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Scientific article

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Prospects of using graphic programs in the development of independent cognitive activity in teaching descriptive geometry

Abstract. This article examines the prospects of using modern graphics software in teaching descriptive geometry and its impact on the development of students' independent cognitive activity. The relevance of the study stems from the need to improve the graphical training of future specialists, develop spatial thinking and logical reasoning, and foster the ability to solve engineering and geometric problems independently. Particular attention is paid to the application of Rhino (Rhinoceros 3D), AutoCAD, GeoGebra, and Grasshopper in the educational process. The didactic potential of these software tools is explored in terms of spatial object visualization, dynamic modification of geometric parameters, rapid error correction, and independent experimentation. Using the metric problem of determining the shortest distance from a given point to a plane as an example, the study examines Rhino's capabilities for performing geometric constructions and obtaining precise numerical results. The potential of Grasshopper for automating calculations and implementing parametric modeling when initial data change is also analyzed. Practical approaches to organizing students' independent work are proposed, including project-based learning and problem-solving tasks. The findings indicate that integrating graphics software into descriptive geometry instruction facilitates a transition from traditional drawing techniques to the active investigation of geometric relationships, while supporting the development of spatial visualization and technical thinking. The findings can be applied to improving the teaching methodology of graphic disciplines in technical and pedagogical higher education institutions.

Keywords: descriptive geometry, graphics software, independent cognitive activity, metric problems, spatial visualization, educational technologies, geometric modeling.

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Introduction

The modern education system is focused on the formation of a student's personality that is active, logical, and able to make decisions on their own. Descriptive geometry is the fundamental basis of technical education, which it is important not only to memorize the rules, but also to work with spatial imagination and logical algorithms (Gutiérrez de Ravé et al., 2025).

But working with traditional paper and drawing tools can cause students to have difficulty visualizing complex shapes and quickly correcting mistakes (Yessekeshova & Tuleuova, 2024). Therefore, the use of graphics programs is considered as an important factor that accelerates independent cognitive activity (Tashimov, 2026).

Independent learning is when a student takes control of the process of acquiring knowledge. Graphic programs (for example, Rino, AutoCAD, GeoGebra) provide student with the following features:

- Experimental opportunity: the student can immediately see how the result will change by changing the parameters of the geometric shape in his hand (for example, angle or size). This helps to realize the chain «hypothesis - experiment — conclusion» (Nugaeva & Serikkalikyzy, 2022).

- Dealing with mistakes: Re-erasing and re-sketching when you make mistakes on paper takes time and energy. And in the program, a quick error correction ensures that there will be no obstacles to self-search (Fung & Poon, 2021).

- Visualization: the ability to view spatial shapes (projections) in 3D develops the student's spatial imagination (Suparman et al., 2024).

Methodology

When teaching descriptive geometry, programs can be applied in two different forms:

1. As a didactic tool: the teacher becomes an example for the student by showing complex geometric constructions using the screen.

2. As an educational tool: students perform their independent work and practical tasks precisely within the framework of these programs.

For example, the GeoGebra program serves students to develop independent cognitive activity by creating dynamic models for proving geometric theorems. AutoCAD, on the other hand, ensures compliance with technical drawing standards and understanding of engineering textures.

Let's look at its main advantages in determining the short distance from a point to a plane using the Rhino graphics program (Rhinoceros 3D), which relates to solving metric problems in the science of descriptive geometry:

Rhino uses the mathematical model NURBS (Nonuniform Rational B-splines). This ensures that the distance between a point and a plane is calculated not by pixels, but by real mathematical coordinates with very high accuracy.

- Distance detection tool: by selecting a point using the measuring instruments of the program, you can determine the distance to the intersection point or the nearest point of the plane in a few seconds.

- Using the Analyze Command: Distance or Point to Surface commands, the distance can not only be seen, but also taken as an exact numerical value. This is the biggest advantage of the Rhino graphics program. If you need a distance from many points to a plane:

- The algorithm is compiled using Grasshopper.

- The distance calculation process is automated.

- When changing points or planes, distances are automatically recalculated (parametric calculation).

If by «plane» we mean not only a simple plane, but also a complex surface, Rhino offers professional solutions for finding the nearest point on this surface. Rhino returns the exact XYZ coordinates for each point and plane. This is convenient for transferring calculations to other engineering applications (such as Excel or MATLAB).

If you need to measure the distance in just one point, there are enough measuring tools in the rhino graphics program. If you need a lot of data and automation, Grasshopper is the most powerful solution.

The small distance from the specified point S in Figure 1 to the plane indicated by the triangle ABC (A′B′C′;A″B″C″) was made in a 2D drawing using the AutoCAD graph program. In this drawing, one can see the abundance of lines, the lack of sympathy, and the difficulty of developing students' spatial imagination.

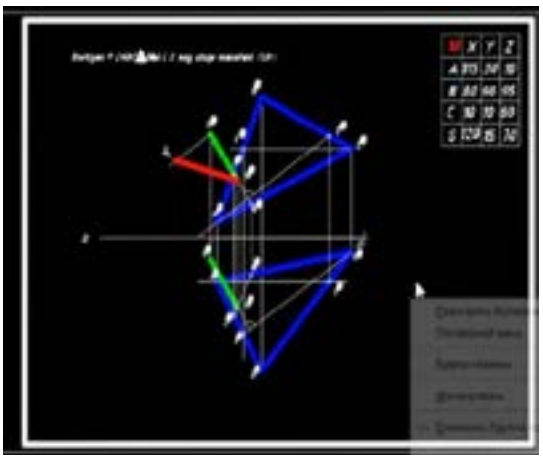


Figure 1. 2D drawing of the distance from point S to plane ABC using AutoCAD

A small distance from a given point S in Figure 2 to the plane defined by triangle ABC (A´B´C´;A˝B˝C˝) was simultaneously parallelized in 2D and 3D drawings using the Rhino graph program. In these drawings, one can see the individuality of the students' spatial imagination, which makes it possible to determine a small distance from a point to a plane.

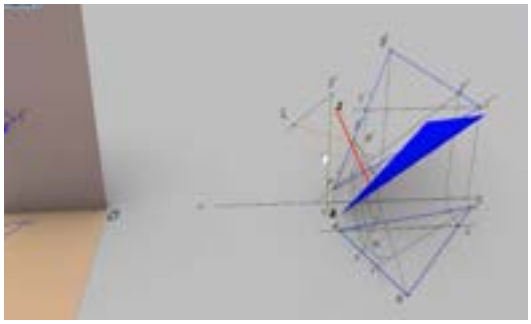


Figure 2. 2D and 3D visualization of the shortest distance from point S to plane ABC

From a given point S in Figure 3 ABC (A´b´c´; ABC), the spatial arrangement of the plane defined by the triangle and the images in the projection plane is set. If students are shown this drawing in 2D before completing the assignment, their spatial imagination will be better understood.

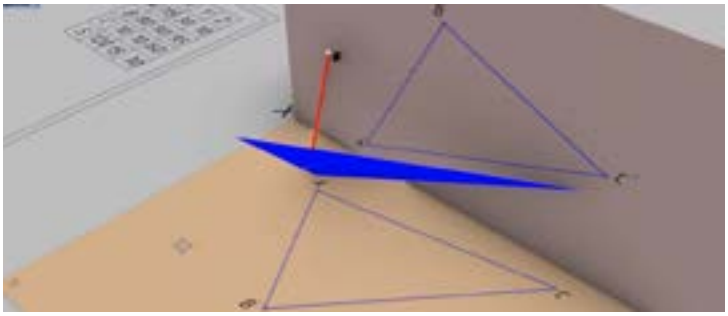


Figure 3. Spatial arrangement of plane ABC and its projections from a given point S

Results and discussion

The following approaches are proposed to increase the student's independent activity:

- Project method: give the student the task to draw from scratch a drawing of a certain technical part or structure and transform it into a 3D model.

- Problematic situations: «If this size changes, how will the other details in the drawing change?», prompting them to change their models in the program.

Conclusion

The use of graphics software elevates the disciplines of descriptive geometry from simple «sketching» and formalism to the level of «technical analysis and design». Graphic programs help students transform from a passive listener into an active follower. As a result, students acquire not only drawing skills, but also skills in solving complex geometric problems and making technical decisions.

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Сызба геометриясын оқытуда өзіндік танымдық қызметті дамытуда графикалық бағдарламаларды қолдану перспективалары

Аңдатпа. Мақалада сызба геометриясын оқытуда заманауи графикалық бағдарламаларды қолдану перспективалары және олардың студенттердің өзіндік танымдық іс-әрекетін дамытуға ықпалы қарастырылады. Зерттеудің өзектілігі болашақ мамандардың

графикалық даярлығын жетілдіру, кеңістіктік ойлауын, логикалық талдау қабілетін және инженерлік-геометриялық есептерді өз бетінше шешу дағдыларын қалыптастыру қажеттілігімен байланысты. Білім беру үдерісінде Rhino (Rhinoceros 3D), AutoCAD, GeoGebra және Grasshopper бағдарламаларын қолданудың дидактикалық мүмкіндіктеріне ерекше назар аударылады. Аталған бағдарламалардың кеңістіктік нысандарды визуализациялау, геометриялық параметрлерді динамикалық өзгерту, қателерді жедел түзету және білім алушылардың өз бетінше тәжірибе жүргізу қабілетін дамытудағы рөлі сипатталады. Зерттеу барысында берілген нүктеден жазықтыққа дейінгі ең қысқа қашықтықты анықтау сияқты метрлік есепті шешу мысалында Rhino бағдарламасының геометриялық құрылымдарды орындау және нақты сандық нәтижелерді алу мүмкіндіктері талданады. Сонымен қатар Grasshopper бағдарламасының есептеулерді автоматтандыру және бастапқы деректер өзгерген кезде параметрлік модельдеуді жүзеге асыру әлеуеті қарастырылады. Студенттердің өзіндік жұмысын ұйымдастыру үшін жобалық әдіс пен проблемалық тапсырмаларды қолдану ұсынылады. Графикалық бағдарламаларды оқу үдерісіне енгізу дәстүрлі сызба орындаудан геометриялық заңдылықтарды белсенді зерттеуге көшуге, кеңістіктік елестетуді жетілдіруге және техникалық ойлауды дамытуға мүмкіндік беретіні негізделеді. Зерттеу нәтижелерін техникалық және педагогикалық жоғары оқу орындарында графикалық пәндерді оқыту әдістемесін жетілдіруде пайдалануға болады.

Түйін сөздер: сызба геометриясы, графикалық бағдарламалар, өзіндік танымдық іс-әрекет, метрлік есептер, кеңістіктік визуализация, білім беру технологиялары, геометриялық модельдеу.

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Перспективы использования графических программ в развитии самостоятельной познавательной деятельности студентов при обучении начертательной геометрии

Аннотация. В статье рассматриваются перспективы использования современных графических программ в преподавании начертательной геометрии и их влияние на развитие самостоятельной познавательной деятельности студентов. Актуальность исследования обусловлена необходимостью совершенствования графической подготовки будущих специалистов, развития пространственного мышления, логического анализа и навыков самостоятельного решения инженерно-геометрических задач. Особое внимание уделяется применению программных средств Rhino (Rhinoceros 3D), AutoCAD, GeoGebra и Grasshopper в образовательном процессе. Раскрываются дидактические возможности графических программ, связанные с визуализацией пространственных объектов, динамическим изменением геометрических параметров, оперативным исправлением ошибок и проведением самостоятельных экспериментов. На примере решения метрической задачи по определению кратчайшего расстояния от заданной точки до плоскости рассматриваются возможности использования Rhino для

выполнения геометрических построений и получения точных числовых результатов. Также анализируется потенциал Grasshopper для автоматизации вычислений и параметрического моделирования при изменении исходных данных. Предлагаются практические подходы к организации самостоятельной работы студентов, включая проектный метод и решение проблемных задач. Показано, что интеграция графических программ в обучение начертательной геометрии способствует переходу от традиционного выполнения чертежей к активному исследованию геометрических закономерностей, формированию пространственного воображения и развитию технического мышления. Полученные положения могут использоваться при совершенствовании методики преподавания графических дисциплин в технических и педагогических вузах.

Ключевые слова: начертательная геометрия, графические программы, самостоятельная познавательная деятельность, метрические задачи, пространственная визуализация, образовательные технологии, геометрическое моделирование.

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