Educational electronic platforms for STEAM-oriented learning environment at general education school

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Abstract. The article is devoted to the problem of the use of educational electronic platform for the organization of a STEAM-oriented environment of the general school. The purpose of the article is to analyze the use of educational electronic platforms for organizing the STEAM-oriented school learning environment and to identify the basic requirements for supporting the implementation and development of STEAM education in Ukraine. One of the main trends of education modernization is the STEAM education, which involves the integration between the natural sciences, the technological sciences, engineering, mathematics and art in the learning process of educational institutions, in particular, general school. The main components of electronic platform for education of the organization STEAM-oriented educational environment should be open e-learning and educational resources that include resources for students and resources for teachers; information and communication technologies that provide communication and collaboration among students; between teachers; between students and teachers; between specialists, employers, students, and teachers; information and communication technologies that promote the development of STEAM education and its implementation in the educational process of the school; online assessment and self-assessment of skills and competences in STEAM education and information and communication technologies fields; STEAM education labs that may include simulators, games, imitation models, etc.; STEAM-oriented educational environment profiles that reflect unconfirmed participants' data, their contributions to projects and STEAM education, plans, ideas, personal forums, and more. Prospects for further research are the design of an educational electronic platform for the organization of the STEAM-oriented learning environment in accordance with the requirements specified in the paper.

Keywords: STEAM-oriented approach, STEAM education, STEAM-oriented educational environment, electronic platform for education.

1 Introduction

The rapid knowledge society development requires from competitive young people not only demonstrating knowledge, skills and competences in specific fields of science but also making creative solutions to various professional problems. This leads to the search for effective ways of organizing such learning environment that can ensure the formation of students' competences in accordance with the ever-increasing requirements for graduates of educational institutions.

One of these ways, in our opinion, is using an Electronic Platform (E-Platform) for the STEAM-oriented educational environment, which should facilitate the implementation of practical-oriented, interdisciplinary and project approaches in the study of the disciplines of the natural-mathematical cycle and robotics, the formation of creative thinking of students through the use in the educational process of various arts (for example, writing, rhetoric, literature, theater, dance, drawing, music) (Jacina T. Leong [5], David A. Sousa and Tom Pilecki [16]).

Heidi Sublette considers that STEM education prepares students for the challenges and opportunities in the information society and economy in the 21st century [17]. She determines STEM-education as a transdisciplinary pedagogical approach through which students are given the opportunity, through the use of the project method, to independently solve the real problems that may arise in the bit and the teaching tasks set by the teacher, during which the teacher carries out the role of facilitator.

Nataliia V. Valko, Nataliya O. Kushnir and Viacheslav V. Osadchyi consider that STEAM-education provides the study of Science and Technology through the application of technical creativity and Engineering, based on Mathematics, modeling and integrating the use of various tools of other sciences (All) [22].

Peter Charles Sinclair Taylor explains that STEAM is not just another curriculum fad but an important response to the pressing need to prepare young people with higher-order abilities to deal positively and productively with 21st century global challenges (crises) that are impacting the economy, the natural environment and our diverse cultural heritage [19].

The STEAM-oriented approach is to examine the relationship between exposure to the arts and performance in Science, Technology, Engineering, and Math (STEM) subjects (Mark E. Rabalais [12]).

The STEAM-oriented environment in school teaching is the way of motivating students to participate in educational projects related to issues with the application of science, technology, engineering, art and mathematics (Georgette Yakman) [24].

2 Theoretical backgrounds

The role of STEM-education (S – Sciences, T – technological sciences, E – engineering, and M – mathematics) implementation in a general school for student competences development has been considered by Fabian Andruszkiewicz [14], Maïté Debry and Agueda Gras-Velazquez [2], Nataliya O. Kushnir [22], Viacheslav V. Osadchyi [8],

Viktor B. Shapovalov [13], Yevhenii B. Shapovalov [15] , Heidi Sublette [17], Nataliia V. Valko [21], Nataliia P. Volkova [20] et al.

The arguments that the Arts ("A") and creative approaches must be contributing to the effectiveness of STEM-education (STEAM) were considered and analyzed by Julia Smith and Louis Bergonzi [1], John Tarnoff [18], EunJung Kim, SunHoi Kim, DongSoo Nam and TaeWuk Lee [4], Daniel F. Keefe and David H. Laidlaw [3], David A. Sousa and Tom Pilecki [16] etc.

Despite a large number of scientific works on the implementation of STEM education in the general education school and the need to involve Art in the STEAM-oriented learning approach, the problem of using educational platforms for the STEAM-oriented environment that meets practical needs and demands of the society for the high level of learning outcomes is still under consideration and requires deep scientific research to improve educational platforms in order to organize the STEAM-oriented educational environment of the general school.

The purpose of the article is to analyze the use of educational electronic platforms for organizing the STEAM-oriented school learning environment and to identify the basic requirements for supporting implementation and development of the STEAM education in Ukraine.

3 Research methods

To achieve the purpose of our study and also to clarify the problem of creating the STEAM-oriented educational environment regarding the main ways of using educational e-platforms to support STEAM education there were used the following methods: systematic and comparative analysis of pedagogical, psychological, philosophical, sociological works, methodological and specialized literature; analysis of the pedagogical experience of using the STEAM-oriented educational environment in general school; synthesis and generalization to formulate the main points of the study; interpretation of the research results.

4 Results and discussion

In Provisions on the National Educational Electronic Platform, approved by the Order of the Ministry of Education and Science of Ukraine No 523 on May 22, 2018, it is noted that e-Platform is "specifically known information and telecommunication system work", the goals of which include technological support for secondary education reform; providing participants with modern educational process electronic educational resources and services; providing electronic textbooks in open access for students of complete secondary general education and relevant pedagogical staff; providing and creating the enabling environment for the development of national e-learning resources, services and e-textbooks; development of e-learning and formation of digital competence of participants in the educational process in our country [10].

Learning Platform correlates with the learning environment [9] and Learning Management System (LMS) [7]. LMS is a software specially designed to provide

educational services, learning management and monitoring the learning process in distance education (Karim Qayumi) [11].

Learning Management Systems should ensure the creation of an electronic environment for education which is to be equivalent to the physical environment. This environment should be designed to facilitate teaching, management and educational processes within the on-line courses for students, in particular, systems using computer equipment and software that include distance learning as an educational concept [23].

For example, The Centre of Excellence for Simulation Education and Innovation (CESEI) at University of British Columbia (Canada) gives an access to the Electronic Platform for Education and Research (e-PER), which is an interactive Internet-based software for developing, presenting, tracking, and managing training programs, as well as for students' collaborative learning and research. Based on the ATutor, the E-Platform is an Open Source Web-based LMS to develop and deliver online courses (https://elearningindustry.com/directory/elearning-software/atutor). The ATutor is used in a variety of contexts, including online course management, continuing teacher's professional development, career development, and research. The ATutor is international and has been translated into more than fifteen languages with support for over forty additional language modules. The software is unique due to its accessibility (it can be used by students with visual disorders and disabled people) and suitability for education according to software evaluation criteria defined by The American Society for Training and Development (ASTD).

One of the requirements for the educational E-Platform in an educational institution is, above all, the selection of software that will meet the needs of teachers to deploy, use and create electronic educational resources, cooperate with all participants in this process and motivate them to teach students. Among them, Online Learning Platforms users distinguish 5 most popular ones in 2019 (https://www.g2.com/categories/online-learning-platform): Udemy, Infosec Flex, TalentLMS, McGraw-Hill, WebAssign.

Udemy is a content covering a variety of key business and technical topics ranging from development and IT to marketing, leadership, design and stress management. In addition to a curated content collection, organizations can also host and distribute their own proprietary content on Udemy. For teachers, this platform provides a wider range of audience for distance learning.

Infosec Flex is a Platform, that helps teachers to give team convenient access to training anytime, anywhere; provides award-winning security skills training and certification preparation courses.

TalentLMS is a Platform, that provides LMS ideas for delivering engaging online training courses, creating courses, and supporting multiple file types and multimedia (presentations, videos, iFrame, SCORM, etc.).

McGraw-Hill is a Platform, that combines such features as: remote computer monitoring, website and application blocking, teacher/student screensharing, interactive Quizzes, presentation Building, instant messaging.

WebAssign is the technology choice for STEM education, its wide selection of affordable, peer-reviewed academic content makes web-design within the STEM disciplines seamless and the products of tutorial banks and assessments are versatile.

Examples of international Learning Platforms for supporting the STEAM-education in general schools are as follows: STEAM Portal (https://educationcloset.com/steam/), STEAM Education (https://steamedu.com/), "GLOBE International STEM Network" (GISN) (https://www.globe.gov/web/globe-international-stem-network), STEAM CRAF (https://www.steamcraftedu.com), "A&E" (https://www.aandeedu.com/steam) etc.

The STEAM Portal is Learning Platform, which provides free support for teachers to enhance their professional development, including information and digital competence, and understand how and why STEAM-oriented approach can transform the educational system.

This portal offers free samples of tutorials for all levels starting from elementary to high school education (Free STEAM Lessons), Take the course, where you can learn how to create a STEAM student training course, Attend a conference, STEAM projects, online tools for STEAM research, for example, Robot Factory (http://tinybop.com/apps/the-robot-factory) for designing robots according to given functions, to their work environment, etc.; Pixel Press Floors (http://www.projectpixelpress.com) for designing and creating STEAM games for students, drawing models, etc.; Kahoot (https://kahoot.com) for creating games, quizzes, tests and others.

STEAM Edu (https://steamedu.com/) is a platform for teachers, which provides electronic educational resources and consultations by tutors of distance courses on implementing the STEAM-oriented approach in general school education activity. It includes adaptable concepts for recognizing and socio-emotional and academic considerations for individual and team work for the STEAM education. Here one can find information about:

- Understanding, Customizing & Implementing STEAM Program Development;
- Integrative Curriculum Mapping & Theme Development;
- Staff Development;
- Building, lab, space, equipment suggestions;
- Community Involvement & Event Planning;
- Program Sustainability.

The platform offers ideas from fellow educators how to expand on your own ideas and be exposed to new ones to adapt for your style and students; gives assistance in teachers' network and their projects by connecting with educational professionals and experts from all over the world.

The GLOBE International STEM Network (GISN) is an international network of STEM professionals who contribute meaningfully to GLOBE students around the world involved in scientific field investigations and research projects (https://www.globe.gov/web/globe-international-stem-network). The platform provides the GLOBE Teacher's Guide, an online collection of background information, science protocols (data collection procedures), and learning activities organized by Earth spheres: Atmosphere, Biosphere, Hydrosphere, and Pedosphere (Soil). The science protocols are intended to be used as written, using instruments that meet certain specifications in order to ensure data accuracy worldwide.

Another game educational platform, the "STEAM Craft Edu", was created to encourage and increase the interest of pupils in 3-6 grades in STEAM fields. On this platform, schoolchildren are invited to participate as the main character in an intergalactic adventure (Planeteers) in a fictional universe with Earth-like habitats, flora and fauna. The pupil plays a role of a confused space explorer, collecting vital elements and making scientific discoveries, which is the key to the rebirth of his own planet. Together with his companion robot (Socket), he must build a sustainable living environment as well as study and collect materials and data for his journey back home.

The STEAM Craft Edu platform hosts student profiles, teachers' personal cabinets, where they can track their students' progress and estimate their learning activities; and also, there are blogs for students, teachers, and counselors in which they post articles about their game educational experience.

"A&E" (https://www.aandeedu.com/steam) is aimed at making global and high-quality education more convenient and shareable, in order to facilitate the exploration of innovative learning in the future. As the sole provider for Ningbo-Auckland Education Association, A&E is devoted to promoting cross-cultural communication and cooperation in Education sectors between China and New Zealand (over 80 schools). This platform is built for students and educators to develop future-oriented education such as the STEAM program and enhance multi-dimensional cooperation on student-centred education.

The Go-Lab ecosystem project was created in 2014. The Go-Lab Initiative developed and received its name due to the successful Go-Lab project, which lasted from November, 2012 to October, 2016. The purpose of the Go-Lab Initiative is to promote the use of online labs and educational training applications for science education in schools. The Go-Lab Initiative provides the Go-Lab ecosystem for teachers where they can find various online labs and create special training spaces. In addition, the Go-Lab Initiative includes training programmes on science education in schools and, also, on the use of the Go-Lab ecosystem for teachers all around Europe. The Go-Lab Initiative is currently funded by the Next-Lab project.

The Go-Lab enables inquiry-based learning that promotes acquisition of deep conceptual domain knowledge and inquiry skills, with the further intent of interesting students in careers in science. For students, Go-Lab offers the opportunity to perform scientific experiments with online labs in pedagogically structured learning spaces.

Online labs provide your students with the possibility to conduct scientific experiments in an online environment. Remotely-operated labs (remote labs) offer an opportunity to experiment with real equipment from remote locations. Virtual labs simulate the scientific equipment. Data sets present data from already performed lab experiments. The Go-Lab Ecosystem supports and enriches the teaching of different scientific school subjects, using the inquiry-based learning approach. It is designed to meet the needs of primary and secondary school teachers, and students aged from 6 to 18 years old. The Go-Lab Ecosystem includes two components: The Go-Lab Sharing Platform and The Go-Lab Authoring Platform (Graasp). The Go-Lab Sharing Platform provides hundreds of remote and virtual laboratories (labs), as well as inquiry learning software tools or applications (apps). The Go-Lab Authoring Platform (Graasp) enables teachers to create their own Inquiry Learning Spaces (ILS) by combining labs, apps and

other resources to share with their students. A wide variety of online labs for physics, astronomy, chemistry, biology, math, and other subject domains are available.

We conducted a survey of teachers (12 primary teachers and 35 secondary school teachers) at Brovary secondary school of I-III levels No. 1 (Ukraine) in order to clarify the basic requirements and functions of the STEAM-oriented educational environment of school. The learning environment was another theme in the questionnaire as presented in Table 1. By using a five Likert scale ranging from very undesirable (1) to very desirable (5), the participants were asked what functions should the STEAM-oriented educational environment provide to support the implementation of the STEAM-oriented approach in the school [6].

The survey results are presented below (Table 1).

Table 1. The results of teachers' survey on the main functions of the STEAM-oriented educational environment to be provided for supporting the STEAM-oriented approach in school education activity

Functions to be provided by the STEAM-oriented educational environment for supporting the implementation of the STEAM approach in the general school teaching process	Mean
ensuring student learning mobility	4.9
ensuring teachers academic mobility	4.4
carrying out Olympiads, Competitions	3.2
carrying out distance courses	2.9
providing tools for STEAM research	4.7
conducting experiments within STEAM disciplines	3.8
students' algorithmic thinking development	3.5
developing students' skills to creatively solve STEM learning problems	3.8
ensuring communication and collaboration between students; between teachers; between students, teachers, professionals and employers	3.2
providing tools for students' STEAM knowledge, skills and competences self-assessment and validation	4.5
support for student and teacher collaboration within STEAM learning projects	4.2
Total (N = 47)	

According to the questionnaire analysis of the main functions of the STEAM-oriented educational environment to be provided for supporting the STEAM-oriented approach in general school teaching process, it was found out that teachers give importance to the following functions: "ensuring student learning mobility" (4,9 – 98%) – 40 teachers marked "5" and 7 teachers marked "4"; "providing tools for STEAM research" (4.7) – 35 teachers marked "5", 10 teachers – "4", 2 teachers – "3"; "providing tools for students' STEAM knowledge, skills and competences self-

assessment and validation" (4.5) – 31 teachers marked "5", 10 teachers – "4", 3 teachers – "3"; "support for student and teacher collaboration within STEAM learning projects" (4.2) – 12 teachers marked "5", 32 teachers – "4", 3 teachers – "3"; "ensuring teachers academic mobility" (4,4) – 25 teachers marked "5", 15 teachers marked "4" and 7 teachers marked "3".

At the same time, some functions were found out to be less important. They are: "developing students' skills to creatively solve STEM learning problems" (3,8) – 2 teachers marked "5", 34 teachers – "4", 11 teachers – "3"; "students' algorithmic thinking development" (3,5) – 1 teacher marked "5", 23 teachers marked "4", 23 – "3"; "ensuring communication and collaboration between students; between teachers; between students, teachers, professionals and employers" (3,2) – 13 teachers marked "4", 30 teachers – "3" and 4 teachers – "2"; "carrying out distance courses" (2,9) – 8 teachers marked "4", 26 teachers – "3", 13 teachers marked "2".

The low evaluation of these functions can be explained by teachers' lack of experience in using information and communication technologies (ICT) for communication and collaboration between students; between teachers; between students, teachers, professionals and employers; or for conducting distance courses.

The data show that educational E-Platform for supporting the STEAM-oriented educational environment should host:

- open electronic educational resources, which include resources for students and teachers and can be distributed through e-textbooks, e-libraries, blogs for teachers and teaching staff, Ministry of Education and Science websites, distance courses, etc.;
- tools (ICT) that provide communication and collaboration between students; between teachers; between students and teachers; between professionals, employers, students, teachers, etc., that can be implemented, for example, throughout open forums, webinars, Internet conferences, etc.;
- online assessment and self-assessment, which can be conducted through contests, competitions, quests, tests, projects, etc., that motivate students to study STEAM and develop teachers digital-digital competence to ensure the modernization of education in accordance with demands of the society;
- laboratories covering simulators, games, imitation models, etc.;
- individual profiles of participants of the STEAM-oriented educational environment, where there can be placed the data about participants, their achievements in training, participation in STEAM projects or various forums; certificates, electronic educational resources, necessary for training and teaching.

The STEAM-oriented educational environment should meet the following tasks:

- supporting formal education: the environment should enable students to carry out experiments in laboratories (virtual laboratories) on physics, astronomy, chemistry, biology, math, and other subject domains, supporting students' learning activities in the classroom; supporting teachers' preparation for lessons, implementation of new ideas, and monitoring students' learning activities;

- supporting non-formal education: the environment should motivate students to learn in the STEAM fields, to work in a group on a training project, to communicate with experts in the STEAM fields and others;
- supporting informal education: the environment should promote self-organized acquisition of competence by a person in the STEAM fields, related either to professional activity or community or family or other activities.

According to the analysis of the teachers' survey results and scientific literature review, we can determine the following functions, which the STEAM-oriented educational environment at school should provide for supporting implementation and development of the STEAM education in Ukraine:

- technological, which provides communication between the subjects of the educational process, supports the implementation of laboratory, practical, control works and their assessment, gives an access to various data sources (databases, conferences, electronic libraries, etc.);
- psychological, which motivates the subjects of the educational process (teachers; students; parents; specialists in certain scientific fields of education, science, business, etc.) to participate in the STEAM educational projects, forms students' responsibility when conducting these projects and develops teachers' professional competence to encourage the participation of the subjects of the educational process in these projects;
- educational, which forms students' competences and knowledge in accordance with the educational program disciplines of the general educational institutions, and also provides the guidelines for their further professional careers;
- educative, which builds responsible behavior of students when they participate in the STEAM educational projects, take part in group activities and defend the project results;
- didactic, which implies the expedient use of computer-based educational tools, electronic educational resources, tools and services of institutions' information and communication networks in order to facilitate the educational process in accordance with the calendar and thematic plans of the educational program disciplines.

For the effective introduction of the STEAM approach into general school teaching process, it is highly important to use educational E-Platforms that will satisfy students' learning interests in the STEAM fields, affect the development of their research, creative skills and abilities. Educational E-Platforms can help teachers solve problems of students' motivation in learning by creating such tasks, educational projects, questions for students that will encourage them to use all their skills and abilities based on the synergy of knowledge from all STEAM disciplines.

5 Conclusions and prospects for further research

Thus, creating the STEAM-oriented educational environment is one of the ways to develop and reform the educational system, which, in particular, should influence on

students' motivation of learning STEAM disciplines, on forming their creative thinking through the use of ICT and various arts in the educational process to solve STEM research problems.

The STEAM-oriented educational environment has to impact on the formation of students' skills in the fields of natural sciences, technology, mathematics, the formation students creative critical thinking, solving practical research issues through synergy between STEAM disciplines and the use of ICTs. The STEAM-oriented educational environment is an educational environment, in which ICTs create learning and teaching conditions in synergy with the natural sciences, technology, engineering, arts, mathematics, teamwork, cooperative work of teachers and students for the effective achievement of teaching goals, and comprehensive personality development.

Educational E-Platforms for the STEAM-oriented educational environment should include (these are general requirements): the teachers' and students' profiles; an electronic class; a discussion forum; open Digital learning objects that include resources for students and resources for teachers; a calendar of key activities, ICTs to provide communication and collaboration between participants in the educational process; ICTs that contribute to the development of STEAM education and its introduction into the general education school; tools for online assessment and self-assessment of STEAM educational skills; STEAM education labs that may include simulators, games, imitation models, and others.

The further research, therefore, should aim at adjusting a general e-platform for the STEAM-oriented educational environment to school education in Ukraine in compliance with the abovementioned requirements.

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