Technology of creating educational content for open digital resources in general technical disciplines

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Abstract. The article presents the technology of creating educational content for open digital resources in general technical disciplines that consist of the four stages: development, design, posting and final. There are proposed to create video, interactive and graphic educational content in the context of the proposed technology at the development stage. Video content is presented in the form of video lectures, video instructions for practical and laboratory tasks, video recording of the educational results. Interactive content is introduced by lectures and laboratory tasks with interactive elements, interactive posters or tests. Graphic content is provided by lectures with graphic models of the technical objects, practical tasks with the use of modelling and design programs, creation of 3D models for laboratory works and performing engineering and technical projects. The design stage includes the selection of services for the specific type of content and creation the tasks for open digital resources. Educational content is implemented in an open digital resource by obtaining a link, QR or implementation code at the posting stage. The final stage of the application of the proposed technology involves the performance of tasks by higher education applicants, obtaining points, acquisition of competencies. The Pearson criterion was used to statistically verify the application of technology of creating educational content for open digital resources in general technical disciplines. The higher education applicants in the experimental group received higher results than in the control group which may indicate the effectiveness of the outlined technology.

1. Introduction

The main goal of modern education is to introduce new information technologies into the educational process and management of educational institutions, to create free access to cultural, educational and scientific information. Informatization of education contributes to the development of a system of lifelong learning, which provides an individual learning trajectory for each person. Access of higher education applicants to various sources of information develops critical thinking and independence, provides a creative approach to education. Integrating open education content into training in general technical disciplines is an effective way to overcome the higher education challenges posed by the pandemic.

Digital skills are based on digital information skills, they are an important aspect in acquiring subsequent professional skills [1]. The use of digital educational resources increases the impact of intrinsic motivation within the institution [2]. It is necessary to take into account the general principles of design the engineering and technological educational content and its updating to

the requirements of time [3]. The effectiveness of the content of general technical disciplines and methods of teaching technology is determined by the execution of professional activity [4]. It was outlined the main features for the development and implementation of practice-oriented classes activating and stimulating students' cognitive interest in mastering the necessary professional competencies in the study of general technical disciplines [5].

Higher education applicants increasingly demand more constructive online courses that not only provide information but also facilitate studying experiences [6]. Higher education applicants proceeded with four interrelated steps when studying in the open digital resources: locating information, information use, remix and repurpose, and knowledge sharing [7]. Suggestions, based on the finding, are offered for institutions looking to pursue open educational resources programs on their campuses [8]. There is a need for digital repositories to reflect or make visible how resources corresponded to the particular instructional models [9]. So, it is necessary in the digital competence trainings for tutors to structure their courses so that pre-service teachers can see them as role models, as well as the theoretical and practical information should be offered [10]. There are a plenty of learning tools for using in general technical disciplines. It was investigated the use and benefit of an incentive system in a computer-based physics game on students' learning and efficiency of educational results [11]. It is important to understand YouTube EDU videos characteristics which can be used for making decisions for improving educational content and learning technologies [12]. Also using remote labs in higher education in the condition of open digital resources showed positive findings [13].

The cloud solutions for 3D modeling is used in technology education to create and visualize technical objects, 3D modeling is implemented in the educational process of documenting students' projects as architectural exercises [14]. Online meetings, distance learning and live streaming make the video content become more popular [15]. The investigation is dedicated to implementation of interactive educational content using 3D visualization technologies [16]. Methodological and technological aspects as well as architecture and elaboration algorithms of educational 3D visualization are considered [17]. However, wide spreading of interactive 3D content on the web requires efficient methods of content creation and it also should be competency-based [18]. Interactive and web-based content of simulation education may be an answer to deficit of professional tools and space and lack of teaching personnel [19]. It was investigated the potential of using Holograms as technology for delivering educational content to the audience [20]. It is determined the need in methodical support for the preparation of educational content on the basis of distance education platforms for higher educational institutions [21]. The study presents the possibilities of using augmented reality in the study of different fields [22]. In the investigation it is considered the study of application of Augmented Reality technology for mathematical disciplines [23].

The authors explored some aspects of engineering education, for example, it was presented the implementation of future agricultural engineers' training technology in the informational and educational environment [24] and the technology of application of competence-based educational simulators for learning general technical disciplines [25]. Also there is the investigation about technological model of training of Masters in Electrical Engineering to electrical installation and commissioning [26], but the learning content of open educational resources in general technical disciplines can be varied, including courses, course materials, learning objects, content of modules, collections, journals, etc. Creating media and interactive content of open digital resources is an effective way to prepare higher education applicants.

The aim of the article is to develop the technology of creating educational content for open digital resources in general technical disciplines, which includes the creation of video, graphic and interactive content and describe the stages of implementation of the proposed technology.

2. Methods

The assembly of methods of the research process is represented by: theoretical methods – categorical and logical analyses in order to development the technology of creating educational content for open digital resources in general technical disciplines, generalization of the results and experience; empirical methods – surveys, questionnaires, self-assessment, testing, observation of the learning process and educational results, pedagogical experiment; statistical methods – quantitative processing of indicators and verification of the reliability of the obtained empirical results using the Pearson criterion. The control group (CG) takes into account the comparison of self-assessment, and the experimental group (EG) – the results of the analysis of the quality of knowledge. The result of the experiment involved 227 higher education applicants. There were 115 people in the control group and 112 in the experimental group. The Pearson criterion [27] was used to compare the results of the experimental and control groups. In order to statistically verify the equality of use of educational content for open digital resources in general technical disciplines in control and experimental groups, there were formulated hypotheses: H0 – there are no significant difference in the level of application of educational content for open digital resources in general technical disciplines; H1– there are significant difference in the level of application of educational content for open digital resources in general technical disciplines in control and experimental groups.

3. Technology of creating educational content for open digital resources in general technical disciplines

There are presented the technology of creating educational content for open digital resources in general technical disciplines (figure 1). It includes the creation of video, interactive and graphic content. The outlined technology consist of the four stages: development, design, posting and final stage. The stages of creation of each of the specified types of educational content and its implementation into open educational resources have some peculiarities.

The development stage includes the creation of video, graphic and interactive content for the lectures, laboratory and practical classes and independent work. Lectures for open digital resources are recommended to be submitted in the form of video lectures, lectures with interactive elements and lectures with graphic models of mechanisms. Practical tasks in general technical disciplines are presented through the video instructions, interactive posters and practical tasks with the use of modelling and design programs. Laboratory tasks include the video instructions, laboratory works with interactive elements and creation of 3D models. The higher education applicants during their independent work in the conditions of open digital resources in general technical disciplines present the recording of their reports, the result of the engineering and technical projects and perform the interactive tests.

The design stage includes creation of materials on the basis of specified services. Video content can be designed through the selection of text and visual materials and be presented in the form of presentations with video elements or video recording of information. The interactive content is developed with the services for interactive tasks and posters, worksheets, dictionary cards and info-graphics. Graphic content is created on the basis of 3D models.

The features of the posting stage are conditioned by the type of the service used at the previous stage. Video content is downloaded on the YouTube channel and posted in the conditions of open digital resources through the implementation code. The access to the interactive content need to be set up in the previously selected service and placed in the open digital resources through the link, QR or implementation code. The graphic content at the following stage is presented in the form of 3D models of the technical objects, mechanisms and machines in the conditions of open digital resources.

The final stage it devoted to getting results. The result of using this technology is the performance of tasks by higher education applicants, obtaining points and acquiring

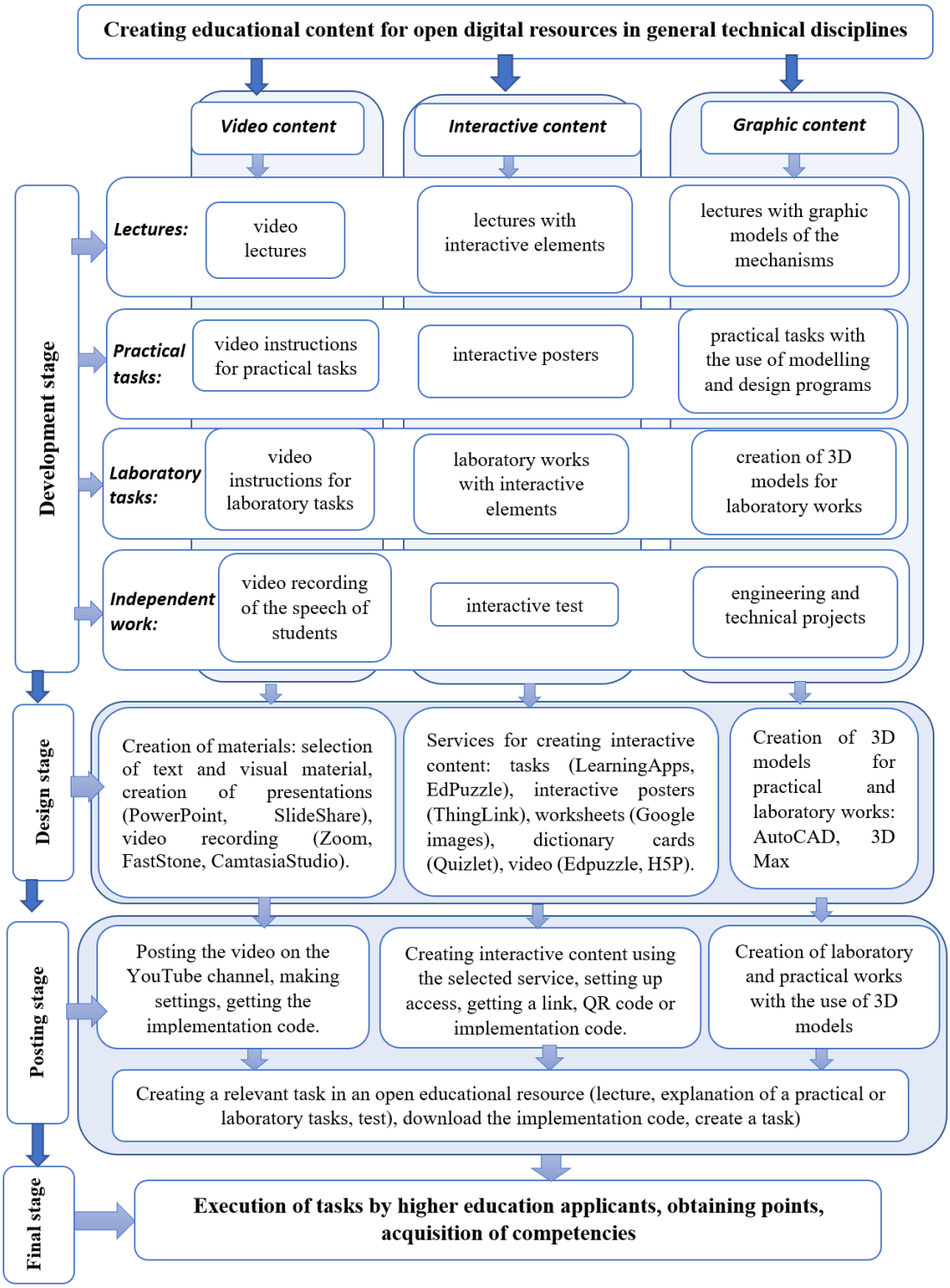

Figure 1. Technology of creating educational content for open digital resources in general technical disciplines.

competencies. The use of modern multimedia and interactive technologies allows to increase the clarity and ergonomics of the perception of educational material, which has a positive effect on learning motivation and efficiency. The research outlined the creation of each type of content for open digital resources in general technical disciplines.

3.1. Educational videos

Creating educational videos can increase higher education applicants' involvement in learning and significantly diversify the learning process in blended and online courses. It is possible to effectively integrate audio and visual elements to help students better understand complex concepts. Educational videos can have different purposes to achieve the educational goals of the course. This can be either a video lecture taken on camera or an explanation of educational material in a screencast format (video from the screen) using slides of presentations, diagrams or other graphic elements. In the context of preparing to record a training video, it is necessary to: review the syllabus of the course (expected results, goals, objectives, materials), choose digital tools for recording and editing video. There are considered some resources for recording video content. Zoom – a service for video conferencing, online meetings and distance learning, suitable for individual and group classes. The advantages when using this program are the ability to share the screen with the sound. FastStone Capture is a powerful, lightweight, but functional program for creating screenshots. It allows to record any action on the screen, including moving the mouse and voice from the microphone, in highly compressed video files. Camtasia Studio allows to edit a clip after creating it. The editor has all the necessary tools, such as slicing and adding various effects. There is an option to add audio and video tracks to the project, compile and edit them.

3.2. Interactive technologies

Interactive technologies enrich the learning process, involving in the process of perception of educational information most of the sensory components of learners. They integrate powerful distributed educational resources, can provide an environment for the formation of key competencies, which include primarily information and communication. The use of interactive technologies, in particular, interactive tasks and exercises allows to: individualize the learning process; organize educational material taking into account different ways of educational activity; compactly present a large amount of clearly structured and consistently organized educational information; strengthen the visual perception and facilitate the assimilation of educational material. With the help of a huge number of Internet resources, it is possible to create a collection of interactive tasks. These can be tasks of the following nature: correlation of concepts and definitions; insert a missing letter or word; crosswords, riddles, charades, puzzles; word search; quizzes with one and many correct answers; interactive games; construction of a timeline, etc.

The study considered services for creating interactive content: tasks (LearningApps, EdPuzzle), interactive posters (ThingLink), worksheets (Google images), dictionary cards (Quizlet), video (H5P).

The Learning Apps interactive task designer is created to support the learning process with the help of interactive modules (exercises). At the same time, both the learner and the tutor can create interactive modules based on templates.

The main idea of interactive tasks that can be created in this service is that students can test and consolidate their knowledge in the form of game, which contributes to the formation of their cognitive interest in a particular discipline. Edpuzzle is an online service for creating video clips with the ability to add voice comments and questions from the material. The tutor can take videos from YouTube, Vimeo, Khan Academy, TED-Ed, LearnZillio as a basis, as well as download them from the PC. EDpuzzle is integrated with Google Class. Based on one video, there is an ability to create an interactive quiz with open-ended questions or with

the choice of one answer from several, give voice comments and explanations to the video or completely voice it. The Thinglink service is a tool for creating interactive infographics or interactive posters: interactive map, diagram, table. Furthermore, its capabilities extend to other methods of multimedia didactic. The interactive map avoids overloading with information, images, icons, inscriptions. The interactive table has the following features: cost-effectiveness and logical construction, readability, interactivity, visualization of table cells. The table can also be animated, with a minimal amount of printed text. In the case of working with an interactive reference scheme, by clicking on individual elements, there is a possibility to get more complete information or a visual image. An interactive worksheet in Google Docs is a digital tool for organizing student learning activities through cloud services and web tools. It may include: test elements, organization of work with the text, problem tasks with step-by-step execution, tasks for the ability to classify, compare. Feedback from a tutor in interactive worksheet technology in Google Docs often takes the form of comments in the margins of an already completed worksheet. The Quizlet service for creating dictionary cards allows to memorize information that can be presented in the form of training cards. It is enough to enter the basic concepts and definitions once, adding pictures and audio files to them, and the system itself combines different exercises and games. There are some ways to work in Quizlet: card mode - cards can be flipped over to repeat terms and definitions; memorization mode – it is necessary to answer each question correctly twice; letter mode – a definition or picture of the term will be given and it is assessed how well the student knows the material and makes mistakes in writing, it is necessary to answer each question correctly twice; spelling mode – it is necessary to write what is heard; testing mode – different versions of tests are automatically created (correlation, multiple choice, true / false, filling in gaps); two types of games. H5P is a handy designer for creating interactive tasks based on templates. All H5P components are made in a modern HTML5 format. It is possible to create interactive videos, assignments, skip items, questionnaires, quizzes, and more.

3.3. Graphic content

The proper graphic content is crucial to creating the perfect 3D model. 3D model depicts an object in 3D graphics mode. 3D modelling is used in industries such as 3D printing, interior design, architecture, film, games and animation, digital production. In 3D Max it is possible to make three-dimensional models, there is a built-in physics and kinematics, a system of particles, it is easy to build an animation and get a video. 3Ds Max is a commonly used visualizer for interior or exterior design. Advantages of 3Ds Max: many training materials, extensions and ready-made libraries; demand for specialists in the market. Autodesk AutoCAD is a more specialized environment that is used mainly by engineers, architects and other design professionals. AutoCAD has great potential for modelling technical processes. There are advantages of AutoCAD: a large number of training materials; ease of use; specialization in the technical field. Sketch-Up is a very easy-to-use program for simple modelling of buildings and interiors. It is designed for mass use, and therefore has a built-in training system and a minimum of tools, and to operate them is not difficult. It is integrated with the Google Maps service so that users can add to the map their three-dimensional models of houses and other attractions.

3.4. Educational content for open digital resources in general technical disciplines

The proposed technology of creating educational content for open digital resources in general technical disciplines is presented on the example of Mechanics of Materials and Constructions, Engineering and Computer Graphics and Theory of Mechanisms and Machines.

Lectures in training modules on Mechanics of Materials and Constructions are presented in the form of video lectures and recorded with Zoom.

There are designed the videos instructions for the calculation of practical works of the module "Geometric characteristics of flat sections". The interactive posters for calculation the centre of gravity of the construction, the moment of inertia, the moment of resistance of the section and the radius of inertia were performed in the Thinglink service.

In the context of the studying modules "Central tension and compression of the rods", "Torsion" there were developed the video instructions for practical works and interactive posters "Determination of longitudinal force in sections", "Determination of total elongation or shortening of the rod" and "Determination of torque", "Determination of twist angle".

In the laboratory works "Tensile testing of steel sample", "Testing of samples of anisotropic materials for compression" and "Testing of steel rod for torsion" used 3D models of these samples before and after deformation.

In addition to video lectures and instructions for practical work of the module "Bending" there are presented the interactive posters "Determination of transverse force and bending moment".

Video lectures and video instructions for practical work increase the visibility while mastering the theoretical material. Interactive posters assigned to get acquainted with the sequence of practical work, make important concepts, reference tables, figures and more. 3D models in laboratory works form an idea of the course of deformation and its consequences. After each module, higher education applicants take an interactive test and consolidate their knowledge and skills.

In the mastering tasks for training modules "Point, line and plane on a complex drawing", "The technical drawing" in the course of Engineering and Computer Graphics created video lectures on the basis of work with design and modelling programs Autodesk AutoCAD, 3D Max. The H5P module used to record the video lectures with interactive questions after each part of the material.

Also it was presented the explanation to the practical tasks with the modelling and design programs for the modules "Point, line and plane on a complex drawing", "The technical drawing" for drawing in two-dimensional space and for the modules "Axonometry, sections cross-sections", "Construction Drawing" for the creation of 3D models.

Exercises and tests that created in the Learning Apps application have been created to consolidate the skills acquired while performing graphic works.

In the context of studying Theory of Mechanisms and Machines, there were created the lectures with interactive elements on the basis of service the Camtasia Studio. Execution and discussion of practical work of the module "Structural analysis of mechanisms" need to be performed using an interactive worksheet in Google Docs.

Drawing of structural and kinematic schemes of mechanisms, construction of plans of speeds, forces and accelerations of modules "Kinematic analysis of mechanisms" and "Kinetostatic analysis of mechanisms" is carried out by means of modelling and designing programs. Thus, the creation of educational content in general technical disciplines for open digital resources requires the involvement of additional programs for video recording, creating interactive tasks, posters, tables, tests and the use of design and modelling programs.

4. Results and discussion

Upon completion of the development of the presented technology, an experimental study was conducted, which included the identification of the appropriate level of application of the technology of creating educational content for open digital resources in general technical disciplines. The obtained experimental results before and after the experiment were verified using Pearson criterion and are presented in tables 1, 2.

There are considered the levels of use educational content for open digital resources in general technical disciplines.

Table 1. The results of the study of the level of use educational content for open digital resources in general technical disciplines before the experiment.

Level	EG,%	EG, n_i	CG, %	CG, n_{i_1}	$(n_1 - n_{i_1})^2$	$(n_1 - n_{i_1})^2/n_{i_1}$
High (A)	1.79	2	2.61	3	1	0.333333
Sufficient (BC)	27.68	31	32.17	37	36	0.972973
Initial(CD)	70.53	79	65.22	75	16	0.213333
Total	100	112	100	115		1.52

Table 2. The results of the study of the level of use educational content for open digital resources in general technical disciplines after the experiment.

Level	EG,%	EG, n_i	CG, %	CG, n_{i_1}	$(n_1 - n_{i_1})^2$	$(n_1 - n_{i_1})^2/n_{i_1}$
High (A)	18.76	21	12.17	14	49	4,725
Sufficient (BC)	71.44	80	50.44	58	484	11,26552
Initial(CD)	9.8	11	37.39	43	1024	32,14884
Total	100	112	100	115		18,27783

The initial level (DE) of use of educational content for open digital resources in general technical disciplines is characterized by the acquisition with the theoretical material with video or interactive lectures. The sufficient level (BC) is considered the calculating the practical tasks with video instructions and interactive posters and performing interactive tests. The high level (A) takes into account the ability to prepare laboratory works and engineering and technical projects with creation of 3D models and performance of practical works with the use of modelling and design programs.

It is calculated the degree of freedom ν by the formula $\nu = k - 1$, k – number of levels. Therefore, $\nu = 2$. It is defined a critical value for the degree of freedom χ^2_{crit} (5.991; 9.210) for levels of statistical significance $\rho \leq 0.05$ and $\rho \leq 0.01$. The levels of statistical significance allow to define zones of significance and insignificance for the received values.

Before the experiment χ^2_{emp}=1.52, $\chi^2_{emp} \leq \chi^2_{crit}$, which means that the deviations between distributions are insignificant. Therefore, it is accepted hypothesis H0 – there are no significant differences in the level of use educational content for open digital resources in general technical disciplines in the experimental and control groups.

After the experiment χ^2_{emp}=18.2, $\chi^2_{emp} \geq \chi^2_{crit}$, which means that the deviations between distributions are significant. Therefore, it is accepted hypothesis H1 – there are significant differences in the level of use educational content for open digital resources in general technical disciplines in the experimental and control groups.

In the context of the discussion of the developed technology of creating educational content for open digital resources in general technical disciplines and its implementation to the educational process it is necessary to note that the educational horizon has changed with the arrival of open educational resources [28]. Empirical studies of using open digital resources noticed the numerous effects on a number of topics such as increased engineering knowledge, STEM skills etc [29]. Using open digital resources, in particular in studying general technical disciplines, contributes to generating and sharing educational knowledge. It can be adapted and combined to create new resources that better meet the specific needs of different kinds of users and scenarios [30].

The technology of creating educational content for open digital resources in general technical disciplines includes the construction of the video, graphic and interactive content. Various studies have demonstrated that video education can be helpful tool for studying technical disciplines, particularly for hard-to-visualize processes. Videos allow students to view content at their own pace and revisit materials on demand. Also well-designed videos can be repurposed

by tutors, eventually reducing time needed to make high-quality educational content [31]. It is important to adopt the cloud technologies to the needs of educational institutions [32]. In general, it is necessary to develop skills in the use of technology for significant increase in student practice scores. However, the guidance of the tutors in the conditions of open digital resources plays crucial role [33]. Open digital resources are developed for a specific purpose and aligned with the specialized subject content, and the resource must be precise and peer reviewed for quality measures [34]. The proposed technology was developed for the general technical disciplines and it takes into account the specific of those disciplines. Video, graphic and interactive content as well as using special engineering services for this content makes it possible to demonstrate natural objects and phenomena, study the principles of operation of machines and equipment, present step-by-step the method of calculation of engineering objects and to consider and design technical objects in the dimension.

It is important to rise the lecturers' awareness and knowledge to utilising the free online digital tools available [35]. In the conditions of studying technical disciplines, it is necessary to understand and gain skills in the digital environment at a practical level and learn how to work in it, to give an understanding of the digital tools of the future specialist and their effectiveness [36]. The paper highlights practical aspects and experience of the functional approach applying to the development of contemporary digital learning aids in the progress of project-driven activity [37].

In the context of organizing the individual work of students it is principal to apply new approaches in the educational process with the using of the modern information technologies [38]. In studying general technical disciplines, particularly Engineering and Computer Graphic, there is a need to use modelling and design programs and 3D geometric environment [39]. Graphical content provides a more visual representation of the product, the absence of the need for an additional physical model, process automation, the possibility of using 3D models in various programs and devices. There is also the possibility of automated calculation of various properties of the product, such as the calculation of heat distribution, mass-inertial characteristics, which is important for interdisciplinary connections when studying general technical disciplines.

The experience of developing and implementing visualized cases using a combination of Google services and digital computer measurement system in the process of teaching STEM disciplines shows positive results [40]. It is important to take into account the specific of engineering disciplines [41]. Interactive laboratory tools and engineering calculators can be useful in order to avoid routine calculations in order to concentrate on the immediate topic of the lesson. Interactive infographics in the context of interactive lectures is a more attractive version of such a tool, as it more broadly reveals concepts and concepts. Interactive posters for practical work allow you to maintain the sequence and logic of the work and provide hints and useful tips during the execution. The use of interactive content in digital educational resources when studying general technical disciplines helps to carry out operations with their elements, interact with images, tests, surveys, videos, physical and technical models.

As a result of using proposed technology, higher education applicants execute tasks, obtain points and achieve competencies in general technical disciplines. The using of the technology of creating educational content for open digital resources in general technical disciplines is effective that was confirmed experimentally.

5. Conclusion

The processes of informatization of education, which have recently become more widespread, are aimed at the digitization of educational resources. The formation of the educational content for open digital resources in general technical disciplines has certain features due to the large number of graphic objects, calculations and natural and mathematical concepts. It is presented the technology of creating educational content for open digital resources in general technical disciplines. The proposed technology consist of the following stages: development, design,

posting, final. The development stage outlines the methodical peculiarities of creating video, interactive, graphic content for different forms of classes: lectures, practical and laboratory classes and independent work. Video content includes video lectures, video instructions for practical and laboratory work, video recording of the speech of higher education applicants. Interactive content consists of the lectures and labs with interactive elements, interactive posters and tests. Graphic content includes creation of lectures with graphical models, 3D models for laboratory works, performance of practical works with the use of modelling and design programs and creation of engineering and technical projects. There are outlined services for achievement of the educational purposes for creating each type of content at the design stage of the proposed technology. At the posting stage the tutor download the relevant task (lecture, explanation for the practical or laboratory task, test) in an open digital resource. Final stage takes into account the execution of tasks by higher education applicants, obtaining points, acquisition of competencies. The result of using proposed technology is achieving competencies in general technical disciplines in the conditions of open digital resources. The reliability of the results was checked using the Pearson criterion. It is determined that the technology of using educational content for open digital resources in general technical disciplines is effective.

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