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ENHANCING THE SPATIAL IMAGINATION OF HIGHER EDUCATION STUDENTS THROUGH COMPUTER SIMULATIONS IN PERFORMING GEOMETRIC PROBLEMS

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Today, computer technology is actively used in teaching the subject "Descriptive Geometry and Engineering Graphics". Advances in computer technology have made it possible to create graphic images quickly and easily, process them, and use them as teaching aids in education. Many researchers have suggested in their research that the use of modern computer technology in teaching the subject of "Descriptive Geometry and Engineering Graphics" increases the effectiveness of education. They conducted research on the capabilities of graphic programs used in the teaching of "Descriptive Geometry and Engineering Graphics" and their application in teaching.

Marianna V. Voroninaa, Zlata O. Tretyakovaa [13], A.Yu. Goryachkina, I.A. Goryunova, O.M. Koryagina [14] A. Kakhkharov [11], A. Khamrakulov [2,3,4,5,6,7,8], Farid Nassery [12] conducted research.

In the scientific researches of Khamrakulov AK [2,3,4,5,6,7,8] PowerPoint program was used in teaching the subject "Drawing geometry and engineering graphics". First of all, let's get acquainted with the capabilities of PowerPoint. The Drawing section of the program menu provides ready-made primitives of basic geometric objects (straight lines, curves, rectangles, circles, etc.). However, the most widely used point in descriptive geometry is not given as a ready-made primitive. In PowerPoint, all presentations in Graphic Geometry are represented by a dot in the form of a circle, which is scaled to show a point. For example, in AB, a section is drawn first, and then two circular points are attached to it. This inconvenience can cause the cut-off points to shift. Perpendicular straight lines are often used in descriptive geometry. There is no command in the program that makes two straight lines perpendicular. In created presentations, perpendiculars are created in other ways (for example, by turning a straight line 90 ° relative to the second straight line). This lack of precision also leads to some errors in drawing. Only 2D drawings are created in this program.

As a result of AKKhamrakulov's research didactic requirements for e-learning and methodical work on the subject of descriptive geometry were developed [2,5,7]: minimization is shown. Work has been done to improve the methods of using AutoCAD graphics programs in the teaching of descriptive geometry and engineering graphics [3,6,8]. As a result, students' mastery of the subject and quality indicators have increased.

A. Kakhkharov [11] in his research used AutoCAD to explain the topic of "intersection of surfaces" in the discipline "Descriptive Geometry and Engineering Graphics". The sketch of the drawing was made in PowerPoint, and the spatial solutions are shown in AutoCAD. But the only downside to AutoCAD is that it can't draw a point in space. We can only make a sphere in space and take it as a point.

In the research work of Sh.Tursunov [11] special attention is paid to the design and presentation of e-learning materials.

As a result of the above considerations and questionnaires conducted with students, didactic requirements for 2D and 3D models created in the field of descriptive geometry were developed.

1. 2D and 3D views of the created virtual models are displayed in one program at the same time;

2. Each point in the drawing given in 2D is also reflected in 3D;

3. When rotating the 3D virtual model from different angles, the names of each point, straight line and intersection given in the drawing remain the same for the user;

4. The animated sequence performed in 2D can be displayed in 3D at the same time;

5. The created virtual model is interactive. In this case, the student will be able to review the order of the problem by entering the appropriate values;

6. Ability to zoom in or out on the desired part of the created virtual model.

7. In virtual models, the projection planes should be of different colors and as transparent as necessary. The geometric object at the back of the projection planes should be partially visible and the student should be able to observe them [1].

Graphic applications that meet the above requirements were compared with each other. Experimental experiments were conducted on their capabilities and compliance with the above requirements. The possibilities of graphic programs in the creation of virtual models of geometric objects, points, straight lines, rays, planes and sites used in the science of descriptive geometry were analyzed (Table 1). For example, in PowerPoint, AutoCAD, 3D MAX, Paint, and other graphics programs, the names of the points used in the subject "Drawing Geometry and Engineering Graphics" are not given. In PowerPoint, to describe a point, we first mark the shape of the circle and then write the name of the point next to it. In AutoCAD and 3D MAX, a point in space is marked with a ball and then named. In this case, the name of the point is that when you rotate a geometric object in 3D space, its side view (profile) appears as a line relative to the observer (Figure 1).

Faith analysis of graphical programs

Table 1

	Possibilities of creation and use of basic geometric objects	The name of the graphics program						
		Paint	Power Point	AutoCAD	3d MAX	Blendr	Geogebra	Note
	Ability to create a point in a plane	-	-	+	+	+	+	By order
	Point and the ability to create it in 3D space	-	-	-	-	-	+	By order
	Named automatically when a full stop is set	-	-	-	-	-	+	In the form of A, B, C, D, and so on
	Draw a section in a plane with two points	-	- The intersection	-	-	-	+	AB in cross section

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			points are hidden.					
	Depiction of a cross section in 3D with two points	-	-	-	-	-	+	AB in cross section
	Draw a straight line in a plane	-	-	+	+	-	+	A, B are straight lines
	Draw a straight line in 3D	-	-	-	-	-	+	A, B are straight lines
	Imaging light in 2D and 3D view	-	-	-	-	-	+	Lig ht passing through A, B.
	Creating a plane in 3D space	-	-	-	-	-	+	All sides of the plane are infinite
0	Creating geometric objects in 3D space	-	-	+	+	+	+	Dec ort in the coordin ate

								system
1	Depict the created 3D model in one plane (Epyur view)	-	-	+	-	-	+	Image in one window
2	Ability to change the parameters of the created 3D and 2D virtual models (Interactive)	-	-	-	-	-	+	An e-textbook is available

As can be seen from Table 1, the possibility of preparing e-learning resources in the subject of descriptive geometry The Geogebra program has great potential compared to other graphics programs. Therefore, the possibilities of the program Geogebra [15] to meet the didactic requirements developed for the creation of models 2 and 3 in the discipline of descriptive geometry were considered. From this program it is possible to visualize drawings in the field of descriptive geometry in 2D and 3D and create various interactive models.

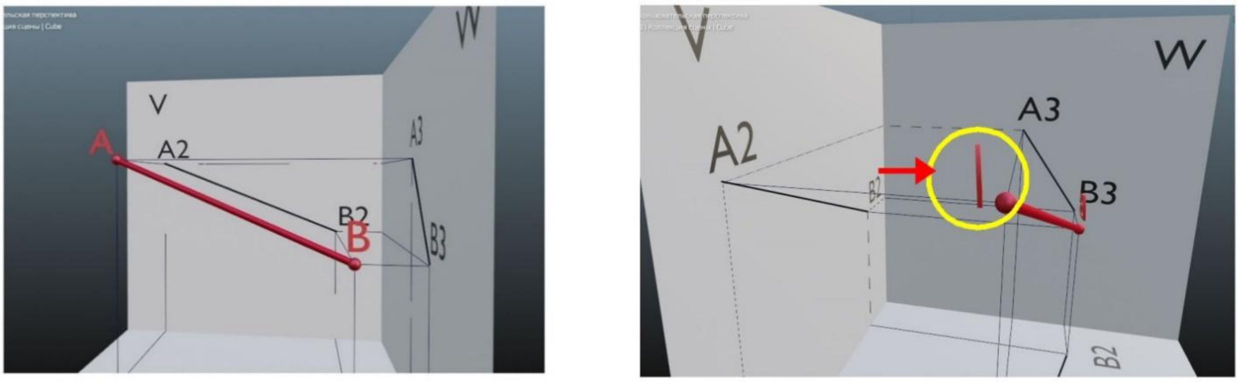


Figure 1. a) The initial view of the AB section prepared in 3D MAX b) After the AB section is rotated in space, the names of points A and B appear as lines to the observer (point A is given in a yellow circle).

Each geometric object point created in the geogebra program was automatically named by the program. For example, if we define the first point in a program in space or plane, it is called A. It then automatically marks the second point to be marked with the letter B. All dots are created in the order of the Latin letters. (A, B, C, D,… and so on). The name of a given geometric object point in space remains the same for the user even when the geometric object is rotated. For example, let's say point A is in space. The position of the letter A does not change with respect to the observer during the rotation of the point in space (Figure 2).

Most of the electronic textbooks on the subject "Drawing Geometry and Engineering Graphics" are created in PowerPoint, AutoCad, 3D MAX and so on. PowerPoint does not allow you to create geometric objects in 3D. AutoCAD and 3D MAX have the ability to create a spatial 3D model of the drawing. In these applications, the 3D model is displayed in three projection planes. However, the planes of orthogonal projections V, H, W are opened in separate windows.

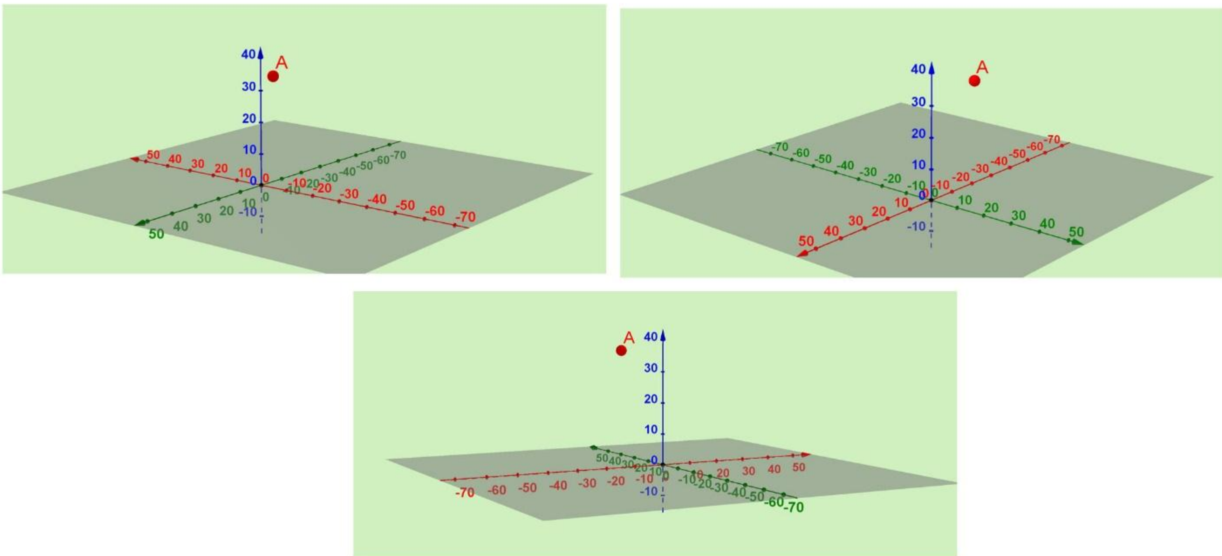


Figure 2. The point A in space is unchanged relative to the observer as it is rotated in space.

It is a time-consuming process for a teacher to bring the projections of a geometric object formed in the plane of the three projections to the same scale. In both programs, it is not possible to depict three projection planes in a single window.

It is possible to represent the created 3D model in one plane (in the view of Epur) in the program Geogebra. For example, a virtual model of point A in space in 3D and 2D. Let's look at the construction stages of this virtual model:

Sequence of construction stages.

1. Launch the Geogebra program and activate the 3D Graphics window.

2. Through the Input Bar*x=0, y=0,z=0* entering values horizontally*(g),* frontal*(f)*and profile*(eq1) projections are created by planes (Fig. 3).*

Name	Value
Plane eq1	eq1: x = 0
Plane f	f: y = 0
Plane g	g: z = 0

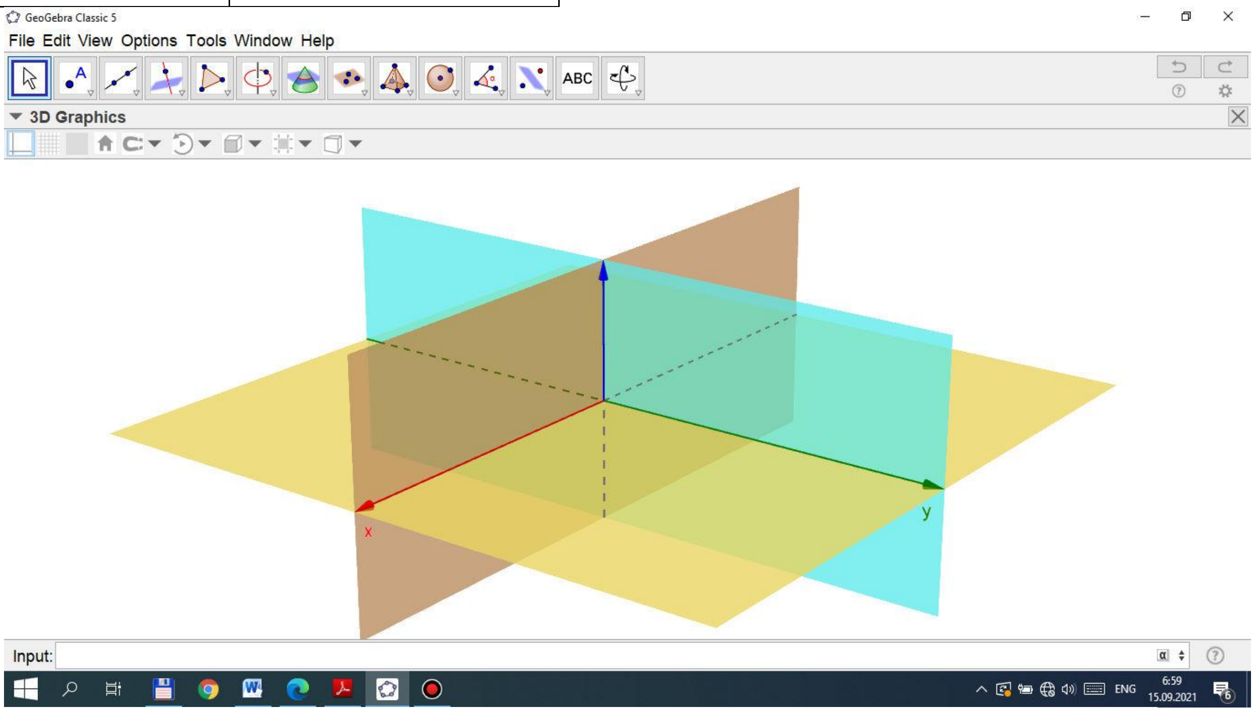
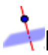
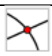


Figure 3. The plane of horizontal, frontal and profile projections in a 3D graphic window

3. Use the Point command to create A with any coordinate.

4. Point A draws straight lines perpendicular to the planes of horizontal (g), frontal (f) and profile (eq1) projections.

Name	Definition
Line h	PerpendicularLine(A, g)
Line i	PerpendicularLine(A, f)
Line j	PerpendicularLine(A, eq1)

5. We define the points of intersection of the projection planes g, f, eq1 with the perpendicular straight lines h, i, j, B, C, and D. Mark the points B, C, D with each cursor

and enter the settings panel. Then we change point B to A1, point C to point A2, and point D to Caption.

Name	Description	Caption
Point B	Intersection point of h, g	A1
Point C	Intersection point of i, f	A2
Point D	Intersection point of j, eq1	A3

6. *A perpendicular line is drawn from point B to the plane f and eq1, from point C to the plane eq1 and g, and from point D to the plane f and g.*

7	Description
Line k	PerpendicularLine(B, f)
Line m	PerpendicularLine(C, eq1)
Line l	PerpendicularLine(B, eq1)
Line n	PerpendicularLine(D, f)
Line p	PerpendicularLine(C, g)
Line q	PerpendicularLine(D, g)

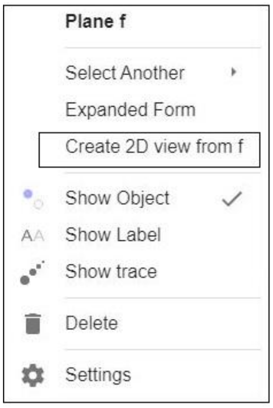
7. All straight lines (Line h, i, j, k, l, m, n, p, q) are hidden using the Show, Hide Object command. .

8. Use the Segment command to create the sections in the table. The 3D Graphics window creates a spatial view of the projections of point A (Figure 4).

Name	Description
Segment r	Segment(C, E)
Segment s	Segment(C, F)
Segment t	Segment(F, D)
Segment a	Segment(D, H)
Segment b	Segment(H, B)
Segment c	Segment(B, E)

Segment d	Segment(A, C)
Segment e	Segment(A, B)
Segment f_1	Segment(A, D)

9. Mark the frontal plane (Plane f) with the cursor and click the right mouse button. Open the Object Properties window. In the window, select "2D view from f" (Wiev of plane f). The result is 3D graphicsa 2D Graphic window of the f plane is formed next to the



window.

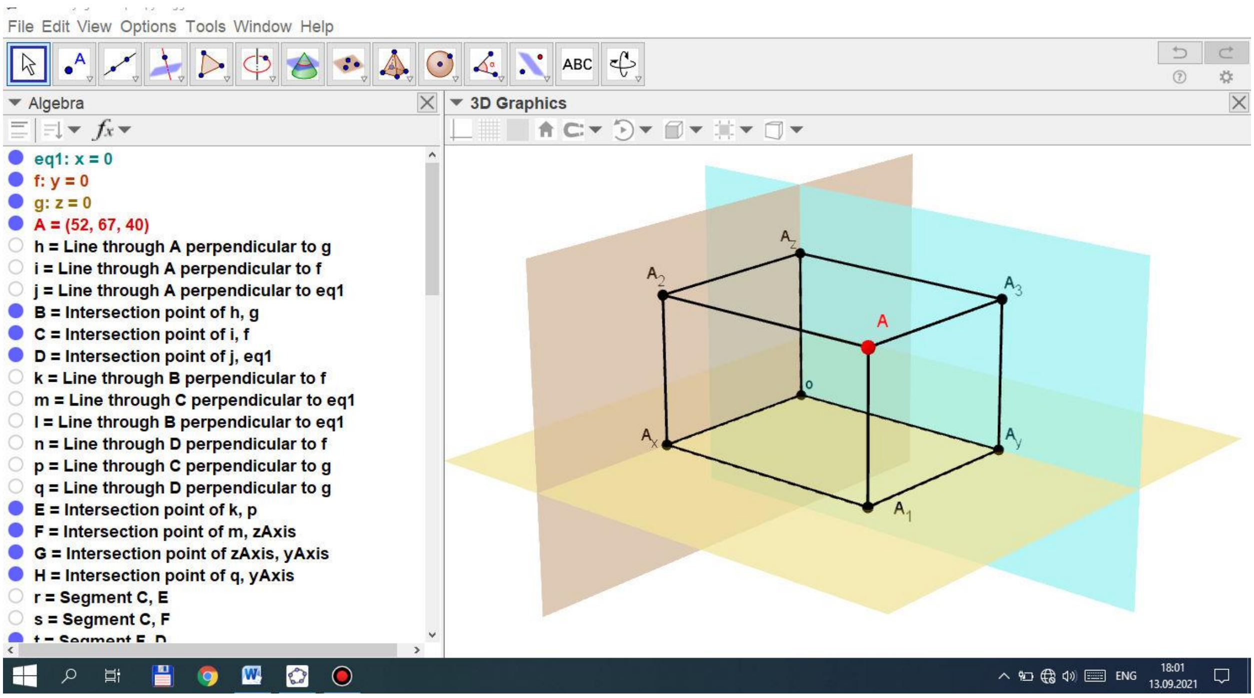
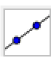


Figure 4. The position of point A between the projection planes

10.  In the 2D graphic window of the new plane f, we draw straight lines g1 passing through points F, G and h1 passing through points F, E. These straight lines are the x, y, z axes of the erpyur.

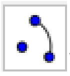
Name	Description	Caption
Line g_1	Line(F, G)	z
Line h_1	Line(G, E)	x

12. "In the 3D Graphics window, points B, D, and H are shown at the axis given in the table, clockwise (90 °) or counterclockwise (-90 °). rotate around the line "(Rotate around Line). Point B ', D', H ', H'1 formed in the frotal plane (Plane f) with the cursor to select "Object Properties", "Advanced", "Condition") delete all characters except "Extra Views". As a result, these points are visible only in the 2D graphic window of the plane f. Again we replace these points with the headings A1, A3, Moon, and Moon.

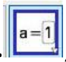
Name	Description	Caption
Point B'	Rotate(B, -90°, xAxis)	A_1
Point D'	Rotate(D, 90°, zAxis)	A_3
Point H'	Rotate(H, 90°, zAxis)	A_y
Point H'_1	Rotate(H, -90°, xAxis)	A_y

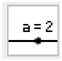
13. With the "Segment" we create the intersections given in the table in the 2D graphical window of the plane f.

Name	Description
Segment i_1	Segment(E, B')
Segment j_1	Segment(B', H'_1)
Segment k_1	Segment(F, D')
Segment l_1	Segment(D', H')

14. With the Curcular Arc command, we draw an arc through H ', H'1, centered on point G. The result is a spatial view of the point A in the 3D graphic window with projections, and a diagram view on the right (Figure 5).

Name	Description
Arc c_1	CircularArc(G, H', H'_1, f)

15. 

, 

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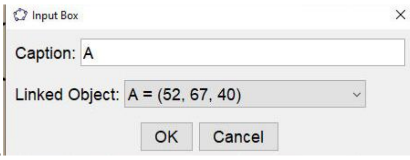
From the main menu, go to the "View" menu and open the "Graphics" window. Open the Input Box window from the toolbar. We write point A to the title (Caption).

We assign point A to the Linked Object. The x, y, z coordinates of point A appear in the Craphics window. At the top of it we enter the name of the drawing and the text x, y, z with the command "Text". We create a value for Son-a (Number-a) with an interval of 1 to 12. We call it the Construction Stages. Now in the Craphics window there is a slider to control the name of the drawing, the x, y, z coordinate values of point A and the construction steps (Figure 6).

Name	Description	Value	Caption
InputBoxInput Field1	InputBox(A)	Input field1	A
Text matn2		"The epyury of point A and spatial view"	
Texttext2		"x y z"	
Number α		α = 12	Constructionstages

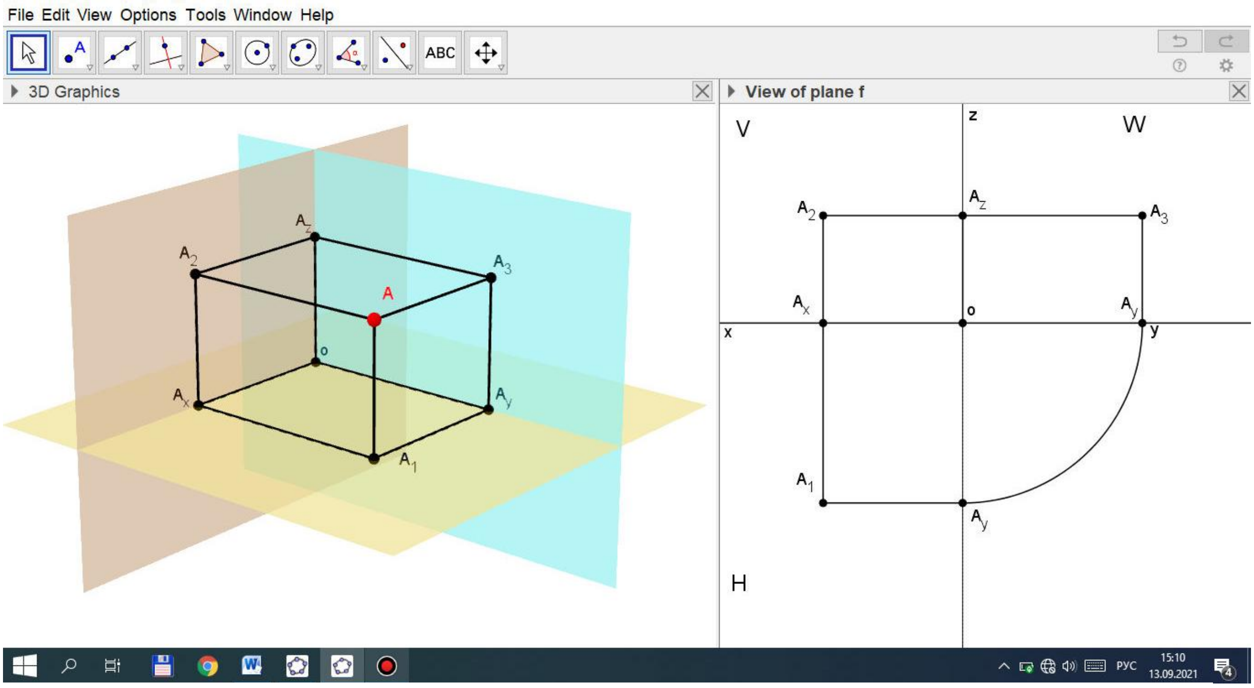
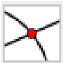


Figure 5. 3D model and 2D view of point A.

16.  In the graphic view "f from 2D" we define the point of intersection k1 and l1 O, the point of intersection i1 and j1 P and the point of intersection s and r N. Select each of the points with a separate cursor and go to "Object Properties". Then replace point O with point A1, point P with point A2, and point N with heading A3.

Name	Description	Caption
Point O	Intersection point of k1, l1	A3
Point P	Intersection point of i1, j1	A1
Point N	Intersection point of s, r	A2

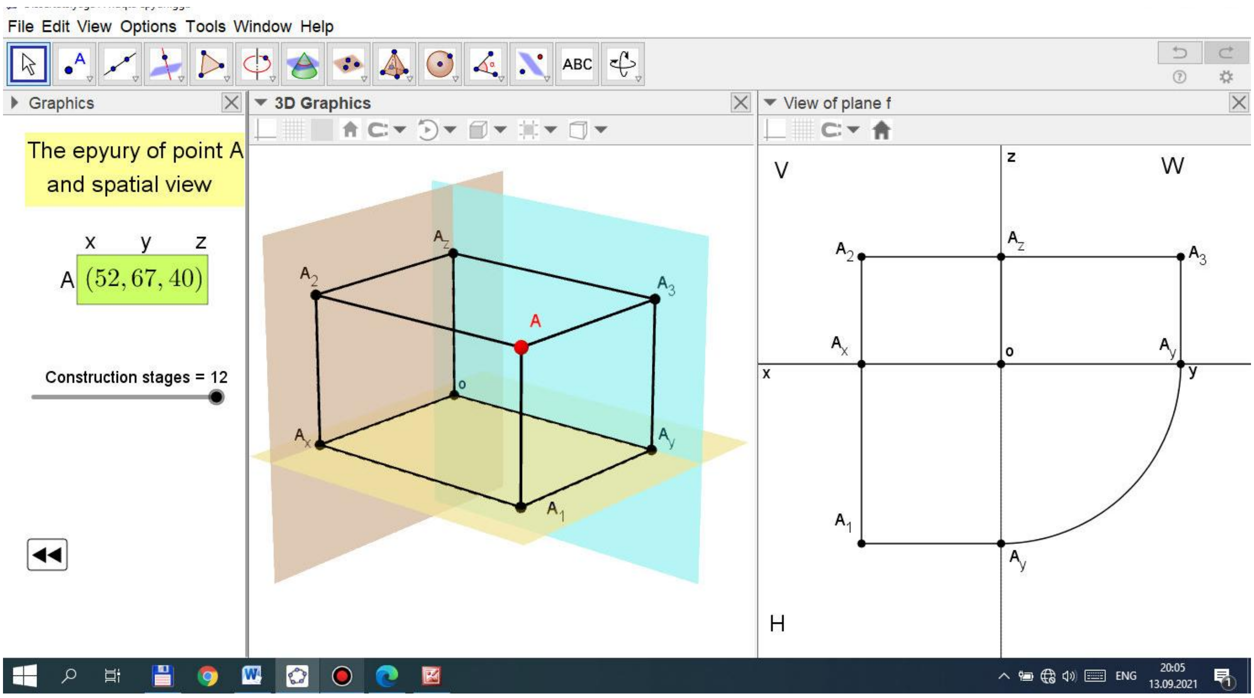
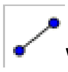
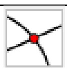


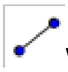
Figure 6. An interactive 3D virtual dynamic model of a point.

17.  With the Cut command, we create the cuts given in the table in the "2D view from f" graphic window.

Name	Description
Segment t_1	Segment Q, R
Segment a_1	Segment Q, S

18. In the "2D view from f" graph window, we define the point of intersection V with i and f. Mark the point with the cursor and go to "Object Properties". Then we replace point V with the title A2.

Name	Description	Caption
Point V	Intersection point of i, f	A2

19.  With the section command, we create the sections in the table in the "2D graph of the plane f" window.

Name	**Description**
Segment e1	Segment E, G
Segment f2	Segment G, F
Segment g2	Segment G, H

The resulting electronic exhibition can be called a "live exhibition". Because here we can hold point A in space with the mouse and drag it to any octant. Whichever octant we take the point on, the projection of the point on that octant is formed in the epyur. Or if you change the value by placing the cursor on the given values of the coordinates of point A, its position in both space and epheme will change. From this opportunity, students can independently conduct virtual experiments. The teacher can change the parameters to show the position of the geometric object in space and on the plot. As a result, students increase their spatial perception by comparing a geometric object in space to an epyur. It is also possible to observe the sequence of construction of the drawing in both space and epyur. To do this, move the construction sequence step by step from left to right (Figure 7).

The Geogebra program can receive data created in other programs, the created exhibitions can be animated (dynamic), stored on the Internet in the form of an interactive web page, its menu is translated into all languages of the world, the model created in the program is 2D and the ability to view in a 3D environment, the simplicity of the program itself and its ease of operation led us to choose it as a base.

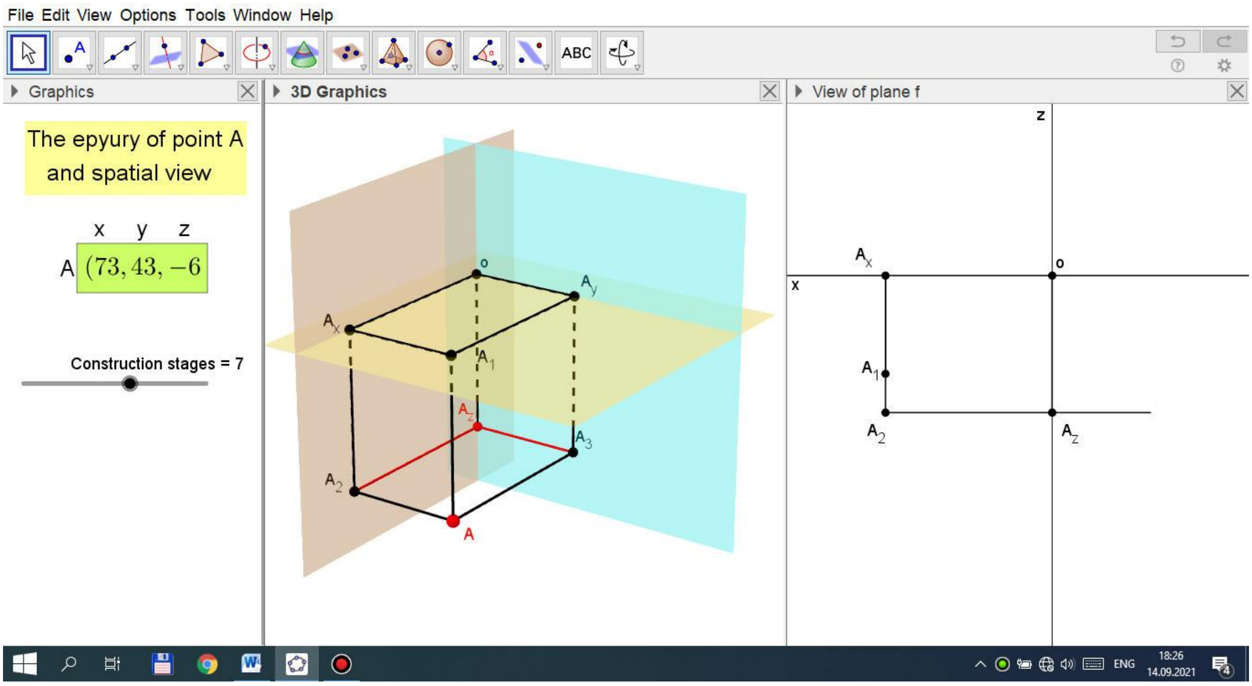


Figure 7. Construct a 4-octane diagram of point A using a slider called "Construction Stages".

Conclusion

2D and 3D virtual models on the subject of "Descriptive Geometry and Engineering Graphics" were created on the basis of didactic requirements and applied in the educational process. Drawing geometry classes using 2D and 3D virtual models have been introduced in higher education institutions. Experimental and test groups analyzed the performance of students. As a result, it was found that the students of the test group have a high level of mastery. After testing the graphics capabilities of these 2D and 3D virtual models in lectures and workshops, the following conclusions were reached:

- The program will show the drawing in 2D and 3D graphics windows, will increase the ability of students to fully explain the topic.

- By changing the parameters (color, shape, size, construction algorithm and spatial position) of 3D and 2D virtual models, students will be able to independently solve the problem.

The fact that each point in the diagram given in -2D is also reflected in 3D allows you to compare the spatial view of a flat plot (diagram).

The fact that the names of each point, straight line, and intersection given in the drawing do not change relative to the user when rotating the -3D virtual model from different angles makes this virtual model more understandable.

The fact that the animated sequence performed in -2D is displayed in 3D at the same time makes it easy to master the construction steps.

This means that the knowledge, skills and abilities of students will be further developed if this program, which is recommended for the course "Descriptive Geometry and Engineering Graphics", is used in the classroom.

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