student if he give the correct answer to the i question ($p_i = 10$ if the student responded correctly and $p_i = 0$ if the student has given an incorrect answer);
- n – the number of questions from the test.

Another indicator is the *degree of successful responses* that is computed using the following metric:

$$DR = \frac{N_S}{N_T} = 1 - \frac{N_U}{N_T}$$

where:

- N_S – number of successful responses
- N_U – number of unsuccessful responses
- N_T – total number of responses.

Depending on the students' training, the number of successful responses can vary.

In the case of a virtual enterprise, the *degree of satisfaction of the employer* can be computed as:

$$DS = \frac{\sum_{i=1}^{R_T} DSR_i}{R_T}$$

where:

- DSR – the degree of satisfaction for the employee i
- R_T – total number of trained employees using mobile learning

The degree of satisfaction for an employer in a virtual organization is a value from 0 (no satisfaction) to 1 (fully satisfied).

Work productivity of trained employee based on inputs is given by:

$$W = \frac{\sum_{i=1}^{n} O_i}{\sum_{j=1}^{m} Ij}$$

where:

- O_i – the output *i* (deliverables, results)
- I_j – the input *j* (manpower, resources per time unit)
- n – the number of outputs
- m – the number of inputs

The performance of mobile learning processes can be also evaluated by applying other formulas and indicators, depending by the process or person that is evaluated.

In [18] is considered that an educational system which can be configured and accessed by both partners, meaning the educational system and the business environment, can provide a real time communication channel that can maintain the link between them and adjust partially the difference between demand and offer in terms of qualified workforce.

VIII. Conclusions and Future Work

The collaborative virtual organizations refer to an effective collaborative system in which people and applications cooperate in order to achieve certain objectives. The situations of Human-Human Interaction and Human-Computer Interaction are much encountered in this case.

Mobile applications fit very well in a collaborative environment specific to virtual organizations.

The mobile learning applications provide the great advantage that can be accessed from anywhere and anytime to achieve educational activities.

In the case of m-learning application designed for collaborative virtual organizations, new educational standards are needed to evaluate and increase the performance of the educational process.

We must take into consideration that education should not be treated only as an opportunity for the society development, because a better education is an opportunity for personal development of students. The knowledge-based society should not focus only on the high level of education, but also on high technology research.

Future work includes the development and implementation of the presented mobile learning application in the virtual campus of Bucharest University of Economic Studies in order to diversify the learning techniques and facilitate the achievement of educational process performance.

A special attention will be given to the marketing of mobile technologies in education, having in mind that not all trainers and learners are aware of its potential.

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