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Implementation of web resources using cloud technologies to demonstrate and organize students' research work

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Abstract. The possibility of increasing the efficiency of research work of students by introducing specialized web applications for group work and presentation of research results is substantiated. The main directions of using web resources in research work are determined. Possibilities of cloud services for the organization of cooperation of teachers and students on scientific projects are opened. The expediency of creating specialized websites and mobile applications to present research results is emphasized. Requirements for the content of web resources used for the presentation and organization of research activities of students, which should provide the ability to manage research projects, communication between all participants in the learning process, as well as providing the necessary scientific and methodological materials are determined. An interactive prototype of a specialized site and a corresponding mobile application has been created, which contains files and services necessary for coverage of research areas and activities of collective scientific work at the department. An experimental study of the effectiveness of using a specialized web service has been carried out. The final survey of the students involved in the experiment indicates a significant increase in the number of students interested in scientific work. This confirms the expediency of using the proposed resources for the development of research work.

1. Introduction

The intensive introduction of high technologies and high-tech industries requires the use of new approaches to the organization of training and the introduction of advanced educational technologies based on the achievements of scientific and technological progress [1–5]. In this regard, the requirements for a modern specialist who are capable of innovative activities and solving non-standard professional tasks based on the development of research competencies are increasing.

The innovative potential of the modern specialist is characterized, first of all, by creative ability to generate the new ideas caused by the professional attitude to achievement of priority

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tasks; the ability to model their ideas in practice; also the perception of new ideas, trends based on the breadth and flexibility of thinking [6].

The introduction of new information technologies in the educational and cognitive activities of students would expand the forms of self-education, intensify the research work of students and contribute to the development of innovative potential among future specialists. These requirements require the transformation of the educational system, namely the transition to a new psychological and pedagogical technology – the creation of an open, intellectually rich educational information environment [7].

Research by S. Amelina [8], V. Bondarenko [9], S. Bondarevskyi [10], V. Bykov [11], M. Kyslova [12], O. Lavrentieva [13], S. Malchenko [14], I. Mintii [15], Y. Modlo [16], N. Morze [17], V. Osadchyi [18], T. Selivanova [19], S. Semerikov [20], K. Slovak [21], V. Soloviev [22], M. Striuk [23], V. Tkachuk [24], S. Tolmachev [25], T. Vakaliuk [26] and others is devoted to the disclosure of new trends in the organization of scientific and communication activities using web resources and the use of mobile information and communication technologies in education. The work of P. Nechupurenko [27], N. Morze [17], A. Gritchenko [28], O. Potapchuk [29], S. Semerikov [20], Y. Shramko [30], I. Sinelnik [31], V. Soloviev [32] and others is devoted to the disclosure of aspects of the use of information technologies that contribute to the activation of scientific and cognitive activity. The analysis of the researches indicates that, despite the theoretical and practical achievements of scientists in the field of information technology, the issues of their application for the organization of research work are relevant and require more careful study. In particular, V. Lamanauskas and D. Augien noted the need to develop scientific cooperation between teachers and students, as a result of which students would have the opportunity to actively participate in scientific research, receive effective support, gain experience and see the results of activities [33]. Therefore, a detailed study of the possibilities of using web technologies for organizing student research work, taking into account the specifics of applied problems, is relevant.

In addition, in the information and educational sphere, it should be noted a fairly low level of information about the conduct of research work in student societies. Information about students' research work presented on the websites of educational institutions is usually limited to announcements of the results of students' participation in competitions, a list of research clubs and a list of master's theses, as well as announcements of planned conferences. Under such conditions, these web resources do not contribute to the activation of students' scientific development. To change this situation, it is important to create specialized web resources (websites and mobile applications) that not only provide information on the list of planned seminars or conferences and the results of participation, but also coordinate student research clubs and provide detailed information on current research.

The analysis of modern research on this issue indicates the relevance of further development and implementation of new methods of using cloud services in higher education, including research [34–48].

The purpose of this study is to reveal the specifics of creating and using specialized web applications using cloud technologies to organize research work of students.

2. Presentation of the main material of the study

2.1. The directions of using of web resources in scientific work of students

Modern scientific research in the context of the application of information technology is taking new forms. This is facilitated primarily by the technology of automatic data collection and processing, statistical data analysis systems, Internet search technology and remote information processing, data storage, presentation of results [28].

The use of the latest information technologies in science leads to the emergence of new methods and directions of research, the development of tools and methods for formalizing

research.

Particularly relevant for research is the use of network technologies at the stage of accumulation of knowledge and facts. Thus, for the analysis of literature sources, searching in electronic catalogues of libraries, ordering literature sources through the internal network of libraries and through online stores is becoming increasingly effective. Also important is the ability to automatically translate the text using online resources, storage and accumulation of information, communication with leading experts [49].

An important area of application of network technologies in science is the organization of the work of virtual research laboratories. This allows, in particular, to attract scientists from different parts of the world to conduct research directly in their laboratories with the subsequent exchange of information through a computer network [50, 51].

It should be noted that modern communication technologies provide unique opportunities for the mass publication of information. However, with the loss of control over publications, the level of information becomes too uneven, in fact, noise, among interesting scientific ideas.

Thus, today there is a problem of awareness among the general public of network users, future professionals about the activities of research laboratories and student research clubs. Most of the research units do not have their own official websites where information about their work would be available. A small number of laboratories are represented online by pages on the websites of higher education institutions and research institutes in the structure of which they are included, but the information on such pages is insufficient and does not allow to get a complete picture of the research, activities and scientific interests of the laboratory. Therefore, there is a need to create your own network resource for the presentation of scientific research.

So, the creation of a web resource for the coverage of research works is relevant and will not only reflect the scientific activities of students for the general public, but also concentrate and systematize useful and reliable information about this applied area on one network resource.

In the process of analysing the available web services for organizing research work, it was found that existing solutions, usually, do not provide the required level of detail of scientific content and are also expensive to maintain. Therefore, we consider it necessary to focus on the benefits of SaaS services for organizing student research work.

2.2. Using cloud SaaS services for organizing research activities of students

It is possible to increase the efficiency of students' scientific work and motivate them for research by introducing Web based systems for organizing joint work on research and maintaining appropriate documentation.

The formation of a cloud educational and scientific environment in higher educational and research institutions is an important condition for the training of ICT specialists capable of further active, scientifically grounded application of cloud technologies in their professional activities [33, 52, 53].

The use of web resources based on cloud services allows to unite both teachers and students into a single university network for collaborative work on projects, organizing web conferences, using e-mail and expanding functionality [11, 54]. The development of cloud technologies makes it possible to introduce an innovative program into the educational process to optimize it, simplifying the joint work of students and teachers, significantly expanding the types of cooperation, developing cooperation skills, rationally using time and learning opportunities [55].

The most common cloud services are: SaaS – software as a service, PaaS – platforms as a service, IaaS – infrastructure as a service, DaaS – virtual workplace as a service [56].

Google's SaaS cloud services are focused on broad and open access, maintain a common mode of operation that ensures communication, collaboration between educational process subjects and significantly enhances the factor of motivation and mutual intellectual activity. For educational institutions, Google offers a free version of the Google Apps Education Edition. SaaS

services have a number of benefits for educational institutions to use in a learning environment. Indeed, at any time, any student can access their resources and make changes [57, 58].

The use of cloud SaaS services in the organization of scientific research has several advantages (see figure 1).

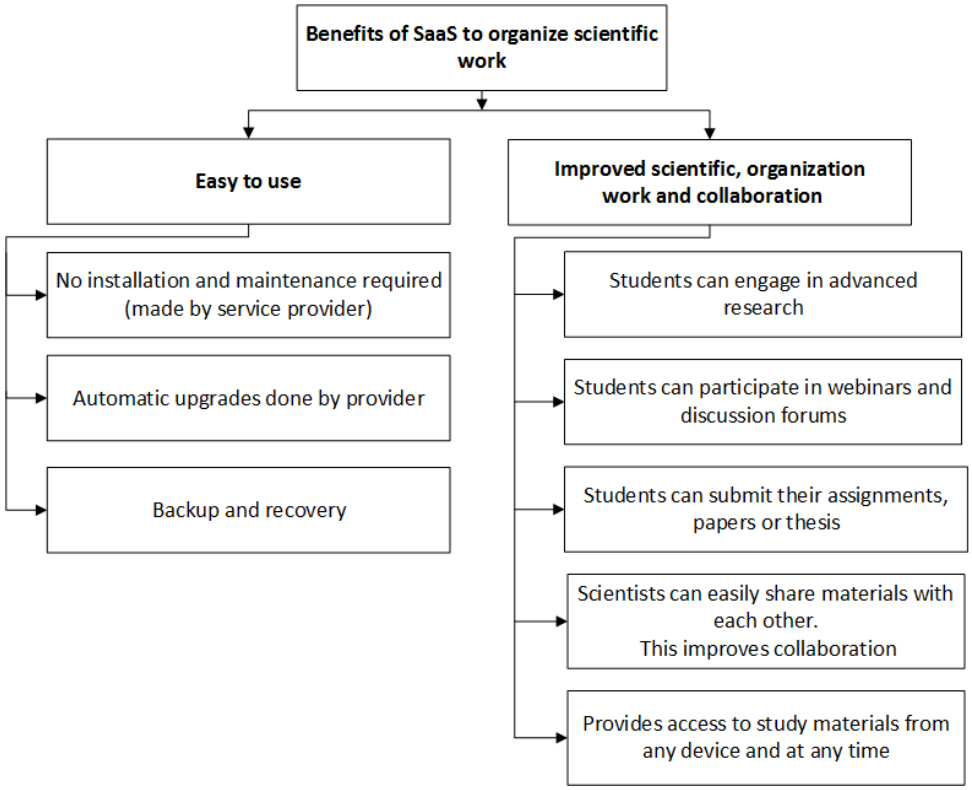

Figure 1. The benefits of SaaS to organize scientific work of students.

It should also highlight the shortcomings of SaaS cloud services: information security problems, vulnerability of personal data; additional training is required to implement this type of system; you need constant access to the Internet Insufficient network bandwidth will lead to incorrect operation of services.

Despite these shortcomings, cloud services today are a full-fledged tool with which you can organize the joint work of teachers and students on research projects, without being tied to the place and time of research. This, in turn, facilitates individual and collective research by students. In addition, the use of SaaS services will not only increase the efficiency of research work and the convenience of teachers and students, but also reduce economic costs.

2.3. Requirements for the structure and design of the web resource

A web resource for the coverage and organization of students' research work in scientific clubs and laboratories should provide:

- the ability to manage a scientific project process (electronic journal, calendar),
- communication between all participants in the educational process (discussion, chat, online consultations, webinars),
- joint activities of students to create joint projects,
- provision of scientific and teaching materials (electronic library, presentations, video files, cloud data storage).

In figure 2 shows diagrams of use cases, which represent the interaction of the user with the system, and also reveals the main capabilities of the web resource, in accordance with certain requirements.

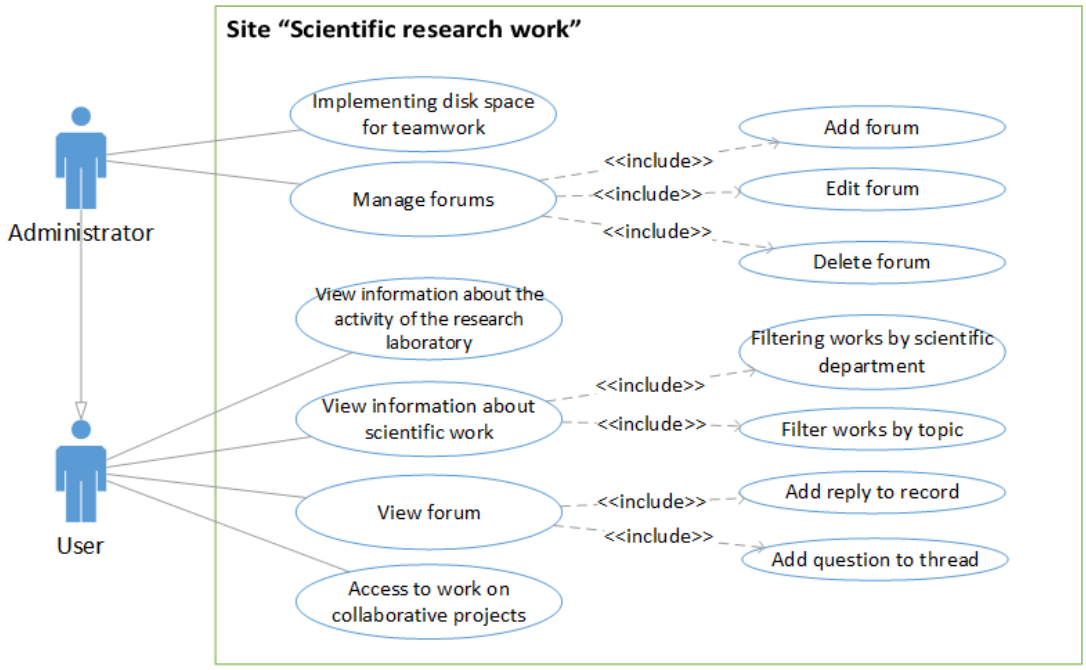

Figure 2. Use case diagram.

Development of site pages is carried out in accordance with the laws of ergonomics: the location of information on the page, ease of navigation, stylistic design, loading speed [59–61].

In the process of designing a web resource to ensure maximum efficiency of work and communication, it is necessary to take into account the ergonomic requirements, the description of which is given in figure 3 [62, 63].

In addition, to ensure communication between students and teachers, it is effective to implement a forum that discusses pressing research topics or provides links to relevant information that reveals the problem in a particular area of application. For the exchange of experience and its accumulation on a web resource, it is necessary to provide for the possibility of archiving, which will save information about the research problems and promising ways to solve them, discussion issues or presentations of scientific research.

2.4. Functional characteristics of the developed web resource

Functions performed by a research site arising from its content. First of all, it contains information about the directions of scientific activity, theoretical and experimental research, presented in a form accessible to both a scientist and a non-specialized reader.

Thus, the purpose of the site is to disseminate scientific achievements and organize research work of students, which will improve the efficiency of research and promote the growth of scientific interest among students.

In addition, the information on the web pages contains information of a scientific and applied nature in the form of general laws and concepts, knowledge of which is necessary to understand the essence of the research.

This web resource is primarily aimed at people who want to apply the results of scientific research in their professional activities, as well as specialists working in related fields of science.

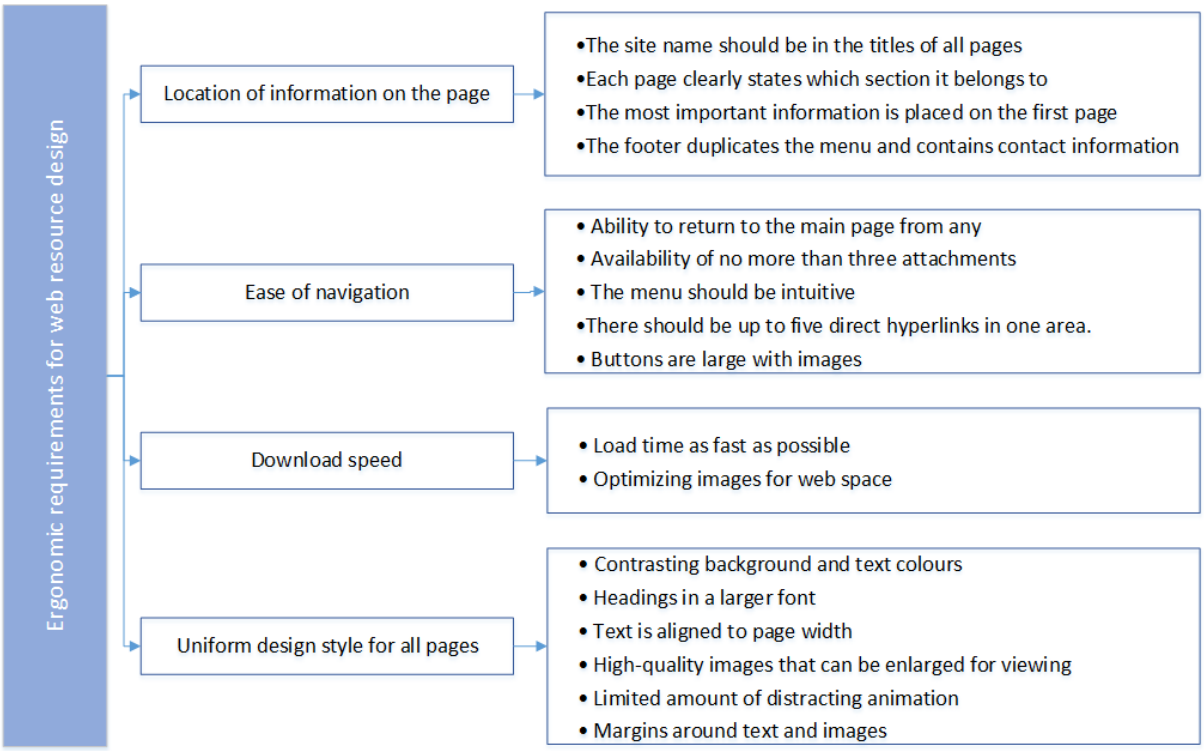

Figure 3. Ergonomic requirements for web resource design

Therefore, such a site performs a number of important functions. The main function is informational, which consists in presenting information on the site about the main areas of scientific work, background information on research problems, interesting news in this area. The communicative function is also important, which allows the use of network technologies to communicate between students and specialists in a general field of scientific interests.

Such a popular science web resource is designed to perform a number of scientific, organizational and educational functions to generalize the results of theoretical or experimental research, stimulate further scientific developments from these problems, consolidate the results of scientific knowledge and stimulate the creative professional activity of young scientists. This helps to create conditions for the exchange of experience and ideas between young scientists representing various scientific schools, to attract students to scientific activities, to acquaint them with the results of the latest research and the latest trends in the applied field.

Thus, the structure of the site is designed in accordance with the tasks that it must solve, and their specifics. As a basis, the hierarchical type of site structure was chosen, which is the most convenient for the user and involves the division of pages into categories and subcategories. In addition, the content of the sections, the structure and formatting of the pages are determined in accordance with the above ergonomic requirements.

Therefore, in order to effectively inform students and researchers about the results of scientific research, the developed online resource contains the following sections:

(i) Section with general information about the activities of the research laboratory or club, its employees, history of development, etc.

(ii) A news section that contains articles about events related to the field of scientific interests. These are, for example, information on conducting scientific seminars and conferences, articles on innovative research solutions.

(iii) The section in which the directions of scientific research are revealed. It reflects information about the scientific work that is carried out on the basis of this scientific unit and the subject of scientific research with a brief description of their content.

(iv) Section with information about student research papers: planned and completed term papers and master's theses. It is also advisable to disclose information about students' participation in scientific seminars, conferences, competitions and olympiads.

(v) Section containing scientific articles of students and laboratory staff, materials of seminars and conferences with their participation.

(vi) Section with presentation materials (photographs of installations, videos, a short description of projects) related to scientific projects that are currently being developed.

(vii) The section for the discussion of scientific problems, which contains a forum, provides an opportunity for online communication between scientists and students, as well as simply interested people on the proposed topics. Topics on the forum are added by registered users or by the site administrator after passing the moderation procedure.

To organize joint work on existing projects, the site also provides a section that gives access to documents for registered users. In addition, a calendar with scheduled events has been added to this section. For example, holding a Zoom or Meet conference to discuss pressing issues.

It should be noted that the learning process involves the use of mobile Internet devices, thereby encouraging each student to work independently, creates a favourable situation for communication and conditions for the development of the creative abilities of the individual, increases the motivation and cognitive activity of students [64, 65]. Thus, for a more convenient access to the site, a mobile application was created on its basis (figure 4). The AppsGeyser platform was used to quickly and efficiently create a mobile application. This platform allows you to turn a developed website into a mobile application for free. Conversion occurs according to the following sequence of steps: template selection, design settings and main sections, publishing the application.

The developed web resource allows to use the information about research work of students as much as possible. The network resource provides interconnection and the possibility of online communication between scientific departments, specialists and research students.

The ability to view your own search results on the site and interactively add to the scientific developments of the department and its laboratories gives the student confidence in the importance of knowledge gained during scientific work or a seminar. The result of this is an increase in the level of interest in scientific research in this area, a wider involvement of future specialists in the development of science.

The importance of using such technologies in research activities is confirmed by the requirements for the formation of the competencies of future specialists, provided for by the standard of higher education in specialty 015 "Professional education". The document notes that in accordance with general and professional competencies, a graduate must have "the skills to use information and communication technologies, the ability to study and master modern knowledge, as well as the ability to use the basic principles and methods of fundamental and applied sciences in professional activities" [66].

In order to analyse the effectiveness of using the developed website and mobile application for the formation of the above professional competencies, an experimental study was carried out. This made it possible to verify the feasibility of using the proposed resources for the development of students' scientific thinking, which is necessary for future scientists to make independent decisions in the process of preparing, writing and defending scientific projects, articles and reports.

The study was carried out on the basis of a research group, which functions at the innovation centre for 3D design and production technologies. It should be noted that before the introduction

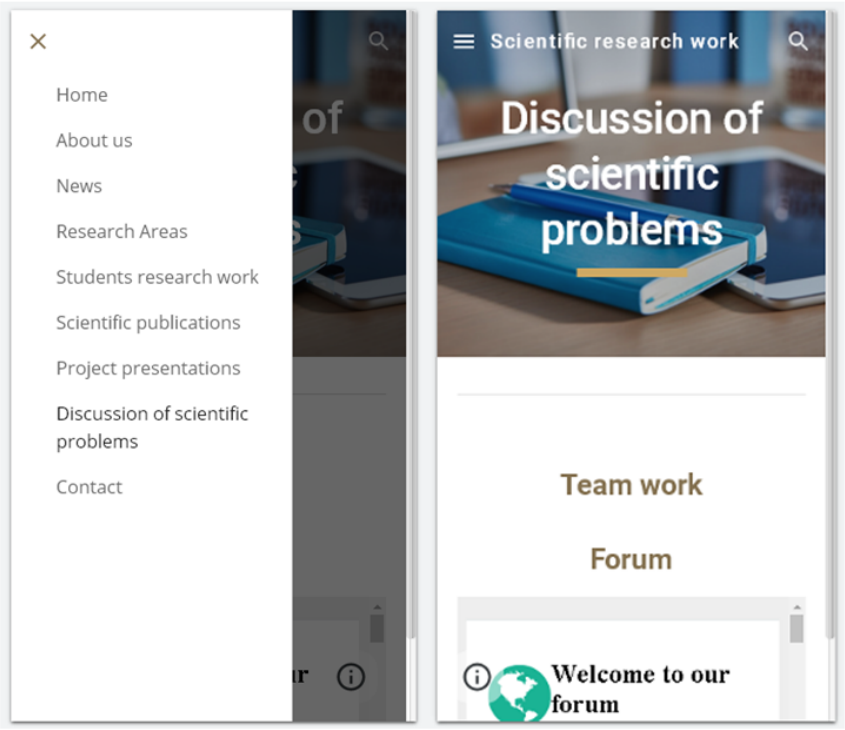

Figure 4. Pages of a mobile application for organizing research work of students

of the proposed resource, there were 14 students in the group. With the introduction of a web resource that popularized research work, the number of students who became interested in research work in the group increased to 27. This indicates a growing interest in research work using specialized web resources.

Today, attracting students to expert groups is an integral part of the quality assurance process in higher education. Therefore, we will consider the results of the survey of students as an expert assessment.

In addition, a survey was conducted among students of the faculty, in which 124 students took part, where they had the opportunity to answer a multiple choice question. Among the questions posed were the following:

- What do you think: is it advisable to use specialized web resources for organizing research work?
- Do you consider this form of organization of student research activities convenient?
- Have you used the proposed mobile application?
- Have you identified any inconveniences the organization of your scientific activity in this format? If so, which ones?
- Indicate (if any) proposals for the structure and content of the developed resource.

A significant number of surveyed students (92%) consider this form of organization of their scientific activities convenient, especially in the conditions of distance learning (figure 5). It also promotes the popularization of research activities (noted by 84% of students) and motivates people to participate in research activities (68%). However, it should be noted that a small number of students showed no interest in the developed resource (12%).

During the survey, students also noted certain features that would improve the work with the web resource. In particular, the respondents' suggestions regarding the foresight of the English-

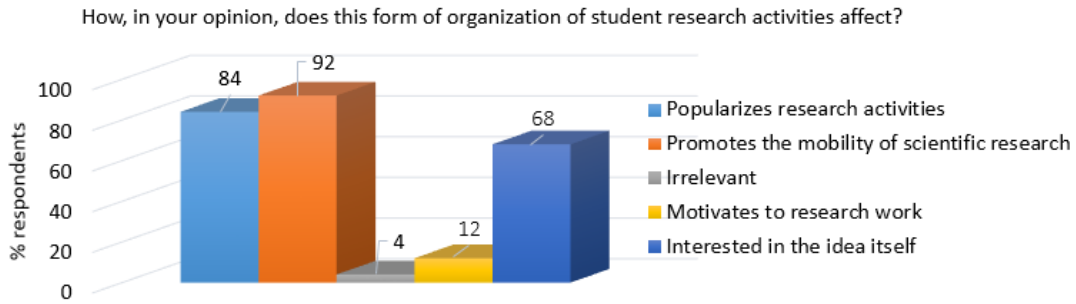

Figure 5. Results of a survey on the feasibility of introducing web resources.

language version of the resource were appropriate, which will contribute to its popularization in the Internet.

After analysing the results of the survey, we conclude that the use of a website and a mobile application to coordinate and present research activities is an effective way to develop students' scientific thinking. It also contributes to the development of professional and research competencies required by future scientists for their scientific activities.

So, using web technologies to organize the research work of students, we get the main advantages:

- ability to obtain relevant scientific information according to the research topic,
- the possibility of operational cooperation of research subjects on-line,
- development of students' cognitive activity and their research competencies.

However, we consider it expedient to highlight the disadvantages of using web technologies for organizing students' research work [29]. This is, first of all, the need for proper hardware and constant monitoring of the resource, its content.

In addition, the negative aspect is the reduction in the time of direct communication with research participants. The use of online conferences only partially compensates for this disadvantage.

Taking into account all the positive and negative aspects of using web technologies for organizing the research work of students of higher educational institutions, it can be argued that the use of such modern technologies contributes to the qualitative formation of professional and research competencies of future specialists.

3. Conclusions

Thus, the use of the capabilities of modern web technologies ensures the effective research work of students, not limited to the time and spatial framework of the organization of educational interaction and cooperation. The use of specialized web resources allows you to systematize and organize information about research conducted in a specific scientific field and to enhance the cognitive activity of students.

The capabilities of Google services allow you to create a full-fledged web resource that will provide online communication between research departments and specialists in the process of working on projects. This will not only increase the efficiency of research, but also reduce economic costs. The development of a web resource based on the free Google Sites platform information about the research work of students, as well as access to files and services used to organize collaboration on projects. Adapting the resource to mobile devices using, for example, the AppGeyser service provides more convenient and faster access to all information on the web resource.

An experimental study of the feasibility of using the created prototype of a web resource has been carried out. The study was carried out on the basis of a student research group, which functions at the innovation center for 3D design and production technologies. The final survey of students involved in the experiment indicates an increase in the number of students interested in scientific work. After the introduction of the proposed service for organizing research work, the number of students interested in research work almost doubled. Thus, as a result of the study, it was found that the use of such means contributes to the improvement of the presentation and coordination of research works and is an effective means of developing student research activities.

The developed resource is currently designed for the organization of research work, without taking into account specialization. Prospects for further research lie in the diversification of the resource, in particular, expansion with the help of external services of specialized content (for example, input / output of mathematical formulas, connection of graphic online editors, etc.). In addition, further research will be aimed at studying the technologies of using other Internet services, including social networks, which contribute to increasing student motivation for research and the effective organization of students' research activities in the process of their professional training in higher educational institutions.

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