Развитие навыков командной работы у будущих педагогов-биологов средствами 3D-моделирования

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АННОТАЦИЯ

Проблема и цель. Модернизация высшего образования открывает перспективы использования технологий обработки трехмерных графических изображений при обучении высококвалифицированных специалистов для Индустрии 4.0. Информационное взаимодействие с 3D-моделями обладает потенциалом в плане формирования востребованных soft skills (креативного мышления, умения работать в команде, управления проектами) и повышения качества подготовки учителей-предметников цифровой школы. *Цель исследования* – выявить возможности использования средств 3D-моделирования для развития навыков командной работы у будущих педагогов-биологов.

Методы исследования. 3D-моделирование и работа в команде у педагогов-биологов поддерживается инструментами облачной платформы Vectary. Опытно-поисковая работа проведена на базе Вятского государственного университета (Российская Федерация). В эксперименте участвует 68 студентов по направлению подготовки 44.03.05. Педагогическое образование, профиль «Биология и английский язык». Работа с трехмерными моделями организована в рамках изучения дисциплины «Современные информационные технологии». Для оценки эффективности выбрана методика Лоры Стэк (пять уровней командообразования). При статистической обработке данных использован критерий χ^2-Пирсона.

Результаты. Работа обучающихся экспериментальной группы (теоретический, практический, методический и демонстрационный этапы), с одной стороны, позволяет подробно изучить функционал программного средства, реализующего возможности 3D-технологии. С другой стороны, взаимодействие в команде, включающее моделирование по инструкции и разработку методических рекомендаций, способствует формированию навыков самоуправления и виртуального общения, распределения ролей в коллективе, управления конфликтами, высокой производительности. Выявлены статистически достоверные различия в качественных изменениях, произошедших в педагогической системе (χ^2 = 10,660; p < 0,05).

Заключение. Определены факторы, влияющие на эффективность применения средств 3D-моделирования для формирования навыков коллаборации: выбор цифрового сервиса, качество и степень детальной проработки инструкций, опыт совместной деятельности и работы с графическими редакторами, профессиональные интересы.

КЛЮЧЕВЫЕ СЛОВА

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Development of teamwork skills in future biology teachers using 3D modeling

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ABSTRACT

The problem and the purpose. Modernization of higher education opens up prospects for using technologies for processing three-dimensional graphic images in training highly qualified specialists for Industry 4.0. Information interaction with 3D models can form popular soft skills (creative thinking, teamwork, project management) and improve the quality of training of subject teachers of the digital school. The purpose of the study is to identify the possibilities of using 3D modeling tools to develop teamwork skills in future biology teachers.

Research methods. 3D modeling and teamwork in biology teachers are supported by the tools of the Vectary cloud platform. The experimental and exploratory work was conducted at Vyatka State University (Russian Federation). The experiment involves 68 students in the field of study 44.03.05. Pedagogical education, profile "Biology and English language". Work with three-dimensional models is organized within the framework of studying the discipline "Modern information technologies". The Laura Stack method (five levels of team building) was chosen to evaluate the effectiveness. In statistical data processing, the Pearson's chi-squared test was used.

Results. The work of the students of the experimental group (theoretical, practical, methodological, and demonstration stages), on the one hand, allows for a detailed study of the functionality of the software tool implementing the capabilities of 3D technology. On the other hand, teamwork, including modeling according to instructions and developing methodological recommendations, contributes to the formation of self-management and virtual communication skills, distribution of roles in a team, conflict management, and high productivity. Statistically significant differences in the qualitative changes that occurred in the pedagogical system were revealed (χ^2 = 10,660; $p < 0.05$).

Conclusion. The factors influencing the effectiveness of using 3D modeling tools for developing collaboration skills are identified: the choice of a digital service, the quality and degree of detailed elaboration of instructions, the experience of joint activities and working with graphic editors, and professional interests.

KEYWORDS

innovative educational practices, group interaction, information model, digital technology, team building, Vectary cloud platform

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INTRODUCTION

1. The report "Reimagining Our Futures Together: A New Social Contract for Education", published by UNESCO in 2022, calls on the scientific community to take active steps to strengthen solidarity and international cooperation in education. According to the organization's experts, this is necessary to: increase global research power; strengthen humanity's ability to anticipate and respond to future changes [1].

The Centre for the New Economy and Society notes that to create a strong economy for Industry 5.0 society that can support prosperity and growth, closer collaboration is needed between government, business, and organizations implementing innovative educational practices [2]. The ability to lead and make decisions, influence a team and group thinking, curiosity and continuous learning are the skills that, according to the findings of scientists from the Centre for the New Economy and Society, are expected to grow in demand.

Among the new sociological, environmental, and technological trends that are radically changing the field of education, UNESCO representatives note: artificial intelligence, AR/VR, and 3D technologies. Both the education system and participants in didactic interaction should quickly adapt to these new directions.

In particular, according to the conclusions announced at the World Economic Forum's Future of Jobs – 2023, sought-after professionals of the future will need the following skills [3]: that form the basis of emotional intelligence, collaboration, and project work; that form the basis of computational thinking, digital literacy. According to the conclusions of the forum's experts, the technological literacy of employees is the third fastest-growing key skill.

2. The formation of technological literacy (or corresponding digital skills at the school level), according to the conclusions of M. Klement, and K. Bártek, occurs effectively with the help of 3D modeling tools [4]. Manipulation in 3D environments helps to gain experience in several disciplines. This determines the need for teachers to take into account emerging new technologies for their subsequent methodically verified implementation in the educational process [5].

3. In 2019, a group of scientists under the auspices of the Institute of Education of the National Research University Higher School of Economics and with the support of the Sberbank Charitable Foundation "Investment in the Future" presented the results of their research into areas of training professionals related to universal skills, including teamwork and the ability to continuously learn [6]. The researchers note that many core (current) skills of employees will be lost. This is because technologies are developing faster than companies can develop and scale their training programs. In this regard, there is an objective need for teachers: who are proficient in modern technologies, in particular, 3D modeling; capable of collaboration, and managing teams of people.

Moreover, as noted earlier in the study by E. V. Soboleva et al., many modern digital tools, in particular gamification services, have the potential to develop collaborative skills [7]. In this work, the authors clarify this potential for student training in pedagogical specialties. They give examples of methodological developments in the context of the specifics of future work functions of mentors (subject teachers) of a digital school.

Similar ideas were formulated by E. Ferenc, R. Nemeth, and B. Firuza [8]. The authors substantiate that many modern educational tools and spaces are available for developing students' teamwork skills, which contain additional factors of cognition and motivation.

However, it is the visual 3D experience based on the gamified world of didactic purposes that allows students to fully immerse in the project. In addition, to maintain a high level of detail of the object under study. Yet, the main focus of modern scientific research is on the use of 3D modeling for training specialists in the fields of construction, architecture, and medicine [9]. Or the use of three-dimensional modeling in teaching teachers to develop their spatial thinking and gain visualization experience [10]. Rare studies concern teaching using digital biology with the support of 3D models [11].

So, on the one hand, skills in working with innovative digital technologies (including 3D modeling), experience in collaboration, and project management are important in-demand universal skills for in-demand specialists of the future. On the other hand, work on 3D modeling also has didactic potential in terms of developing the skill of "teamwork".

The hypothesis of the study is that the inclusion of elements of 3D modeling in the training of students of pedagogical specialties will provide additional conditions for the development of in-demand skills of "teamwork".

The work aims to identify the features of developing teamwork skills in future biology teachers using 3D modeling.

Research objectives:

- to clarify the problems of implementation and the possibilities of 3D modeling tools in teaching biology teachers;
- to describe options for organizing teamwork of biology teachers using 3D modeling, taking into account the specifics of their training;
- to identify factors influencing the quality of using 3D modeling tools to develop collaboration skills in future biology teachers;
- to experimentally test the effectiveness of the proposed option for organizing 3D modeling.

MATERIALS AND METHODS

3D modeling is an educational activity of creating a three-dimensional model of an object using specialized computer programs. The task of 3D modeling is to design and implement an information model, that is a visual volumetric (three-dimensional) image of a real or imaginary (ideal) object. The skill of "teamwork" in the activities of a biology teacher includes the ability to be an active participant in didactic information group interaction, achieve common goals, solve problems, and build relationships in a team in a digital educational space solving professional problems.

The experiment involved 68 students of the Faculty of Pedagogy and Psychology of Vyatka State University (Russian Federation). The direction of training – 44.03.05 Pedagogical education, with the profile "Biology and English language". Average age – 20 years (65% – girls, 35% – boys). All students are third-year bachelor's students. For 3D modeling, the Vectary platform is used. This is an online tool that allows you to create, edit, and publish 3D projects.

During modeling, teams consistently work with the service tools and discuss the studied functionality and educational opportunities. As a result of the discussion, each student comes to a personal conclusion about the didactic potential for solving problems in the context of future professional activity.

To support 3D modeling, the course teachers developed instructions of varying levels of complexity (text description, with the addition of images of sample examples, with video comments). 3D modeling activities are implemented within the framework of the discipline "Modern Information Technologies".

Laura Stack's method for diagnosing the level of team building is used. The method includes tools for assessing personal and team effectiveness. The main idea is that each participant in the survey performs an individual assessment of the team's work (through a description of their own experience and perception).

4 sections of the methodology: "Fair attitude", "Readiness to be responsible for the result", "Systems", and "Technologies". Factors for accelerating teamwork are also provided. In the "Fair attitude" section, these are the factors: building relationships, managing conflicts, and strengthening integrity. The "Readiness to be responsible for the result" section: trust in colleagues, awareness of

responsibility, and maximizing efficiency. For the "Systems" section: making effective decisions, time management, increasing efficiency. In "Technologies", effective communications, effective meetings, and compliance with accepted rules are analyzed. Four limiting questions are used for each factor. A total of 48 limiting questions.

All test questions have the same beginning: "To what extent do members of my team..." The answer scale: "1 = absolutely not", "2 = to a minimal extent", "3 = to some extent", "4 = to a significant extent", "5 = to a huge extent". Based on the results, a final form is filled. The Pearson's chi-squared test was used for statistical processing of the data.

LITERATURE REVIEW

The findings of the scientists from the Centre for the New Economy and Society confirm that modern digital technologies are developing so quickly that there is not enough time to assess in detail all the effects and consequences of their implementation [2]. S. Dönmezer et al. conclude that Industry 5.0 marks a large-scale transformation in the industrial sector, caused by the integration of advanced technologies into production processes [12]. The authors study the transformative potential of digital human modeling in the revolutionary transformation of Industry 5.0 for various industries, including the textile industry, robotics, and energy. In addition, S. Dönmezer et al. argue that an insufficient level of digital literacy of employees at any level hinders the unlocking of the potential of the entire organization as a whole [12]. Which ultimately affects the process of digital transformation.

These findings are confirmed by A. I. Verenitsyn using a specific example of designing an information model when creating complex BIM projects for enterprises for the processing of minerals [13].

However, as A. Waqar and C. Bektaş argue, it is the employees’ teamwork skills that significantly influence organizational and technical decisions within the framework of digital transformation [14]. V. Stuikys and R. Burbaite argue that highly qualified specialists need to develop the so-called "integrated skills" (Integrated STEM (ISTEM) Skills): the ability to continuously learn; mathematical thinking; computational thinking and thinking aimed at ensuring activities with technical objects [15].

Heryanto, F. Firmansyah, Y. Rosmansyah prove that a virtual development environment (multi-user) maximally contributes to the formation of these skills [16].

According to the conclusions of N. A. Bushmeleva et al., 3D modeling and 3D printing are promising in terms of supporting digital innovations and training engineers capable of breakthrough discoveries [5]. The conclusions formulated by the authors are developed and confirmed by H. Pearson and A. Dube. Scientists have determined that 3D modeling is a new educational technology that prepares students for a new technologically designed world [17].

M. Klement and K. Bártek note that mastering the basics of 3D modeling is becoming a vital necessity. One of the manifestations of the digitalization of production is the growing interest of the scientific and pedagogical community in 3D modeling [4]. Interest in practice is manifested in the fact that working with 3D models is becoming an integral part of the curriculum (even in several primary schools). M. Klement and K. Bártek describe the experience of using software tools for printing 3D models; testing and analysis. The authors also present ways to modernize models depending on the test results.

One of the main trends in the development of 3D modeling, according to the findings of Ö. Sümen, is its increasing availability [18]. Previously, fundamental theoretical skills and programming skills, powerful computers, and expensive programs were required to create complex three-dimensional objects and animation. But with the advent of online services and cloud technologies, more and more users, according to the findings of G. Mercan, and Z. Varol Selçuk, can carry out design and modeling for didactic purposes [19]. This also applies to students with a pedagogical profile of training [20].

S. Sorour and M. Aziz, start from the fact that another important scientific trend is the increase in speed and productivity in working with 3D models [10]. New algorithms and optimization techniques allow working with more complex objects and scenes without loss of quality. This is especially relevant for the gaming industry, which requires the creation of realistic worlds and characters with a high degree of detail. The authors describe a collaborative and interactive experience of teaching teachers using 3D and animated characters. The study confirmed improvements in teachers' cognitive skills and the development of their design thinking. These findings are similar to those obtained by Ch.-H. Chung, Y. Lin, on the didactic potential of a problem-based learning model based on a 3D game to motivate students and increase their satisfaction with learning [21]. The authors substantiate the significant positive impact of 3D modeling on improving academic performance and receiving satisfaction from labor recognition.

M. S. Marji, N. Che Derasid, and A. Musta’amal argue that a modern specialist should have a developed visual communication skill [22]. Without the ability to represent ideas graphically, it will sometimes be difficult to perform work in many professions of the future (analysis, design, production, training).

M. Zhou shows that teachers in practice can create high-quality educational resources for the development of education in the field of teaching a foreign language using 3D modeling tools [23].

F. Lombard, J. Da Costa, and W. Laura define a theoretical perspective for revealing the potential of teaching digital biology [11]. The authors pay attention to its feasibility. And they propose a methodological scenario supported by original 3D models F. Lombard, J. Da Costa, and W. Laura scientifically substantiate the need to prepare teachers to apply such methodological solutions (namely at the level of training in a higher educational institution) [11].

K.-S. Shin et al. suggest and prove that an educational environment based on 3D modeling is effective in terms of students acquiring in-demand universal skills [24]. This environment also allows us to demonstrate that working with three-dimensional models allows us to reduce costs and work in a safe virtual space.

K. R. Patil et al. note that new technologies offer the opportunity to create inexpensive, immersive multimedia environments that can support types of learning focused on the experience of physical design and construction [25].

E. Ferenc, R. Nemeth, and B. Firuza study the specifics of the work of virtual project teams as groups of specialists involved in ensuring the implementation of a game project, but at the same time territorially separated from each other [8]. Game mechanics in three-dimensional worlds allow us to implement the following innovation in education: if earlier game elements were transferred to the workspace, now the workspace is moved to the virtual universe. The significance of this work for the research being conducted is that it examines teamwork in 3D information virtual worlds. R. Ybañez, A. De La Cruz, and P. Ermita note that when managing virtual project teams, leaders should ensure an effective way of exchanging information between their members [26].

Yu. V. Amelina examines the role of teamwork in the formation of general competencies of students in IT specialties and identifies the following two key problems in organizing such activities: motivating students to continuously interact during the semester and assessing the results of teamwork [27].

The findings of E. Ferenc, R. Nemeth, B. Firuza [8], and Yu. V. Amelina [26] are partially contradicted by the research of J. Han et al. that few studies have demonstrated evidence that group work is superior to individual work in terms of creative design activities in the context of higher education [28].

M. Teplá, P. Teplý, and P. Šmejkal make a conclusion, which influenced the formulation of the hypothesis of the current study, that the attitude of the teachers themselves towards modern technologies plays an important role in the effect of using 3D technologies [29].

Moreover, as E. V. Soboleva, and N. L. Karavaev show, teamwork on a virtual project meets the requirements of a digital school and contributes to the professional self-realization of university graduates only if it is competently planned, directed, and supported by the teacher [30].

The performed analysis of the literature allows us to objectively conclude that:

- the study and application of 3D modeling tools for solving practical problems in terms of digitalization and transformation in teaching is an important step in the preparation of sought-after and highly qualified specialists (including biology teachers);
- information activities on the design of a three-dimensional object in digital biology have their specifics, which are superimposed on the features of teamwork with 3D models;
- the use of 3D modeling to solve problems and projects within the framework of teamwork has certain problems, including the need to motivate students to continuously interact during the project and evaluate the results of the collaboration.

RESEARCH PROGRAM

The first stage included an analysis of literature, experience in using 3D modeling, and relevant software in teaching students (for collaboration). The problems of using 3D tools in the preparation and joint activities of future biology teachers for work in a digital school were considered separately. For example, limited time and financial resources, the need to adapt teaching materials to the teacher's specialization (chemistry, physics, primary school). The types of educational and future professional activities where a teacher majoring in biology and English will be able to use 3D modeling tools were determined. For example, to analyze and determine the structure of molecules, human anatomy, design atlases and encyclopedias. The services and platforms that support 3D modeling were studied and analyzed. Taking into account the results of the literature analysis, it was decided to focus on cloud services (SelfCAD, Vectary, SketchUp, Tinkercad, etc.). Comparison criteria: ease of use, technical accessibility, functionality, availability of training resources, and a community of like-minded people. Based on a set of criteria, Vectary was selected.

The methods for assessing the level of team building were analyzed. In particular, the calculation of the group cohesion index of K. Seashore, the definition of mediated group cohesion, William Stefanson's "Q-sorting" questionnaire, and L. Stack's method. Taking into account the requirements of employers for future teachers of the digital school, and the specifics of virtual teamwork on 3D objects, it was decided to diagnose respondents using L. Stack's method [31]. Her questions are formulated in terms of soft skills and are as consistent as possible with international priorities in education.

Conventional names of levels when determining results. "Ideal Team Model" (from 216 to 240 points): during 3D modeling, the student clearly understands that his group is truly mobile and effective. He actively participates in the formation and maintenance of a constructive interaction environment and is focused on the high quality of the developed model. The need for point adjustments to the work from the leader of the team arises only from time to time.

"Road Model" (from 169 to 215 points): during 3D modeling, the student in the group is mainly focused on a single result and joint creativity. Some types of work (generation of ideas, discussion, implementation) can be improved. The positive attitude and level of motivation depend on the leader of the team.

"Golden Mean Model" (from 121 to 168 points): during 3D modeling, the team is in the process of formation and consolidation. It is necessary to work more actively to improve the efficiency of activities and master new tools and opportunities.

"Weather Vane Model" (72 to 120 points): serious changes are required in group management during 3D modeling. The student needs to reconsider their approaches to organizing joint creativity and implementing projects. The leader is recommended to look for other incentives and motivators for collaboration. It is necessary to improve the general professional competence of the team in each stage of 3D modeling.

"Model of unrelated and unfixed elements" (48 to 71 points): a team of future biology teachers should start working on improving the efficiency of 3D modeling activities. For now, the personal goals of each participant take priority over the general ones. It is necessary to develop the skills of joint creativity and group thinking.

Next, the place of work with 3D modeling tools and the structure of the discipline was clarified. Instructions with methodological recommendations for each stage of teamwork (theoretical, practical, methodological, demonstration) were compiled. At the second stage of the study, future biology teachers studied the materials of the discipline and used 3D modeling tools to complete team projects on digital biology. In the third stage, factors influencing the quality of the use of 3D modeling tools on the level of development of teamwork skills were identified.

RESEARCH RESULTS

The discipline "Modern information technologies" for the selected direction of students of the pedagogical specialty "Biology and English language" is studied in the third year in the first semester. It continues the sections and topics studied by future teachers in the first year within the framework of the discipline "Digital technologies of education".

In the first and second years, students have already studied the fundamental sections of biology, chemistry, ecology, and the discipline of the language module (English language, theory and practice of the English language, lexical and grammar practical course).

All participants in the experiment have experience in biology and interaction at school. According to the work program of the discipline, students must learn to understand the principles of modern information technologies and use them to solve problems of professional activity. In this regard, they must learn to reasonably choose software and study its functionality, taking into account their existing ideas. In the first-year classes, students studied the classification of modern information technologies, stages of problem-solving, and the basics of information modeling. Therefore, they have an idea of a graphical editor, their types, and examples of software. They also got an idea of 3D Paint as a means of creating three-dimensional models.

Theoretical stage. Working with 3D models was preceded by studying the basics of 3D modeling and such concepts as polygonal modeling; sculpting; texturing and unfolding a 3D model onto a flat surface for applying textures; lighting and rendering, adding effects (glare, shadows, etc.); compositing, etc. Students considered the principles of creating 3D models: topology, scale and proportions, deformation and animation, etc. The students also worked with an interactive 3D atlas of human anatomy, which was developed by the staff of the university department. Didactic purpose: rotate models at any angle; zoom in and out; delete structures on the surface to reveal the anatomical structures hidden underneath. Additional functions: organize quizzes to clarify the location; enable/disable various anatomy systems; support for Russian, English, and Chinese languages.

Analytical stage. Then the students looked at online services for 3D modeling: Vectary, SketchUp, Tinkercad, etc. They found that Vectary has the following features:

1. Intuitive interface: the service offers a convenient and easy-to-use interface that makes 3D modeling accessible to beginners while providing powerful tools for experienced users;

2. Cloud storage: all projects are saved in the cloud, which allows users to access their models from any device without the need to install additional software;

3. Collaboration: Vectary supports collaborative editing, allowing multiple users to work on the same model at the same time. This makes the platform ideal for team projects and remote work;

4. Libraries of objects and templates: the platform provides extensive libraries of ready-made 3D objects and templates that can be used to speed up the model creation process;

5. Integration with other tools: Vectary easily integrates with various tools and platforms such as Sketchfab, Figma, and others, allowing the created models to be used in various contexts;

6. AR and VR support: the created models can be used in augmented and virtual reality applications, which opens up wide possibilities for application in various fields such as architecture, interior design, gaming, and marketing;

7. Export and import: Vectary supports various file formats for exporting and importing 3D models, such as OBJ, STL, and others, ensuring compatibility with other 3D editors and printers.

Areas of application of Vectary: for designers, architects, marketers, and developers. Since the service provides tools for quickly creating and editing 3D models without the need for complex and expensive software.

Stage "Practical". After identifying such undoubted didactic advantages of the service in the experimental group, the teacher proceeded to divide into teams. After dividing into teams, the students of the experimental group began to work according to the instructions (studied the interface and functionality concerning 3D modeling of the object "computer mouse").

Below is a version of the simplest instruction, containing only text explanations and methodological recommendations. If necessary (at the request of the group with expressed unanimous consent), the teacher provided them with more detailed instructions (with images during the work or videos).

Step 1. Go to the website and register (https:// https://vectary.vercel.app/). You can register using your Google account. The account interface opens, then select the "+new project" button. Go to this page and you will have a working platform for creating projects. To create an initially empty sheet for working with objects, select the "Empty" button. Let's look at the controls and hotkeys: scrolling the mouse wheel allows you to zoom in and out of the camera; the right mouse button is used to move the camera along all three axes; the left mouse button can be used to move the camera around the axis of a certain area.

Step 2. Before starting to create models that biology teachers can use in practice, students need to consolidate their knowledge of fundamental theoretical concepts in computer science (studied in previous disciplines). The structure of a computer (in particular, an input-output device) is one of the universal topics that is studied at the university. As an example, let's consider the creation of a model of a computer mouse. And at the methodological stage, future digital biologists will be able to use the acquired knowledge to design a professionally oriented model.

2.1. To select a suitable figure, look at the upper horizontal panel. On the left are tools, among which you must hover the cursor over the cube-shaped figure. When you hover over this tool, a menu for selecting figures appears. For the basis of the three-dimensional object "computer mouse", you will need the "Box" figure. Methodological recommendation. After creating the initial object, consider working with figures in more detail. For example, the colored arrows indicated in different colors are tools for moving the object along three axes.

Next to the colored arrows, there are arched lines that are intended to be able to rotate the figure. To do this, move the cursor with the mouse button held down along the line, and the figure will begin to unfold along the trajectory we have chosen. The white dots outlined with a blue marker are intended to change the scale of the figure. The blue dot located on the corner of the cube is intended to smooth the corners and sides of the figure.

2.2. To create a cylinder, add an additional cylinder to the working plane. Next, you need to adjust the same size of the figures and combine them for the base of our mouse. To do this, select the figures in the menu on the left, holding down the Ctrl key. Then right-click on the object and select the unite item. After you have combined the figure, rotate it to a horizontal position using colored arcuate lines. Adjust the size of the computer mouse.

2.3. To create the top buttons on the computer mouse, select the designed object and duplicate it, leaving one inside the other. Next, using the arrows and scaling tools, lift the duplicated object above the main figure and adjust the dimensions. In this case, you can choose a color for two objects. To do this, select the object you need and use the "Color" setting in the right menu that appears. Select the two resulting objects. And using the hotkeys "CTRL + G" create a group for them.

2.4. Separating the buttons. To separate the right and left mouse buttons, you need to go to the polygonal change of the figure. To do this, "click" twice on the selected figure. In this case, these are the mouse buttons. Next, in the menu at the top, select the "Cut" tool. And in the center of the figure, draw two lines that will lie very close to each other. Thus, you have created new polygons. Next, you need to select the polygons instead of which we want to cut. To do this, hold down "Shift" and select the desired polygons. In the top panel, find the "Push" tool and drag the polygons down, thereby making holes.

2.5. After the resulting buttons, create a mouse wheel. To do this, create a "Ring", and adjust the ring size to the size of the computer mouse. Drag it to the desired location. Methodical recommendation: add additional buttons to the "computer mouse" object.

Step 3. This program also has various models that you can use to complement your work. To do this, go to the "Workspaces" tab in the left menu. On the tab, you can find a lot of ready-made high-quality models, change them, edit textures, smoothness, and the number of polygons.

3.1. Working with textures. The uniqueness of this program is the change of textures, lighting, and rendering of finished models. Let's consider changing the textures of computer mouse objects. To do this, when selecting an object, pay attention to the menu on the right side of the screen. At the very bottom of the selected object, you can change the texture. It is also possible to completely change the texture of the selected object. To do this, go to the "Color" settings, and instead of "Solid" put the name "Texture". After that, upload the previously downloaded texture to the model.

3.2. Lighting. In this program, you can also configure the lighting for the object, for this, in the horizontal top menu, select the "Spot Light" tool, and place the camera on the working plane. In the light settings, you can also add a shadow to objects, and use dynamic lighting, the angle of illumination, and its softness.

3.3. Background. In the left menu in Projects, select the project itself. The background and environment settings appear on the right. These settings also affect the visualization of the finished object. Use these settings and set up the ideal visual environment for you.

3.4. Edit the finished object and capture it as a screenshot.

Step 4. Creative task: add a mouse pad or additional accessories to the resulting object, provided that at least one object has modified polygons.

The "Methodical" stage. Next, team members began to develop an idea for a team project (according to their training profile), implement it in the form of a 3D model, and draw up instructions for potential users (their students). Let's look at one example - the result of the team's work on drawing up instructions for a "3D DNA model".

Pace 1: Add basic shapes. In the upper right corner, select the "Shapes" tab. Add two cylindrical shapes (or "Tubes") to the work area. These will be the "spirals" of your DNA. Resize the cylinders so that they are long and thin. To do this, select a cylinder and use the "Scale" options in the right menu.

Pace 2: Form a spiral. Select one of the cylinders and find the "Twist" option in the right menu. Increase the "Twist" value to the desired level to create a spiral shape. Repeat this process for the second cylinder so that both spirals have the same shape. (picture on the next page).

Pace 3: Adding Connecting Bases. Go to the "Shapes" section and add spherical shapes (or "Sphere") to create bases (nucleotides). Reduce the size of the spheres to match the scale of the helices. Place spheres between the helices to connect them. You can use the "Duplicate" function to quickly create multiple spheres.

Pace 4: Setting Up Materials. Select each of the helices and go to the "Materials" section. Choose different colors and textures for the helices and spheres to make the model more realistic and attractive. Adjust the reflection and transparency if necessary.

Pace 5: Finishing and Exporting. Test the model from different angles using the "Orbit" tool. When you are satisfied with the result, go to the "Export" menu in the upper right corner. Select the file format you want to save the model in (for example, "*.OBJ" or "*.STL") and click "Export".

Pace 6: Save the project. Don't forget to save your project by clicking the "Save" button in the top menu.

Stage "Demonstration". Team representatives presented both the instructions (methodological recommendations) and the resulting model. For example, a fragment of the final speech of the team leaders on the presented instructions: "Now you have a 3D model of DNA created in Vectary 3D. You can use this model for educational purposes, presentations, or just for practice in 3D modeling".

The students of the control group were not involved in creating 3D models as part of teamwork at the specified stages (theoretical, practical, methodological, and demonstration). Examples of projects that they implemented using the 3D editor: the interior of a school biology (English) subject room, the creation of a school located among trees and bushes, and the creation of a 3D model of a pear (pumpkin, spruce, etc.).

Students could complete the specified projects individually or in pairs. At the fixation stage of the experiment, L. Stack's method was used again. Table 1 presents the results of the analysis of the levels of team building – before and after 3D modeling within the framework of group work.

Table 1

Level of formed skills and abilities of team work

Level	Groups			
	Experimental (34 master's students)		Control (34 master's students)	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Ideal Team Model	9% (3)	26% (9)	9% (3)	12% (4)
Road Model	12% (4)	38% (13)	15% (5)	15% (5)
Golden Mean Model	41% (14)	21% (7)	38% (13)	43% (15)
Weather Vane Model	26% (9)	9% (3)	29% (10)	24% (8)
Model of Unrelated and Unfastened Elements	12% (4)	6% (2)	9% (3)	6% (2)

The following hypotheses were accepted: H0: the level of teamwork skills in the experimental group is statistically equal to the level in the control group; H1: the level in the experimental group is higher than the level of the control group. For $\alpha = 0.05$, according to the distribution tables, $\chi 2crit$ is 9.488. Thus, we obtain: $\chi 2obs.\ 1 < \chi 2crit$ ($0.344 < 9.488$), and $\chi 2obs.2 > \chi 2crit$ ($10.660 > 9.488$).

Consequently, changes in the level of skill development are not random. Let us analyze the dynamics by team building levels:

1. In the experimental group, the greatest dynamics are observed at the "Road Model" level (26% of the total share); the smallest – at the "Model of Unrelated and Unfastened Elements" level (6% of the total number).

2. In the control group, we recorded the maximum increase in the levels of the "Golden Mean Model" and "Weather Vane Model" (6% of the group); there is no increase in the level of the "Road Model" (0%). That is, the level of training of the participants changed because there were positive shifts in the levels of the "Weather Vane Model" and "Unrelated and Unfixed Elements Model". Thus, the use of 3D modeling tools is implemented as follows at each stage of teamwork:

- at the "Theoretical Stage" – the experiment participants updated and studied new theoretical material in the context of solving future professional problems in digital biology (polygonal modeling; texturing; scaling; lighting, adding effects, etc.). There is an accumulation of knowledge and skills for teamwork.

- at the "Practical Stage" – the participants, already divided into groups, create a 3D model using Vectary (or another alternative editor for processing 3D images). They do this according to the instructions proposed by the teacher. The team (upon making a unanimous decision) can ask for additions to the instructions: in the form of images of sample models or videos. Distribution of roles, style of virtual communication, conflict management – all this is manifested at the stage of studying the functionality and applying it to solving the task.
- at the "Methodological Stage" – teams develop their instructions, which they subsequently implement to build a 3D model of digital biology. For example, a 3D DNA model. Here, innovative directions were searched for, problems were revealed, a search for bold decisions was carried out, and personal and organizational growth was activated. Participants noted that it is easier to choose a riskier but promising option for visualization when you know that you will be supported and responsibility for a difficult choice will be shared.
- at the "Demonstration Stage" – team representatives demonstrated communication skills and presented the result of the group work. Participants noted that at this stage it is important to follow one rule: "Do not think about how to beat another team. But think about how to become better, and by joining efforts, achieve results together".

DISCUSSION

The presented study is considered by the authors as a solution to the urgent need that is clearly outlined in the report "Reimagining Our Futures Together: A New Social Contract for Education", and outlined the problem of strengthening international cooperation in the field of education using innovative technologies (AR, VR, 3D modeling, etc.) [1]. In addition, the findings continue the research of scientists from the Institute of Education of the National Research University Higher School of Economics on the importance of improving the training programs for professionals for Industry 4.0, to master those in-demand universal skills (emotional intelligence, computational thinking, "teamwork") [6].

The results of this study are consistent with the conclusions of E. Ferenc, R. Nemeth, and B. Firuza, that joint activities and collaboration on a virtual project are useful for developing teamwork skills [8]. The results obtained complement the conclusions of E. V. Soboleva et al., that many modern digital tools have the potential for team building [7]. In particular, 3D modeling tools are considered.

The central point of the article is that it logically continues the identification and study of the didactic potential of 3D graphics tools [5], begun in the work of N. A. Bushmeleva et al. It is continued in the direction designated by F. Lombard, J. Da Costa, and W. Laura: in teaching digital biology [11].

As other directions for the development and clarification of the results formulated in this work, we can propose:

- to add to the assessment of the formed skills and abilities of teamwork also monitoring the quality of educational results;
- to provide that students can choose an alternative software tool for 3D modeling. For example, Tinkercad. As a result, there is a need to develop additional instructions from teachers of the discipline.

CONCLUSION

The results of the study show that the use of 3D modeling tools helps to develop such skills as self-management and virtual communication; competence in using digital technologies; distribution of roles in a team; problem-solving and conflict management; maintaining a high level of productivity; application of the rules of pedagogical communication. The following features of teamwork on 3D models were identified: collaboration encourages prompt search for errors and selection of the optimal solution to problems; joint activities save resources that are spent on studying all the nuances of a new technology or software; support for the group in making extraordinary decisions; acceleration of personal and organizational growth; reduction of anxiety and burnout. Let us note the difficulties that complicate the use of 3D modeling tools for the collaboration of biology teachers:

- distribution of participants into groups that are maximally focused on solving the corresponding problem;
- the optimal choice of software taking into account the trends of digitalization and globalization;
- development of instructions of varying levels of complexity (writing a text description, determining the minimum and additional set of images, recording videos);
- selection of possible options for digital biology models (if the team cannot offer its idea):
- monitoring the progress of the current work by each group;
- different digital competence of team members. The lack of real results (when working with instructions, when creating your 3D model), and inconsistency in technical solutions between team members can negatively affect morale, and the quality of decision-making and lead to a loss of trust in the team;
- difficulties in organizing control. Teamwork in a virtual environment when solving a professional problem requires a high level of self-control, self-organization, and self-motivation.

We will also note the factors that influence the quality of using 3D modeling tools to develop collaboration skills:

- the degree of detail in which the teacher of the discipline elaborates the instructions for the "Practical" stage of the team's work. This is where the foundation for future collaboration is laid since all team members must study and master the modeling tools. But at the same time, connections are established, and experience is gained in finding a compromise in technical solutions;
- the existing experience of users working with 3D image processing tools and the quality of previously learned material in previous disciplines;
- the interests of future specialists in the chosen professional field;
- previous experience of participating in team projects.

The results obtained can be used to improve the training programs for future subject teachers in the context of the priorities of the digital school and the challenges of Industry 5.0.

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