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## **Blended learning of physics in the context of the professional development of teachers**

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Lyubov Alekseevna Krasnova and  
Viktor Yurjevich Shurygin\*

Elabuga Institute,  
Kazan Federal University (Volga Region),  
423600, Elabuga, Kazan Street, 89,  
Republic of Tatarstan, Russia  
Email: l.krasn@mail.ru  
Email: viktor\_shurygin@mail.ru  
Email: shuryginviktor@yahoo.com  
\*Corresponding author

**Abstract:** This paper introduces the refresher courses designed for the physics teachers. These courses are based on the blended learning technology combining traditional full-time education with the elements of distance learning supported by LMS Moodle. The courses were tested at the Elabuga Institute of Kazan Federal University in 2016–2018. This paper describes the module-based course structure and methods for applying the e-learning modules. The distinctive feature of the course is that the content of the learning modules was designed to deliver different methods for teaching physics and to improve the general cultural competence of a teacher. The analysis of polling results (poll included 89 physics teachers) allowed assessing the efficiency of designed courses in the context of teacher's professional development, his/her readiness to work in modern learning environment. The research outcomes will be also useful for foreign educational establishments implementing the teacher professional development programs.

**Keywords:** learning technologies; distance learning; e-learning; LMS Moodle; physics.

**Reference** to this paper should be made as follows: Krasnova, L.A. and Shurygin, V.Y. (2020) 'Blended learning of physics in the context of the professional development of teachers', *Int. J. Technology Enhanced Learning*, Vol. 12, No. 1, pp.38–52.

**Biographical notes:** Lyubov Alekseevna Krasnova graduated from the Faculty of Physics and Mathematics of the Yelabuga State Pedagogical Institute with a degree in Physics and Mathematics. From 2006 to present, she works as an Associate Professor of the Department of Physics in Elabuga Institute of Kazan (Volga region) Federal University. Her research interests are improving the efficiency of training physics teachers, forming their professional competence; use of information technologies in teaching. Within the framework of these studies, she has published 49 papers.

Viktor Yurjevich Shurygin graduated from the Faculty of Physics and Mathematics of Yelabuga State Pedagogical Institute with the degree in Physics and Mathematics. From 1990 to present, he works as an Associate Professor at the Department of Physics in Elabuga Institute of Kazan (Volga region) Federal University. His research interests are investigation of the

microscopic structure and dynamics of condensed matter by the methods of statistical physics; electronic and mixed training in physics. He has published almost 100 scientific papers in these fields.

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## **1 Introduction**

Changes that occur in the education system, as well as new modifications made on the back of these changes, are a good reason for identifying new approaches and teaching modes in order to prepare the teachers for solving a variety of arising problems (Embacher and Primetshofer, 2008; Kintu et al., 2017). In these circumstances, special attention should be paid to the advanced professional development of teachers (Gomez Zaccarelli et al., 2018). At this point, refresher courses should be based on modern learning technologies. Integrated online (usually distance courses) and traditional learning are one of the models of modern education (Fraser, 2017). This model is known as blended learning (Banados, 2006; Bonk and Graham, 2006).

In truth, there is no generally accepted classification of the specific blended learning models (Burns, 2011; Kintu et al., 2017). The most common are Rotation models (Station Rotation, Lab Rotation, Individual Rotation, Flipped Classroom), Flex model, A La Carte model, Enriched Virtual model.

Despite the differences, all existing models of blended learning lean the following three pillars:

- 1 Traditional direct face-to-face interaction between the participants of the teaching and learning process.
- 2 Technology-mediated interaction.
- 3 Self-teaching.

It is believed that the technology of blended learning combines formal and informal learning, face-to-face and online communication, guided activity and independent selection of a path towards personal goals and objectives (Rosett and Frazee, 2003; Moore, 2012).

Blended learning is about teaching students how to make decisions, how to plan and organise their activities independently, how to handle the online learning platform, and how to search for, select and analyse the information (Moore et al., 2011).

The e-learning component of blended learning can be put into practice by all manner of tools (Gonen and Basaran, 2008; Linn, 2013; Bowen et al., 2014), including the social network, for example – the Facebook (Meishar-Tal et al., 2012; Jones and Bogle, 2017). In most cases, however, teachers tend to apply various learning management systems (LMSs). These systems are a complex of web-based software and hardware tools, teaching methods and technical measures (Naveh et al., 2010). Currently, there are lots of such systems in the world, for example – the BlackBoard, WebCT, Top-Class, Claroline, ILIAS, Desire2Learn, Moodle, etc. (Green et al., 2012). They allow teachers to create interactive e-learning courses that contain all the necessary teaching and support aids, and tests (Almarabeh, 2014). The availability of such courses provides an opportunity to take a blended learning approach effectively, as a combination of traditional and distance e-learning (Cerezo et al., 2016).

Online learning platform, that is known as the Modular Object-Oriented Dynamic Learning Environment (Moodle) is widespread in Russia, as well as in many other countries.

LMS Moodle has been effectively used in education for more than ten years (Melton, 2006; Cole and Foster, 2007). Both universities (Costa et al., 2012; Escobar-Rodriguez and Monge-Lozano, 2012) and schools handle the platform and benefit from it (Psycharis et al., 2013). This system has become widespread over the years, in particular, in the field of teaching physics at various levels of education (Benito et al., 2007; Martin-Blas and Serrano-Fernandez, 2009; Ekici et al., 2012; Bednarova and Merickova, 2012; Basitere and Ivala, 2017).

Distance learning becomes more popular from day to day, significantly expanding the learning space (Beese, 2014; Baytiyeh, 2017) and allowing students to delve into university programs on a deeper level (Aktaruzzaman and Plunkett, 2016). Computer-based technologies allow participants in the learning process to exchange information at any distance (So and Brush, 2008). Besides, such a learning mode has a number of advantages over traditional one, as it provides students the opportunity to learn at their own pace and within their own space (Thoms and Eryilmaz, 2014).

Enhancing distance learning is a problem nowadays because teachers are not ready for such an experience, they lack IT competence and necessary skills to use computer-based online learning systems (Badia et al., 2014; Leontyeva, 2018). In current settings, success of distance learning is tied to how teachers view the process. Some often question the effectiveness of online education because of time factors and technical issues (Anderson and Dron, 2011; Hung, 2016). We believe that adding some of the elements of distance learning into refresher courses for teachers will raise their trust with the said mode and give a boost to their IT competence development.

## **2 Aim**

Currently, it is beyond argument that various types of e-learning are good when it comes to education quality improvement (Nguyen, 2015; Krasnova and Shurygin, 2017; Sheshasaayee and Bee, 2018). However, we believe that this problem is little studied in the context of refresher courses design for teachers. In particular, issues related to the optimal structure and content of e-courses, as well as to the course-specific methods of their application, remain relevant and open. At the same time, creating a comfortable e-learning environment for any course as a communication system with high degree of interactivity is a significant and important issue within the concept of blended learning.

Thus, the purpose of this paper is to study how the features of blended learning application through a LMS Moodle can be put to design refresher courses for the physics teachers.

## **3 Method**

### *3.1 Participants*

The efficiency of blended refresher courses, designed for the physics teachers, was studied at the Eelabuga Institute of the Kazan Federal University in 2016–2017 and in 2017–2018.

The advanced course syllabus was designed for teachers leading physics courses under the programs for secondary general education.

The total number of course participants was 89 (28% – male participants, 62% – female participants). All of them were working as schoolteachers of physics. The average age of participants was 36 years.

All participants were informed about the project objectives and content, as well as about all the aspects of the research ethics. Participants gave written permission to use some of their personal data as research material (biographical details, photos).

### 3.2 Design

The modular syllabus of blended refresher courses designed for the physics teachers contains the following blocks: *modern educational standards, psycho-pedagogical basics of professional activity, contextual and procedural aspects of professional activity, and applied aspects of solving recent professional problems.*

These modules contain all necessary learning materials: course syllabus; teacher guides containing subject-specific teaching methodologies, current course guides, labs and tests. There is also an interactive glossary; teaching aids, electronic problem books; lists of recommended literature available in the University library, hyperlinks to electronic sources of information, electronic learning resources of other universities; discussion forums; text and video files containing lectures.

In addition to the on-site lecture module, this course includes a distance e-learning module, designed in LMS Moodle. This system has proved to be quite effective in different countries (Amandu et al., 2013; Benta et al., 2014; Costello, 2013), in particular, when it comes to applying a blended learning approach during physics assignments (Ekici et al., 2012; Drigas and Kontopoulou, 2016; Shurygin and Sabirova, 2017).

The distance learning module has a certain structure, containing an outline and a thematic part. It was designed to achieving a certain outcome while training teachers to work in modern learning environment.

Thus, outline contains introductory videos, schedule, syllabus, short compendium, project topics, general teacher/student guidelines and a glossary. It also contains a list of related topics, a news forum and a discussion forum.

Each thematic part contains the following elements: the necessary theoretical material, hands-on material, various independent assignments, tests, and a list of recommended periodicals, as well as hyperlinks to electronic sources of information.

The courses were tuned with traditional face-to-face modes of teaching and learning. The syllabus of these courses provided for a combination of different types of in-class learning, internships and independent activities. Thus, it implied that participants would bring the acquired experience into the real practice to solve the profession-specific problems.

### 3.3 Research tools

Various monitoring methods can be used in order to assess the quality of training: observation, swot analysis, polling, etc. We applied one of the most effective methods for assessing the quality of training – the polling. This method allows assessing the quality of the learning process, analysing the received results, and drawing the corresponding conclusions.

We applied the process approach to establish certain indicators and quality criteria, design the polling tools and select the proper methods for analysing and presenting the results.

Monitoring indicators: opinions on the quality of the blended learning process, gathered through an opinion poll.

The estimates were analysed by means of a 10-point semantic differential scale, where “0” stands for the low quality and “10” for the high quality.

All indicators (questions) are grouped into four blocks; each thereof contains three indicators (quality criteria).

- Block 1. *Information Content of the Course*: relevance, practical focus and the structure.
- Block 2. *The Quality of E-Learning Resources* integrated in the distance learning platform: ease of understanding, exhaustibility, and ease of use.
- Block 3. *Process Features*: correspondence between the module content and the course purpose, application of active teaching methods, participant involvement in this course.
- Block 4. *The Quality of Online Learning Platform* designed with LMS Moodle: interactivity level, interface user-friendliness, possibility to work with training and test modules.

The poll was conducted after the final paper was defended using the LMS Moodle. The course participants were informed about the confidentiality of diagnostic results before the course. The polling data was processed with IBM SPSS Statistics 22.

## 4 Findings

New potential opportunities for implementing the teacher refresher courses were determined with regard to the concept of blended learning, as such model allows organising the teaching and learning process involving additional learning resources and technologies. Such model is also capable of bringing the learning process to a higher level – it can improve its quality, change the educational content, ensure the introduction of innovative learning technologies into the teaching and learning process.

We designed some refresher courses (108 hours) for the physics teachers with regard to a technology-based blended learning approach integrating the traditional face-to-face modules with the distance learning. They were implemented twice during the 2016–2018.

The main purpose of the course was to upgrade the skills that teachers have for delivering the secondary education physics program on the back of changed requirements for organising the modern learning process and gaining professional competencies in the field of learning process and lesson design using the innovation technologies.

Course objectives: *creating* conditions for improving the professionalism of teachers, their professional competencies in designing, implementing and analysing the professional activity in the context of education modernisation; *showing* to course participants the insights into the methodology, structure, content and methods for organising the modern learning process and designing lessons under new conditions; *teaching* the peculiarities of applying health-saving technologies in the teaching and learning process; *shaping* the teacher’s professional culture in the field of ICT-rich environment.

Course units intended for online attendance were put into practical context by LMS Moodle. Our e-learning course is hosted on the University's e-learning platform and is available at any time.

LMS Moodle-based course communication capabilities enable teachers and supervisors to work with course participants in the best possible conditions. The e-learning platform provides access to student profiles, allows them to handle a set of learning modules under the course program via remote access (taking tests, sending the results to the teacher, listening to webinars, etc.).

The courses were tuned with traditional modes of teaching and learning. It should be noted that all learning materials are available in both Russian and English languages. Students have the opportunity to select the language by clicking the "Change language" icon.

The midpoint and final assessments are specific course units of highest-priority. Different types of assignments and tests are used for knowledge assessment.

LMS Moodle has broad options for test design and application (Shurygin and Krasnova, 2016). The system allows you to create various unique tests: traditional tests (tests with open-ended and closed-ended questions, matching tests, etc.) and more complex ones in structure and content. The latest version of LMS MOODLE allows you to create 32 types of tests.

At the same time, course participants, who took the course on problem-solving methodology for problems of different complexity classes, not only participate in controlled assessment, but also gain experience in designing the assessment tasks. A specific test is randomly generated from the originally designed item bank. The course participants believe that the most interesting and insightful types of tests are the "Calculation", "Embedded answers" and "Essays" types.

Thus, each option of the Calculation Test is generated with new numerical data from the given interval. Thus, even if several examinees receive the same task, it will contain different numerical data.

The Essays Test contains open-answer questions with the answer space is defined by size settings. The question can be represented as a text of a high-quality problem and as any media file, such as video or animated presentation. The answer is checked for correctness and graded manually by the teacher. This type of questions informs about how well the examinees understand the physical phenomenon. Such tasks can be used not only as a means of assessment, but also as a means of in-class consolidation of learnt material. They can be also used to form in course participants some skills of applying the gained knowledge to explain specific physical processes and phenomena.

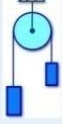
The peculiarity of Embedded Answers Test is that it can include various types of questions, limited only by the originator's imagination (Figure 1). Such system was used when learning the physics problem-solving methods by physics branches and building the related skills.

When it comes to the process of teaching teachers, it is necessary not only to teach them the basics of science and the case-specific teaching methods, but also to foster a common culture within them (McCollough and Ramirez, 2012). The solution of this problem can be boosted by introducing some biographical details into the process that are often left aside during an in class assignment due to the lack of time. Detail on the history of physics was built into the various elements of the online module. We designed a system containing various types of tests with some details on the history of physics included in them to assess the depth of gained knowledge (Figure 2).

Figure 1 Example of the embedded answers test

Question 1  
Not complete  
Marked out of 15.00

Loads with masses 0.3 kg and 0.2 kg are placed on a cord slung over fixed block loads.



(Accept friction in the block as negligible,  $g=10 \text{ m/s}^2$ )

The loads are affected by the following forces:

- Gravity
- Floor reaction force
- The force of friction
- The thread tension force
- The force of inertia

In this problem for the inertial force we can take any reference system rigidly connected with .

Under the influence of such system of forces the loads will move with uniform .

Is the acceleration of goods dependent on their masses? .

The loads acceleration is equal to   $\text{m/s}^2$ .

In 2 seconds each load will pass from the point of standstill a path equal to  m.

What is the force of the thread tension?  N.


What is the force of the thread tension if to hold the smaller load?  N.

What is the force of the thread tension if to hold the bigger load?  N.

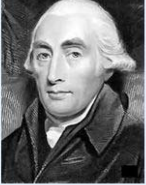
Figure 2 Example of the drag-and-drop matching test

Question 1  
Not complete  
Marked out of 1.00

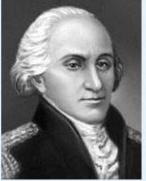
Match the picture of the a scientist and the scheme of his experimental apparatus



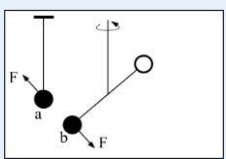
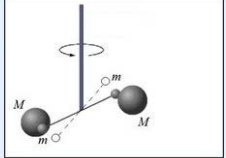
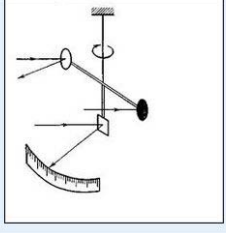
Drag answer here



Drag answer here



Drag answer here

The refresher course culminates with a project defence, which is basically a kind of a discussion platform for the course participants to exchange experience, as well as for innovative ideas and positive attitudes to further teaching activity to spark.

The “poll” and a “questionnaire” are important components of the LMS Moodle when it comes to conducting pedagogical research and analysing learning outcomes.

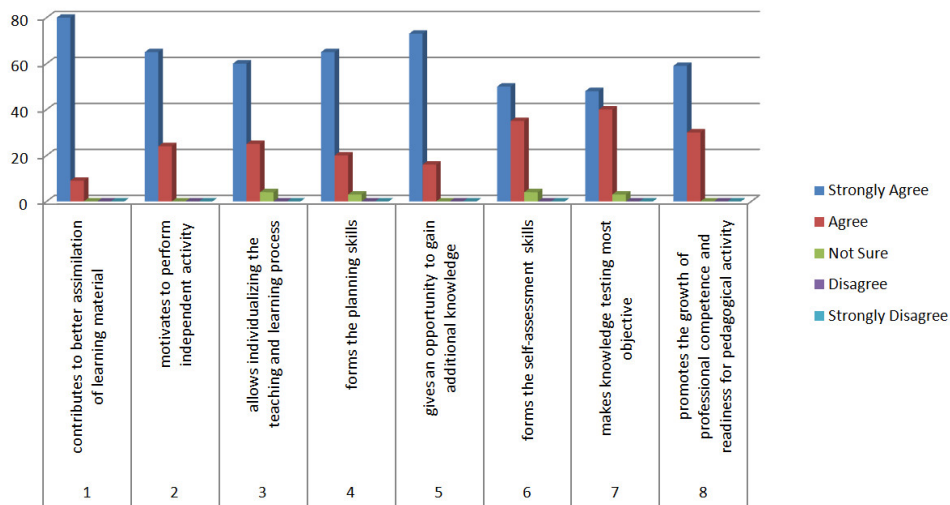
The quality of blended learning was assessed under the process approach (EFQM excellence model). This model implies that the education quality issues are considered against the background of student need satisfaction, while the quality of training is ensured through the process management.

These tools were used to carry out a participant poll at the final stage of training. Its purpose was to find out what opinions the course participants have on the efficiency of blended refresher courses in general, and on the e-learning in particular. In order to get an objective feedback, polling was conducted confidentially when the participants received their certificates.

The polling involved 89 participants.

Polling data were processed with IBM SPSS Statistics 22. The information on questionnaire indicators was collected by calculating moral expectation  $m$  and the standard square deviation  $S$  for each indicator. The results are presented in Figures 3 and 4.

**Figure 3** General polling results



Based on polling results, we can conclude that the quality of blended refresher courses was assessed as high. In particular, course participants enjoyed the e-learning platform, gave credence to the learning materials of the course modules, appreciated their multi-dimensional focus and complementarity, and were pleased with the ease of navigation and compatibility options of the LMS Moodle.

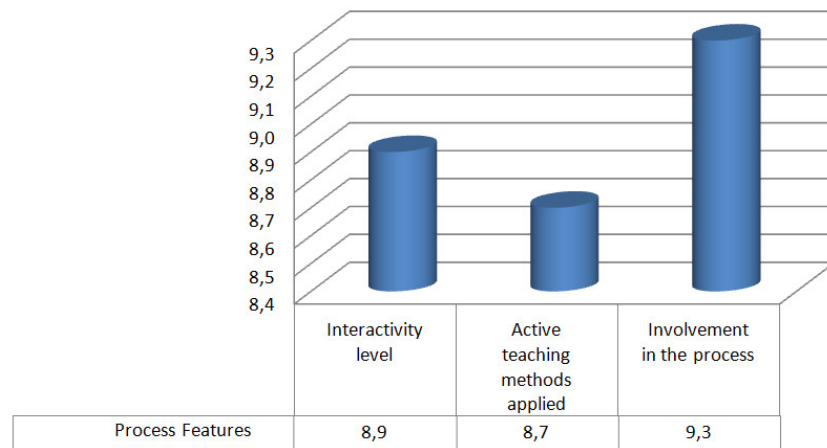
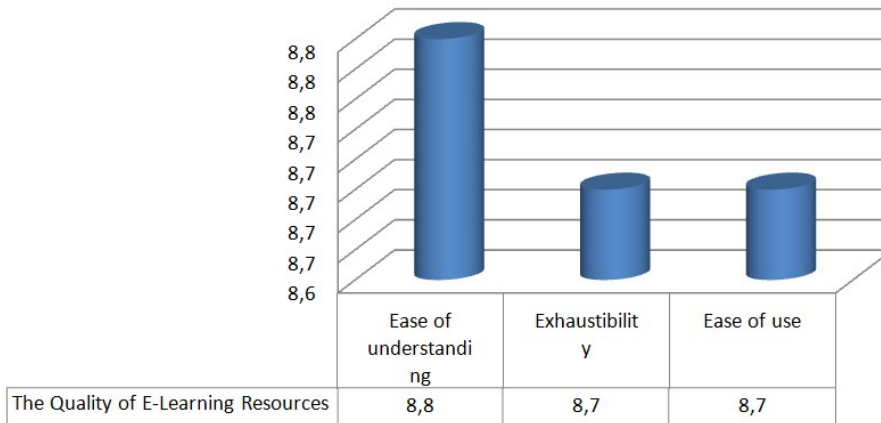
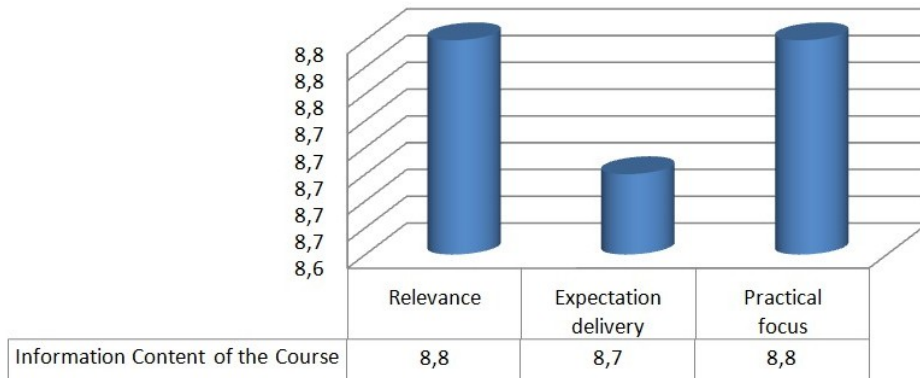
Besides, 79.3% of respondents agreed that the online course contributed to computer competency development.

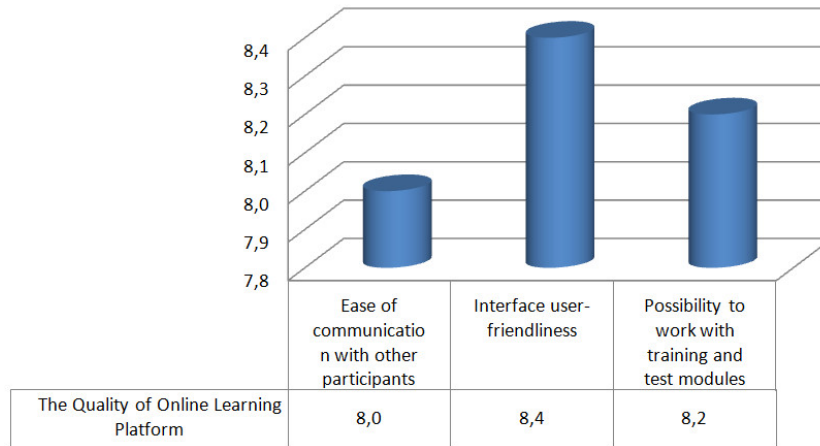
The course participants also pointed to the high professionalism of the teaching staff and supervisors.



Thus, in modern environment, refresher courses are not only an opportunity to improve one’s professional skills and competency, but also an important link between the school and university.

**Figure 4** Polling results obtained with a questionnaire



**Figure 4** Polling results obtained with a questionnaire (continued)

## 5 Discussion

One of the advantages that the e-learning has is its interactivity – means of meaningful teacher-student interaction, performed to create an optimal environment for personality development, are greatly simplified and activated (Bowen et al., 2014; Nguyen, 2015). In this regard, we should point to the special features of social networks, such as Twitter or Facebook (Jones and Bogle, 2017). At the same time, social networks are generally regarded as the dominant platforms for both education and entertainment (Moore et al., 2011). The differences between this approach and the traditional LMS application have already been discussed in Meishar-Tal et al. (2012). This paper outlines the basic requirements for LMS in order to improve its effectiveness in the teaching and learning process. At the same time, tutor guidance issue is at the forefront when the achievement of a certain interactivity level is discussed.

One of the strengths that the LMS Moodle has is the communication opportunity (Essel and Wilson, 2017). The system supports the exchange of files of any format both between the teacher and the student, and between the students. The bulk email service allows anyone to quickly inform all the course participants or individual groups about the current events. The forum provides an opportunity to organise a discussion over the most hard-hitting topics. The chat room allows anyone to organise a discussion in real time.

At this stage, one of the most discussed issues appears to be the Collaborative Case-Based Assessment. Collaboration allows developing both professional and communicative competence in students divided in small groups (Means et al., 2010).

Thus, LMS Moodle has the following features that raise the interest of students in the subject, develop their skills and motivate to independent activity: high level of interactivity, multitude of material presentation, the possibility of modular content structuring and student-centred planning, on-line documentation, comfort and confidentiality (Limongelli et al., 2011). In this regard, a direct relationship is established between the LMS application and learning process efficiency (Mwalumbwe and Mtebe, 2017).

It should also be noted that the course design is adapted to mobile devices. This allows using any modern gadget to handle the course (Titova and Talmo, 2014).

Another important aspect is related to the specific features of physics education, which implies laboratory training and research work. The fact is that there are many experiments that cannot be performed in real laboratories, because they are very dangerous, expensive, complex and time-consuming (Drigas and Kontopoulou, 2016). E-learning opens huge opportunities for the use of various kinds of virtual physics experiments (Grober et al., 2013; Murakami et al., 2017).

The thing is that e-learning (LMS in particular) extends its boundaries beyond the universities to the colleges and schools (Psycharis et al., 2013, Udaya Sri and Vamsi Krishna, 2014). Those, who stand for VR in teaching and learning, prove that virtual environment is an excellent teaching tool (Kapp and O'Driscoll, 2010). At this point, teacher's job is to put virtual technologies in the learning contexts. This imposes high requirements for the IT competence of a modern teacher. It should be noted that we do not have information about any serious researches on this problem in the field of physics education.

Part of our learning modules is focused on the teacher's IT competence development and improvement with regard to modern innovation-driven trends in this field and to the peculiarities of their application in the teaching and learning process.

Some of our results correlate with the observations made with the second-year students at the University of St. Andrews in Scotland. The online course that has been applied when teaching quantum mechanics allowed comparing the experimental and expected data on the back of a rapid data collection, as well as to explain such a difference (Kohnle et al., 2013). Our results are similar to the data obtained by the Technical University of Madrid, where most students had a positive experience of online testing. In addition, blended physics learning improves the learning outcomes significantly (Martin-Blas and Serrano-Fernández, 2009).

The obtained results inspire for further research aimed at improving the online course and methods of its application as part of refresher courses designed for the physics teachers. Further research can be a more detailed insight into the efficiency of some course units tied with the methodology of teaching physics in schools.

## **6 Conclusion**

Thus, this article presents the results from applying the blended refresher courses designed for the physics teachers. The online part of the course is realised through the e-learning modules originally designed with the LMS Moodle platform. A distinctive feature of their content is that it was designed in a way so that physics teachers could improve their competencies in terms of teaching methods, common values and culture. This was achieved, in particular, by including methodological and biographical materials to the course units.

Results display that blended form of education allows building case-specific vectors of training, expanding the range of educational opportunities by making the process more responsive and easy to engage in, and considering educational needs and abilities of participants.

Usable interface of the LMS Moodle platform enables an optimal bridge between knowledge delivery and interactive collaboration so that learning goal and objectives could be achieved, and professional qualities and competences formed.

The analysis of polling results (poll included 89 physics teachers) allows concluding that blended learning has potential in the context of teacher's professional development, his/her readiness to perform professional activities in modern environment. High level of satisfaction with the quality of blended learning and e-learning environment allows us to assume that refresher courses are not only an opportunity for a teacher to improve one's professional skills and competences, but also an essential link between a school and a university.

## 7 Recommendations

The elements of blended learning expand the range of educational opportunities for students, who take these courses. They allow building individual learning paths, promoting the interaction between all the participants and forming the best possible qualities and competencies that a teacher should possess to perform successfully and effectively. It should also be noted that the above-mentioned advantages lay sufficient grounds for the LMS Moodle platform to be applied for this purpose, as the e-learning platform allows improving the IT competencies that are so much required.

In this regard, the outlined experience of holding the blended refresher courses, designed for the physics teachers, integrating traditional face-to-face modules with the distance learning in the LMS Moodle platform can be useful to educational establishments implementing the teacher refresher courses.

Raised issues require further discussion, especially issues like the optimal ratio of full-time (classroom) to online activities, a blended learning model considered suitable for investigating and solving problems in teaching physics and other disciplines, and further improvement of designed courses.

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