Online courses at international and national platforms and the possibility of creating a digital educational environment for megaprojects

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Abstract. Professional training for mega-science projects is a matter of pressing concern. The National Research Nuclear University MEPhI (NRNU MEPhI) created online courses on the topic of Strategic Academic Units (SAU). These courses are published on the most popular international platforms for mass open educational resources: Coursera and edX. NRNU MEPhI online courses are also presented on the National Open Education Platform and the Educational Portal of NRNU MEPhI. NRNU MEPhI students participate in various modern international projects, including megaprojects of the Joint Institute for Nuclear Research (JINR) among which are creation of the NICA collider, experiments on the synthesis of new elements, research in the field of the physics of condensed state of matter and environmental science carried out at a high-resolution neutron source. At the initiative of the JINR University Centre, the JINR Educational Portal was created. It hosts online courses created by JINR scientists on the topic of mega-projects. The report discusses proposals on the possible integration of the efforts of NRNU MEPhI teachers and JINR scientists in creating a digital multidisciplinary educational environment, which will support formation of individual learning trajectories for professionals for their further work in mega-science projects.

1. Introduction

The tasks of developing science in Russia and creating projects of the mega-science class require training a new generation of specialists to conduct research and obtain world-class results from the collider of relativistic nuclei, modern sources of synchrotron radiation and neutrons. Moreover, specialists are needed not only to create and operate these complex research facilities, but also to carry out applied research to use new technological solutions in industry, medicine, ecology and many other areas.

To solve these problems, it is necessary to combine the efforts of various universities and research centers to create new training courses and research workshops. Here, of course, existing methods of modern education will be used. And very important task here is creating a multidisciplinary center using distance and online learning technologies to train personnel for mega-science projects.

The first three online courses on "Introduction to Artificial Intelligence" from Stanford University were published in 2011 and attracted about 160,000 students from 190 countries. A year later, in 2012, two Stanford University professors, Andrew Ng and Daphne Koller, founded Coursera company, which began working with various universities in order to create massive open online courses (MOOCs). In the same year, the Massachusetts Institute of Technology together with Harvard University introduced the edX platform. And in 2013 the open-source platform – Open edX – was published. It became available for use by other educational institutions and private individuals.

In our country the National Open Education Platform (openedu.ru) was created and is being developed. It is an educational platform that offers online courses in basic disciplines studied at Russian universities. The platform was created by the Association "National Platform for Open Education", established by leading Russian universities.

Currently open online courses have shown their effectiveness for additional education in various fields. According to the Class Central resource for 2018, the total number of MOOC students worldwide reached 100 million, and by the end of the year more than 900 universities around the world announced the launch or opening of 11.4 thousands of MOOCs. However, among ready online courses, there are relatively few specialized courses developed by scientists working in modern scientific experiments. Such online courses can contribute, on the one hand, to attract the attention of students to the topics of modern experiments, and, on the other hand, reduce the time for training personnel for these experiments.

## 2. Digital educational environment of the National Research Nuclear University MEPhI

Massive open educational resources, at the moment, are one of the leading directions in modern distance education. The introduction of open educational platforms allows to bring a huge amount of knowledge from universities for a wide audience of students. At the same time, modern information technologies significantly increase the level of visualization of educational information using computer graphics, 2D and 3D models, interactive tables and diagrams, and also include interactive quizzes and checking tasks into educational materials. Therefore, most of the leading universities in the world use these technologies. This allows to increase the degree of university recognition in the world, share achievements in educational technologies with a very wide audience, give access to the courses of outstanding teachers for students from all over the world, and also attract new applicants and graduate students.

Currently, the National Research Nuclear University MEPhI (NRNU MEPhI) has identified several areas for the development of electronic learning resources:

- development of online courses for international MOOC platforms Coursera and edX;
- development of online courses for the National Open Education Platform and Universarium platform;
- development of the Educational Portal of NRNU MEPhI, which includes both open educational resources and distance learning courses for students of NRNU MEPhI, studying both in Moscow and in the branches of the University;
- Cyber Learning Platform for Nuclear Education and Training (IAEA);
- development of joint (network) educational programs;
- development of virtual laboratories;
- development of the Network School of NRNU MEPhI;
- development of the website of NRNU MEPhI International Olympiads for students, graduate students and interns.
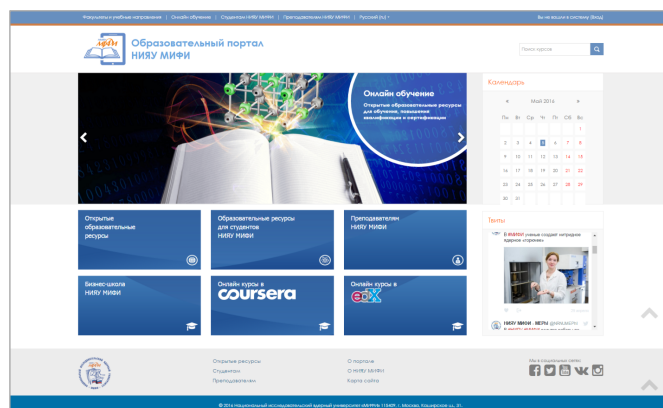
Figure 1. Main page of the Educational Portal of NRNU MEPhI.
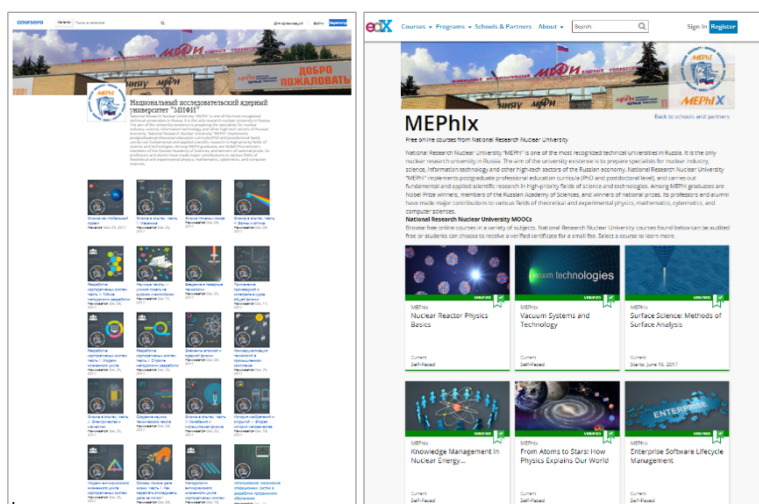
Figure 2. Online courses on Coursera and edX.

Developed electronic educational resources should contribute to the integrated solution of the following tasks:

- increasing the interest of a wide range of students to continue their education and build a career in the field of Physical Science and Physical Engineering;
- increasing the recognition of the University in Russia and at the world level;
- attracting undergraduate and graduate students to study at NRNU MEPhI;
- implementation of the blended learning model both within the university itself and in its branches;
- implementation of online educational programs in collaboration with other universities, research centres and various business partners;
- improving the quality of engineering education through the inclusion of the achievements of modern science and technology in the educational process;
- organization of research work based on real, virtual and online laboratory works using real physical data.

3. Educational Portal of the Joint Institute for Nuclear Research

Modern scientific centers today face a number of educational tasks, which can be greatly solved by online courses and other computer educational tools developed jointly by specialists working in priority research areas and university professors. These tasks include:

- popularization of modern scientific research, achievements in science and technology,
- increasing the attractiveness of scientific and scientific-technical careers for students and graduates,
- attracting young scientists and specialists to participate in specific research projects,
- professional development of school and university teachers,
- possibility to include materials related to modern achievements in science and technology in traditional educational courses.

To solve these problems, the Open Educational Portal has been created and is being developed at the Joint Institute for Nuclear Research in Dubna. It targets students and schoolchildren of the JINR Member States, young specialists and science teachers. The portal hosts courses in the MOOC format on priority JINR activities. The first courses on the topics of the NICA megaproject, on heavy ions and the synthesis of new elements, fundamental and applied research of nanostructures and condensed matter using neutrons have already been created and published. It is planned to create courses on the use of neutrons in ecology and environmental sciences, nuclear planetology, and radiobiology.
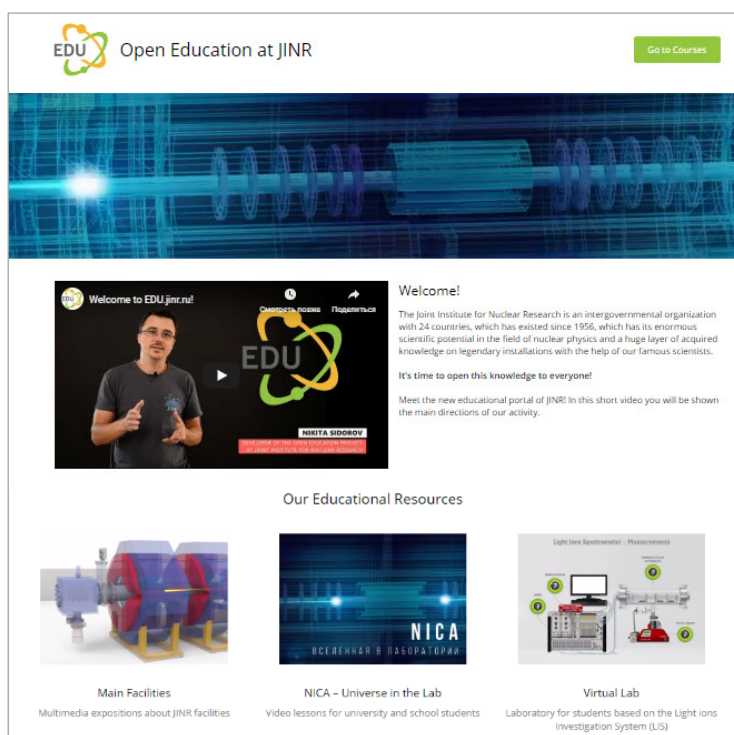
Figure 3. JINR Open Educational Portal.

In addition to online courses, the portal contains links to materials visualizing JINR's basic physical facilities using 3D modeling tools, as well as to the Virtual Laboratory on Experimental Nuclear Physics.
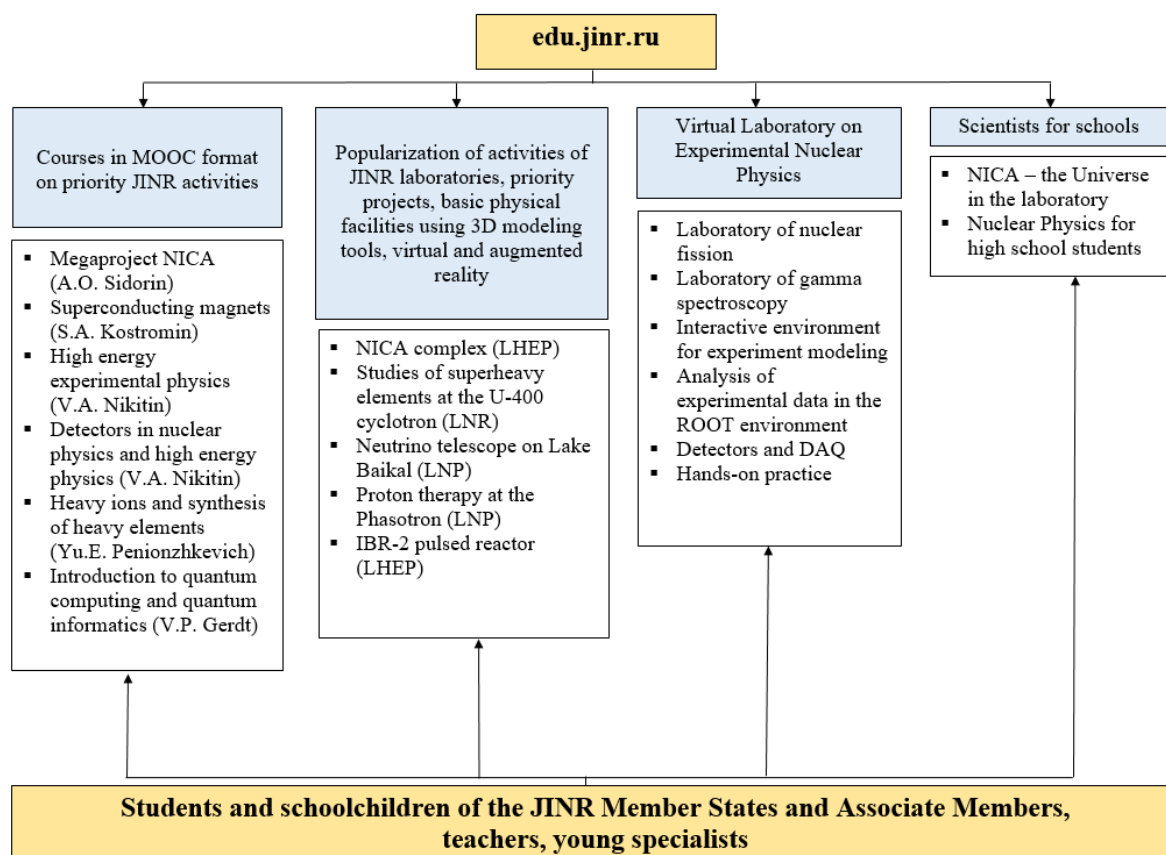
Figure 4. Structure of educational materials of JINR Open Educational Portal.

Another section of the portal – Scientists for Schoolchildren – contains links to the multimedia educational resource "NICA – The Universe in the Laboratory" and the electronic application to the elective course on Nuclear Physics for high school students.

4. Digital educational environment for megaprojects with adaptive learning management system

A logical continuation of the above-described developments is the integration of the efforts of specialists from NRNU MEPhI, JINR and universities from the JINR Member States and Associate Members to develop a common digital educational environment. It will include as existing online courses, virtual laboratories, interactive models of modern physical facilities, as new computer-based training tools designed specifically for this environment.

In modern scientific projects, there is a high need for specialists in the following areas:

- experimental physics,
- accelerator physics and technology,
- distributed computing and working with big data,
- cryogenic technique,
- biomedical physics,
- radiation material science,
- radiobiology,
- use of neutrons and synchrotron light in applied research.

Educational materials of the digital educational environment for megaprojects can be used by students of various universities as additional education, taking into account the chosen direction.

Specializations can be formed from online courses of this environment, upon successful completion of which a student can receive a certificate of additional education or professional development.

Figure 5 presents the tasks which can be solved with use of the digital educational environment for megaprojects.
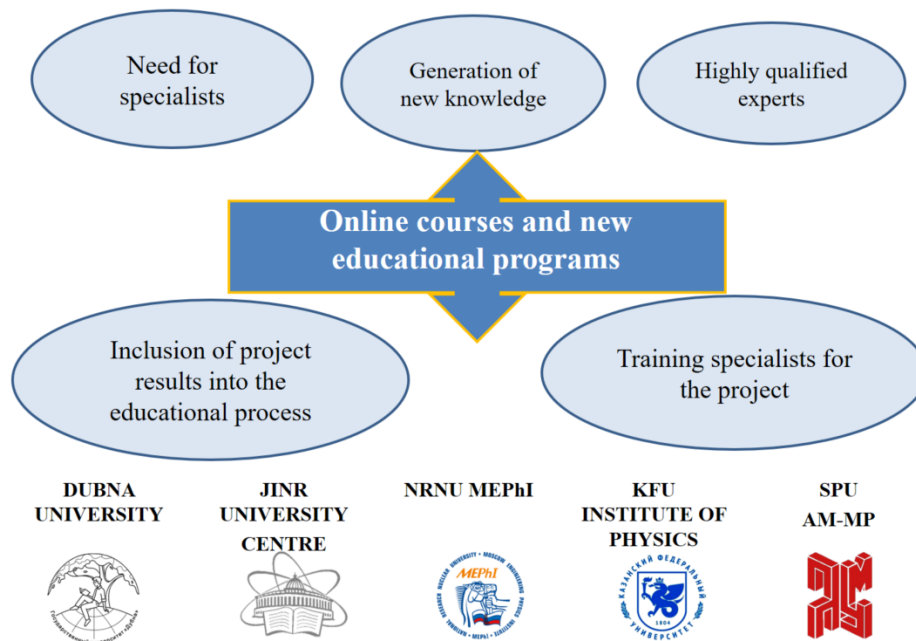
Figure 5. Professional training.

In addition to the independent developments of the environment creators, it is important to give potential students the opportunity to use the rich opportunities provided today by platforms of open online courses. This process can be formalized by developing an adaptive educational process management system.

The structure of most courses is built according to the traditional scheme and may include text materials, images, tests, audio podcasts and video lectures. Course authors can track student progress through test results and correct course content according to the obtained feedback.

The need for monitoring the course accelerated the development of online proctoring technology. In the traditional version, proctoring is a procedure for observing a remote examination, where a person acts as an observer, and the main goal is to ensure the organization and control of the conditions for the implementation of monitoring and evaluation activities. But this approach is quite labor-consuming and in practice is not always possible. Nevertheless, the approaches used in the analysis of user actions in the process of training to identify his personal characteristics can be used not only for tasks of knowledge control, but also for the tasks of implementing various methods of adaptability of the training system.

In this case, adaptability should be understood as an adjustment of one or several characteristics of the training system, which can be realized in three directions:

- correction of form of educational material;
- correction of the sequence of educational material presentation, depending on the progress of training;
- change in the system behaviour in accordance with the learning outcomes, the level of complexity and increasing level of knowledge or qualifications of a student.

Some approaches for adaptive learning are used by all distance learning platforms, but none of them do not have ready-made solutions with adaptability at the level of learning management system.

As a rule, in the process of completing the main course, students face a lack of knowledge in a particular area and they need to fill this gap to understand the material. Existing distance learning platforms do not have mechanisms for tracking student progress online. The use of online proctoring technologies and the data that provide the digital footprint would allow to identify problems associated with a lack of knowledge and provide training material from the system's base formed from open Internet sources and web scraping algorithms.

Currently, a student model is being developed on the basis of digital footprint data, which is formed by the learning management system, based on monitoring the student's actions. This will allow to make the operational monitoring of student behavior in the system and provide missing educational resources from the knowledge base. The knowledge base of the system is generated and constantly updated using open sources and web scraping algorithms of Internet resources.

5. Conclusion

At present, a digital educational environment on the topic of Strategic Academic Units (SAU) has been created and is developing at NRNU MEPhI. This topic is directly related to the development of megaprojects in Russia. The Joint Institute for Nuclear Research is one of the leading multidisciplinary centers, which implements megascience scientific projects with relativistic nuclei and neutrons, and develops modern computing methods for megaprojects.

The combined efforts of specialists from NRNU MEPhI and JINR, professors and teachers from leading universities of Russia in creation of a multidisciplinary training center for specialists could make a significant contribution in training and retraining scientists for new large-scale projects being implemented in Russia.

References

[1] McAuley A, Stewart B, Siemens G and Cormier D 2010 *The MOOC model for digital practice* (Charlottetown: University of Prince Edward Island)
[2] Coursera 2019 *About Coursera* (URL: https://about.coursera.org)
[3] Coursera 2019 *Press* (URL: https://about.coursera.org/press)
[4] EdX 2019 *About Open edX* (URL: https://open.edx.org/about-open-edx)
[5] Araya D and Peters M (Eds.) 2010 *Education in the creative economy: Knowledge and Learning in the age of innovation* (New York: Peter Lang)
[6] ITMO University (St. Petersburg) 2019 *Как российские МООС-платформы конкурируют с мировыми гигантами онлайн-образования, выяснили в Courseburg* (URL: http://news.ifmo.ru/ru/education/trend/news/7692/)
[7] Ministry of Education and Science of the Russian Federation 2019 *Современная цифровая образовательная среда* (URL: http://2017.mmco-expo.ru/program/s/52208/)
[8] National Research University Higher School of Economics 2019 *Proctoring center* (URL: https://elearning.hse.ru/proctoring)
[9] D2L (Desire2Learn) 2019 *What is Adaptive Learning?* (URL: https://www.d2l.com/blog/what-is-adaptive-learning/)