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INFORMATION LITERACY OF STUDENTS IN GENETICS EDUCATION ON THE EXAMPLE OF BIOLOGY AND AGRONOMY MAJORS

Today, digital technologies have become an integral part of education. Integration of information technology plays an important role especially for natural sciences like genetics which requires accuracy and technological support. This paper finds out how well the students are familiar with the use of information technology in the study of genetics. Based on a questionnaire survey, we observed a low level of information literacy among students regardless of the year of study (among students in years 1-4). The fact that most students consider information sites in Google and Yandex search engines as an easy and quick source of information and make them the main source of information does not always form a deep understanding and knowledge. The challenges students face is related to information literacy components such as finding, evaluating, and analyzing specific scholarly sources. In this paper, we examined scientific literature to tackle the issue and present a compilation of websites, virtual realities, and informational resources that enhance the educational experience in genetics. The resources aim to enhance learners' competencies by providing ongoing access to quality content.

Keywords: information literacy, information technology, genetic education, electronic resources, digital technology.

Introduction

The revolution in information technologies has elevated all aspects of human life to a new level. As a result, most pedagogical research has become a relevant topic in the process of continuing education, touching on the problem of technological integration. The education system in the country is tasked with enhancing the skills of future specialists by fostering digital literacy for the labor market. The advancement of science through technology in the same lane as the educational sphere complements the education sphere with scientific innovations from emerging fields such as genetics. For students and educators alike, staying updated with new discoveries is essential. All information technology can be viewed as a potential source of scientific information. Internet resources that meet the requirements associated with the development of technology are relevant in both online and offline formats [1].

Platforms and resources are utilized at different levels depending on the specifics of each subject. For example, technologies for the disciplines of biology, chemistry and physics from the range of natural sciences: supplemented by materials based on visualization, simulation and dynamic models, rely on virtual realities to replace and complement laboratory needs.

As discussed above, the driving force has been the expansion of genetic research and the development of technologies to improve genetics. The fields of statistics based on computer science, biological sciences, and information analysis have created the field of bioinformatics, which is the foundation for genetics to take a step forward. One of the technological breakthroughs that brought discoveries to all living things in the field of genetics was gene/genome sequencing, which is an advanced model of information processing. The sequencing results and speed of sequencing has led to the proliferation of genetic databases. According to the US National Center for Biotechnology Information, the GenBank database grew by 61% in 2020 [2]. Technology has also played a key role in the development of genetic engineering. Technologies such as CRISPR/Cas9 have taken the development of science to a new level. Electronic collections of information have helped visualize and store results. In a research paper by Daniel J. A. and colleagues, the authors conducted a literature review to identify nucleic acid databases in molecular biology. They found 185 articles and 1,645 databases worldwide through 2022, focusing on information collections related to molecular mechanisms. The data includes ranging from microorganisms (Chromatin immunoprecipitation database for prokaryotic organisms), plants (Plant Cell Marker Database), animals (Animal-eRNAdb) related to humans and their health (Human Antigen Receptor database) including all branches [3]. Such technological progress in genetics also affects the content of education. One of the

pressing issues remains the equipment of the educational institution. It is obvious that in the digital revolution era, discipline needs will be supplemented by properly selected technologies. Genetics shapes biological systems at different levels. Since most genetic entities are abstract, the textbooks that accompany the teaching of the subject do not provide a complete picture of the subject. Therefore, the usefulness of ICTs for improving genetics education is undeniable.

The rapid adaptation of the Internet to the educational process necessitates the reconfiguration of new pedagogical techniques that allow for complex and flexible work in the educational arena. To optimize the educational process using ICT, it is important to analyze the scientific results of research, which can lead to the generation of new ideas [4]. One of the theoretical models of effective integration of technologies is the concepts of successful application of the chain 'technology-pedagogy-content of education' TPAC [5]. This triple array: of digital technologies, methodological complex and full-fledged content of education contribute to the creation of a scientific, new educational environment for teachers. Guided by the difficulties and obstacles arising from the study of technology integration in higher education institutions, W. Wiencke proposed based on the TIP model demonstrating level integration with co-authors [6]. The FATI model on the role of pedagogy and literacy in this process as a guide in the process of integrating educators can be seen in the results of the study conducted by co-authors A. Fethi. In addition, the TIM model, which is a scale matrix on the issue of evaluating the level indicator of the digital environment created as developing and supporting educators, was developed by J. Christine Harmes et al [7]. The common goal of all these models is the right way to digitalize education. The large number and variety of technologies and programs used in the educational environment, we noted in the literature review prepared as part of the study. Depending on their purpose, software tools can be divided into the following groups: Modelling; Search engines; Intelligent computer programs; Experimental systems (virtual realities, laboratories); Open-format Internet resources (in the form of audio, video, and recordings) [8, 9].

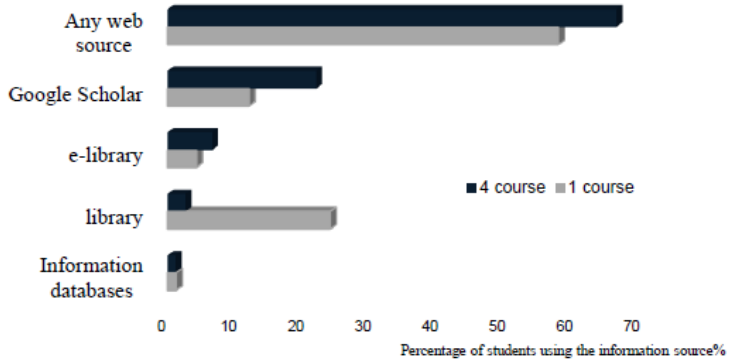
Materials and methods

First and foremost, the digitalization of education and digital literacy are related to the large flow of information on the pages of the Internet. Hence the need to develop students' skills in working with specific and reliable sources when it comes to literacy. To determine the level of information literacy of students, a survey was conducted on the use of information resources in the study of disciplines 'basics of genetics' for the educational program 'biology' of I. Zhansugurov Zhetysu University and 'basics of heredity' for the educational program 'agronomy' (n=68). The survey was administered using the 'Online Test

Pad' program. Along with the results of the questionnaire, a literature review was conducted to identify relevant and successful integrative technologies and information sources across all genetics-related disciplines, in line with current educational goals, to provide students with a list of specific scientific information resources. Articles were selected from Google Scholar, Scopus, Web of Science, and PubMed databases using the keywords: 'information technology in genetics education', 'genetics and information literacy', 'electronic resources in genetics education', and 'ICT in molecular biology'. While analyzing the articles, it was noted that, despite the large number of research papers on the application of ICT in sciences related to general biology, there is little research specifically focused on this area. Most of the identified studies focus on teaching medical genetics. Based on the survey indicators and students' experiences, the best use of these systems in teaching genetics was selected considering the popularity among students of YouTube, web pages, and open-format educational portals as sources of information. The following rules were considered when providing all the identified information to learners and teachers: aavailability of educational portals, channels in an open format; coverage of topics and number of readers; YouTube channels, first source of information of educational portals (channel/ portal created by students, teachers or organization).

Results and discussions

Information databases, digital libraries, and all digital capabilities are certainly not innovations for students. Technology, gradually being introduced into continuing education, impacts both information literacy and scientific literacy. The level of students' awareness of information sources when working with scientific information in the learning process was determined based on a questionnaire. The questionnaire was designed to assess students' ability to work with information in the field of genetics. The survey also included first-year students from the biology education program to evaluate the experiences of relatively new students. As shown in Figure 2, the results indicate that most students limit their information sources when preparing for classes, primarily using sites found through Google or Yandex search engines.



Information bases: Scopus, Web of science, Pubmed....
Library: Libraries within the university
Electronic libraries
Any Internet source: any information sites in search engines Google, Yandex

Figure 1 – Sources of information used by students

According to the survey results, 66.7 % of 1st- and 4th-year students rely on open-access internet sources, despite the greater academic proficiency of final-year students in handling information sources. Using only internet sources as a source of information indicates that it is convenient for students as information can be obtained at any time without processing. The work of senior students with Google Scholar information database for searching articles and publications may be due to the need to work with specific and in-depth sources of information. However, approximately 25% of 1st-year students make use of the university's library collection. This is because students use certain teaching aids as directed by their lecturers. Since teachers play a key role in most educational reforms, some studies have explored the relationship between teachers and innovative technology-based pedagogy. McGuinness, in her study on the role of teachers in addressing digital literacy, believes that teachers have no formal need to teach students the specified skills, believing that students can build information literacy on their own through independent work [10]. In the following research paper, the results of a study of searching, evaluating, and analyzing information on the Internet show that after the technology skills workshop, the level of students' work with academic databases increased, although it was not statistically significant [11]. The lack of these skills in student learning has improved faculty information literacy a prominent topic of research [12]. Information literacy is a key indicator of the success of modern academic libraries in educational practice [1].

One of the main sources of information about new research and advanced technologies in genetics is scientific articles. During the classes, students were given tasks to write essays on the topics 'bioethical problems in human genetics', and 'about some hereditary diseases' to develop students' cognitive skills. Initially, students obtained the given information from information sites in Google, and Yandex search engines. Mostly references were made to sources in Kazakh and Russian languages. But among the given links we noticed very few articles. When solving the problem, students were provided with a list of academic search engines and journals, such as online Scopus, Web of science, Google Scholar, which publish the results of recent genetics research, indicated in Table 1.

Table 1 – List of information retrieval systems for genetics and natural sciences

Information retrieval systems	Content	URL
The Republican Interinstitutional Electronic Library	The materials published on the RIEL online resource and the services offered by RIEL are regarded as a means of obtaining educational and scientific information by international copyright standards in the digital environment.	http://rmebrk.kz/
The National Digital Library of Kazakhstan	A library of textbooks and teaching aids available to all categories of users.	https://kazneb.kz/kk/about
TheScientist	Includes the latest results and findings from genetic and genomic research.	www.thescientist.com
American Journal of Human Genetics	The journal includes research and literature reviews related to human heredity in the fields of molecular biology, cell biology, and genetics.	https://www.cell.com/ajhg/aims
Genes & Development	Genes & Development publishes high-quality research papers of broad interest and biological relevance in molecular biology, molecular genetics, and related fields.	https://genesdev.cshlp
PubMed	A collection of biomedical articles, journals, notes, and online tutorials created by the National Centre for Biotechnology Information	https://pubmed.ncbi.nlm.nih.gov/
Scitcable	A database of publications and e-textbooks from Nature, a British journal publishing research in the natural sciences	https://www.nature.com/scitable/
Oxford Academic	It is Oxford University Press's academic research platform that gives you access to over 40,000 books and 500 journals	https://academic.oup.com/

Analysis of the articles revealed a language barrier: students in the Kazakh group found working with information in English time-consuming and prone to loss of concentration. At the same time, we noticed that there are few information resources in Kazakh language for teaching genetics. However, the importance of video presentations for learning a format in which information is easily perceived by students can be seen from the survey results presented in Figure 3. Students will benefit regardless of whether the video is in English or another language

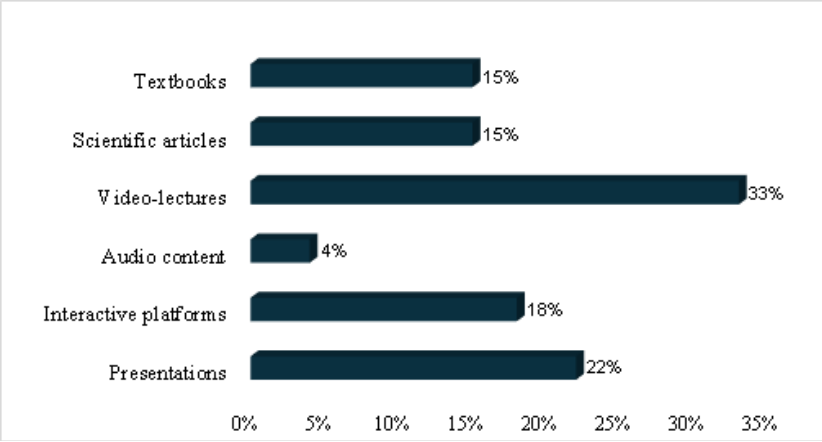


Figure 3 – Students' choice of format for receiving information

H. Hunter et al. demonstrate the effectiveness of electronic visual materials in students' perception of information in finding solutions to some difficulties arising from the abstract content of genetic concepts [1]. However, D.L. Newman et al. note that the volume of genetics videos is large and most of them offer a passive form of information transfer. Videos centered on published questions and real-life situations, designed by the authors to actively educate resource users, develop students' [15] research abilities. YouTube is a repository of open-access videos across various fields. It is a global platform used in formal and informal education. Demonstrations of platform experiments in genetic education can help meet some laboratory needs. Offers lab demonstrations on topics such as genetic cloning, DNA extraction, DNA barcoding, CRISPR. Video visualizations accompanied by graphics and animations help to understand the mechanisms of heredity. There is also an opportunity to listen to podcasts on various topics of interest, such as: 'Can we cure genetic diseases by rewriting DNA?', "Environment and its impact on our genetics", etc. The implementation of this network in the educational process has

been successfully applied to blended learning [16], Flipped class [15] and online learning [7] methods.

The student survey asked the question, 'What YouTube channels are you subscribed to while studying genetics?'. Most students (83%) reported that they watch any video that appears in search results, while the remaining 17% subscribe to specific channels related to studying genetics. The results of the analysis of students' choices and channels are presented in Table 2. Due to the small number of channels in Kazakh, the list includes channels created by official commercial and non-commercial organizations, in Russian and English.

Table 2 – List of YouTube channels recommended for use in genetic education at different levels

Content	Name of the channel	Source of information
Students' Choice	Gulzhaina Kenesova language: Kazakh	Kazakh dubbed versions of English videos on molecular biology
	Qaz med language: Kazakh	Explanatory videos related to human anatomy and molecular mechanisms
	Cor Medical language: Russian	Covers all topics related to medical biology
	Khan Academy Russian language: Russian	Lectures on the basics of genetics and molecular biology/genetics
Research-based mixed format	Nature video language: English	Based on research by Nature and other leading scientific journals from Nature's research portfolio
	Oxford Academic (Oxford University Press) 3d videos language: English	Oxford Academic's official academic YouTube channel is a collection of video lectures and demonstrations by leading experts and academics in a variety of fields
	The Thought Emporium language: English	A research and education group that develops and researches technologies in various scientific fields

Genetic engineering	BIO CPM Molecular biology language: Russian	A set of videos supported by the Department of Biology, RF Centre for Teaching Excellence.
	InternetUrok.ru language: Russian	A collection of short videos on the basics of genetics
	Khan Academy language: Russian	Channel of a non-profit organization containing video lectures on the basics of classical genetics and molecular genetics
Lectures and podcasts	Genomics Education Programme language: English	A collection of online seminars and specially produced videos supported by NHS England.
	BioNetwork language: English	BioNetwork offers high quality science instructional videos that can be used as preparation for lab work or as a post-lab analysis tool.
	Innovative Genomics Institute – IGI language: English	The Institute for Innovative Genomics (IGI) is a joint research institute of the University of California, Berkeley and UCSF. This YouTube channel features the latest educational materials on biology and CRISPR-Cas9 genome editing technology.
Genetic laboratories	Henrik's Lab language: English	Molecular Biology and Genetics offers short scientific lectures and instructional videos on any topic
	The Jackson Laboratory language: English	The Jackson Laboratory is the official channel of the non-profit biomedical research center
	DNA Learning Center language: English	Cold Spring Harbour Laboratory contains technologies and discoveries in genetics

When teaching genetics for both scientific and non-scientific specialties, sources of different levels can be used depending on the scope of the topic and the depth of study. As the survey results presented in Figure 3 show, interactive platforms as an information format are popular among students. Today, the use of modern digital technologies to process large amounts of genetic information is

evident in the variety of large-scale information platforms created collaboratively by genetic programs and companies [16]. However, there are very few scientifically based websites and portals in Kazakh that cover a variety of genetic topics and include animations. Therefore, today educators need to adapt foreign-language resources to the Kazakh language and introduce innovations. For example, the portal 'Genome, Discovering the Life Code' contains lesson plans and educational information for students and teachers on topics in various areas of genetics.

Conclusion

Electronic resources provide students with the opportunity to access large volumes of information and utilize a wide range of tools. They can stay informed about the latest scientific developments, work with online databases, and deepen their understanding through software tools designed for analyzing genetic data. Keep up to date with the latest current trends and develop practical skills. However, students' skills in working with scientific databases need to be developed. Therefore, the research paper presents databases and websites that are convenient to use at any time.

One of the advantages of using information technology in teaching genetics is interactivity. Electronic resources offer interactive tasks that allow students to analyze information and draw conclusions in a virtual laboratory. This helps students develop critical thinking skills when working with genetic information. Consequently, continuous development of technology and knowledge content is required to increase the potential of e-resources in genetics teaching.

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«БИОЛОГИЯ» ЖӘНЕ «АГРОНОМИЯ» МАМАНДЫҚТАРЫ БОЙЫНША СТУДЕНТТЕРДІҢ ГЕНЕТИКА САЛАСЫНДАҒЫ АҚПАРАТТЫҚ САУАТТЫЛЫҒЫ

Бүгінгі таңда цифрлық технологиялар білім берудің ажырамас бөлігіне айналды. Әсіресе нақтылық пен технологиялық қолдауды қажет ететін генетика сияқты жаратылыстану ғылымдары үшін ақпараттық технологиялардың интеграциясы маңызды рөл атқарады. Бұл мақалада студенттердің генетика пәнін оқуда ақпараттық технологияларды қолданумен қаншалықты таныс екендігі анықталды. Сауалнама негізінде білім алушылардың оқу тәжірибелеріне қарамастан (1–4 курс білімгергерлері арсында) ақпараттық сауаттылақ деңгейінің төмендігін аңғардық. Студенттердің басым бөлігі Google және Яндекс ақпаратты іздеу жүйелеріндегі ақпараттық сайттарды жеңіл әрі тез ақпарат көзі ретінде қарастырып, негізгі ақпарат көзіне айналдыруы әрдайым терең түсінік пен білім қалыптастыра бермейді. Студенттерге кездесетін мәселелер нақты ғылыми ақпарат көздерін іздеу, бағалау және талдау сияқты ақпараттық сауаттылық компоненттерімен байланысты. Бұл жұмыста біз осы мәселе бойынша ғылыми әдебиеттерді қарастырдық және генетика саласындағы білім беру тәжірибесін жетілдіретін веб-сайттарды, виртуалды шындықтарды және ақпараттық ресурстарды ұсындық. Ресурстар сапалы мазмұнға тұрақты қолжетімділікті қамтамасыз ету арқылы студенттердің құзыреттілігін арттыруға бағытталған.

Кілтті сөздер: ақпараттық сауаттылық, ақпараттық технологиялар, генетикалық білім беру, электронды ресурстар, цифрлық технология

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ИНФОРМАЦИОННАЯ ГРАМОТНОСТЬ СТУДЕНТОВ В ОБЛАСТИ ГЕНЕТИКИ: ИССЛЕДОВАНИЕ НА ПРИМЕРЕ СПЕЦИАЛЬНОСТЕЙ «БИОЛОГИЯ» И «АГРОНОМИЯ»

Сегодня цифровые технологии стали неотъемлемой частью образования. Интеграция информационных технологий играет важную роль, особенно для таких естественных наук, как генетика, которая требует точности и технологической поддержки. Исходя из решающего роль генетического образования, данная статья направлена на оценку навыков учащихся в эффективном использовании инструментов электронного обучения в современном образовательном ландшафте. На основе анкетного опроса мы отметили низкий уровень информационной грамотности студентов независимо от года обучения (среди студентов 1–4 курсов). Тот факт, что большинство студентов рассматривают информационные сайты в поисковых системах Google и Yandex как легкий и быстрый источник информации и делают их основным источником информации, не всегда формирует глубокое понимание и знания. Проблемы, с которыми сталкиваются студенты, связаны с такими компонентами информационной грамотности, как поиск, оценка и анализ конкретных научных источников. В данной работе мы изучили научную литературу по данной проблеме и представили подборку веб-сайтов, виртуальных реальностей и информационных ресурсов, которые улучшают образовательный опыт в области генетики. Ресурсы направлены на повышение компетенций учащихся путем предоставления постоянного доступа к качественному контенту.

Ключевые слова: информационная грамотность, информационные технологии, генетическое образование, электронные ресурсы, цифровые технологии.

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