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INTERACTIVE TEXTBOOK FOR ASYNCHRONOUS DISTANCE LEARNING IN DESCRIPTIVE GEOMETRY

Abstract: *The paper presents a descriptive geometry textbook used for asynchronous distance learning. The research integrates principles of self-regulated learning, Universal Design for Learning, and constructivist theory into the process of curriculum support development. The textbook is an interactive offline-accessible pdf file, which can be opened in Adobe Reader and contains pop-up windows with text and images, interactive 3D models, animations of the problem-solving process.*
The interactive support material is adapted to different learning styles and paces. The developed materials can be directly integrated into teaching activities in technical colleges or technical university. The proposed curriculum support represents a replicable model of educational resource, focused on individual learning and the development of relevant competencies for the technical field.

Key words: *interactive textbook, educational resource, descriptive geometry, learning, pdf file.*

1. PROBLEM DESCRIPTION

Descriptive geometry is a relatively young discipline, which emerged at the end of the 18th century, becoming a universal graphic language in the field of engineering, architecture, design, etc. Without this subject, it is impossible to study the courses "Technical Drawing", "Machine Parts", "Strength of Materials" and others. It is within this discipline that spatial imagination, the ability to geometric abstraction of real shapes of objects, is formed and developed [1].

Descriptive Geometry forms not only the ability to represent objects in three-dimensional space in the two-dimensional plane, but also develops the sense of proportion, precision, allows the classification and systematization of lines and surfaces from which industrial items are formed. The knowledge acquired in the discipline is necessary for the engineering profession, being the basis of technical and scientific activity [2].

Descriptive geometry develops the skills needed to create and interpret technical drawings, as well as to use computer-aided design (CAD) tools, remaining essential in the contemporary stage as the conceptual foundation of modern representation, modelling and manufacturing technologies. Its importance does not diminish in the context of current technological achievements and the skills required by the contemporary professional environment.

The principles formulated by Descriptive Geometry such as projection, intersection, section, geometric transformations, spatial relationships between elements, etc. are the basis of modern design technologies - CAD, CAE, CAM, BIM. Thus, in the contemporary era, great importance is given to digital visual representations. These technologies offer advanced possibilities for visualizing objects, processes and technical systems.

Descriptive Geometry provides the conceptual foundation necessary for the rigorous representation, interpretation, and control of spatial relationships in virtual and augmented reality environments, in complex three-dimensional simulations, and in the development of digital twins [3], [4]. By developing analytical spatial thinking, it ensures the user's ability to critically validate the correspondence between the virtual object and physical reality.

Automation of operations through current software does not exclude the understanding of geometric logic. This understanding gives the user the ability to correctly interpret digitally generated three-dimensional models, independent of the interface, to anticipate and optimize complex solutions and to identify conceptual design errors. It follows that digital manufacturing requires an understanding of the relationship between geometry, material and technological process.

2 APPLICATION FIELD

In the context of developing teaching materials within the Mechanical Engineering Department of the Technical University of Moldova (TUM), it was proposed to create an interactive teaching material for the Descriptive Geometry discipline, which would provide autonomy in learning and meet the requirements of teachers and students [5]. Taking into account the difficulty in assimilating some theoretical concepts of Descriptive Geometry (e.g. orthogonal projections, etc.), examples and analogies with real life are used.

To avoid students' passivity in going through voluminous and complicated materials, the content is fragmented into small units, with intermediate practical tasks and continuous assessment. The well-structured teaching material allows students to study individually, without exclusive dependence on class hours [6], [7].

The manual is in pdf format and can be downloaded to a personal computer and used offline. This allows students to study effectively in cases where there is no internet connection (transportation, technical or financial problems). The manual opens with Adobe Reader, as it is free software that can be installed on any device, including mobile. Interactive functionalities for visual and asynchronous learning were used in the creation of the manual: internal navigation buttons, explanatory pop-ups, sequential animations, sectional and interactive 3D models.

Thus, the textbook can be adapted depending on the level, speed of knowledge assimilation and cognitive capacity of each student. The textbook is complemented by interactive tests. These tests provide immediate feedback essential for correcting errors and allow students to assess their own progress.

3. METHODS USED

The manual was created using Word and then edited using Adobe Acrobat. The logo for the manual header was created using Gemini AI: Figure 1. The JavaScript codes for the animation, for the Start and Pause buttons, as well as for the tests were created using AI Chat GPT.

The text has been arranged in columns. Text written in columns is more accessible for several reasons: shorter lines of text are easier for the eye to follow, reducing eye fatigue. The distance the eye has to travel from the end of one line to the beginning of the next is shorter, so readers can scroll through text in columns more quickly. Text arranged in columns creates a more airy and organized design, which makes it more attractive and easier to read.

Additional material, which serves to clarify concepts or remind previously studied definitions, is accessed either through pop-up windows or through links to the manual pages.

3.1 Using the pop-ups

Pop-ups in pdf documents are a creative way to highlight information and improve the user experience. They can display additional information or make the document more visually appealing. In this regard, pop-ups with text definitions and drawings that facilitate the understanding of theoretical material were used (Figure 2 and Figure 3).

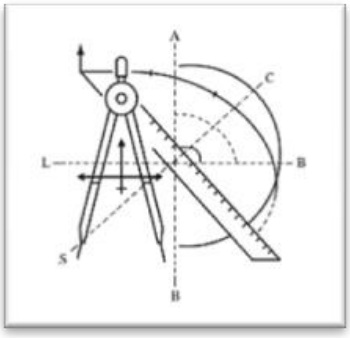


Figure 1 Images created with Gemini AI Artificial Intelligence.

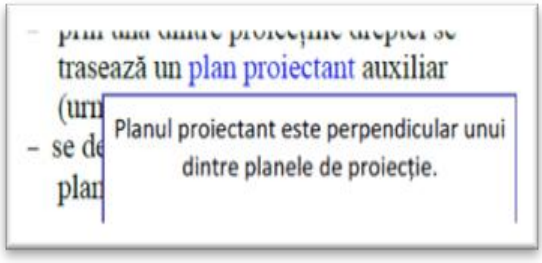


Figure 2 Pop-up windows with text.

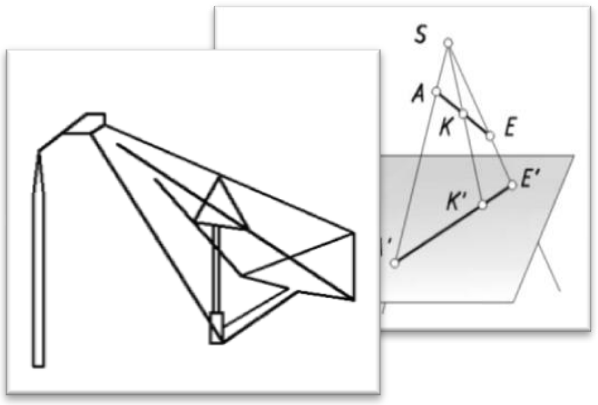


Figure 3 Pop-up windows with images.



Figure 4 Buttons used to display or hide larger pages of content.

Windows are opened either by clicking on highlighted words while hovering over the image, or by using buttons that can be used to show or hide large pages of content (Figure 4).

3.2 Using the interactive spatial models

One of the problems in teaching descriptive geometry is the lack of spatial imagination in students. As a result, problem solving is reduced to applying graphical algorithms without understanding their essence. Thus, students are not able to solve complex problems. To compensate for this disadvantage, it is proposed to supplement the planar drawings with spatial models. Figure 5 shows a spatial model that demonstrates the algorithm for solving the intersection problem of a general position line with a general position plane. The model is interactive and can be rotated to be examined directly on the manual page.

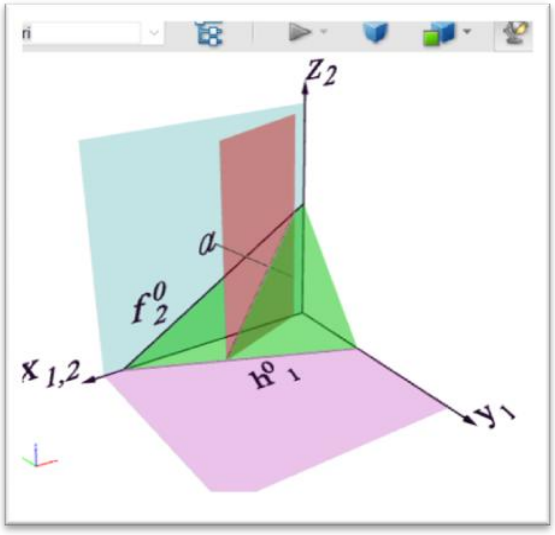


Figure 5 Interactive 3D model.

The model was created using AutoCAD. First, the shell made of lines was created. The rectangles representing the planes were given volume by extrusion. Then the layer in which these planes are located was made transparent. The lines are replaced with cylinders with a diameter of 0.5 mm, and the axis arrows with cones. To give volume to the text, it was converted into polylines with the Explode text command from the Express menu and then extruded.



Figure 6 Buttons with links.

To insert the model into the body of the pdf page, it is necessary to save it in U3D or PRC format. For this action, the Simlab composer software is used [8]. The free version Little Edition is sufficient, which allows importing the dwg file and exporting it in formats supported by Adobe Acrobat.

Buttons containing links to other pages of the same document, files or web pages are also used. Using this function, an interactive menu is created with references to the respective pages.

Figure 6 shows the set of buttons in the footer of the manual pages with a link to the table of contents page (Figure 7), the page with the test on the respective topic and the link to the course web page on Moodle. The table of contents, in turn, consists of links to the respective paragraphs contained in the manual.

3.3 Using the animations

To demonstrate the design processes in dynamics, it is proposed to supplement the problem drawings with animations, which show step by step the execution of the constructions. To create these animations:

- a drawing of the solved problem is made in AutoCAD,
- the drawing is exported in Metafile format (wmf),
- the resulting drawing is inserted into PowerPoint,
- it is ungrouped until separate elements are obtained that are animated consecutively,
- to simulate the process of drawing lines, a Wipe type animation is used,
- other elements, such as points and inscriptions, can be displayed with the Appear type animation,
- the animation is exported in MP4 video format.

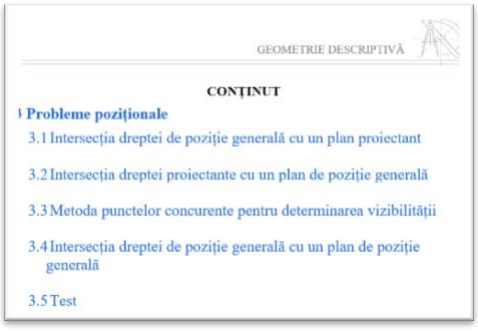


Figure 7 Table of contents.

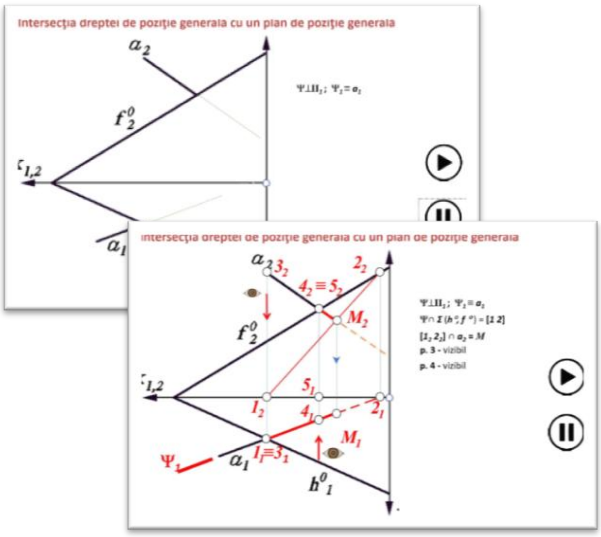


Figure 8 Animation.

The video file captured in PowerPoint is divided into frames. This can be done online using the free program Ezgif, which converts the MP4 file into png format frames [9]. Then the number of frames is reduced by removing duplicate frames. In Adobe Acrobat, the frames are aligned one above the other, then the shape editor is used and buttons are created from the obtained frames. In the proposed example, 68 buttons were created. A JavaScript listing is used to animate the frames by showing and hiding them consecutively. Then the Start and Pause buttons are created, which allow stopping and restarting the animation used (Figure 8).

3.4 Using the quiz

For quiz, a Word document is created with the quiz content, which is then saved in pdf format. The images are created in AutoCAD and saved in png format. In Adobe Acrobat Pro DC, the form containing the questions accompanied by drawings is created (Figure 9).

Form fields are added, such as radio buttons or check boxes for multiple-choice questions. For questions with a single correct answer, grouped radio buttons will be inserted. Pressing a button in the group will determine the value of the field. Clicking the "Check Answers" button checks the user's answers to the questions and calculates the score (Figure 9).

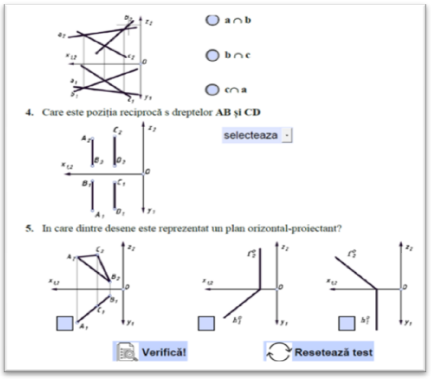


Figure 9 Interactive test.

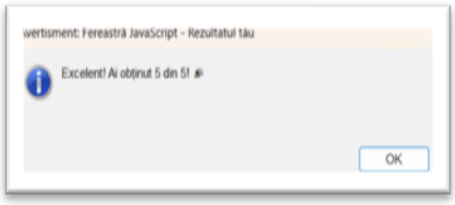


Figure 10 Score of the quiz.

Pressing the "Check Answers" button. Checks the user's answers to the questions and calculates the score (Figure 10).

4. FURTHER RESEARCH

The chapters of the manual were proposed as a teaching aid for first-year students of the Technical University of Moldova. The method of creating the manuals was appreciated by students and teachers. A technical drawing manual is also in the process of being created, which contains the same possibilities. It is proposed to use such a manual within the Technical Drawing discipline at technical colleges.

CONCLUSIONS

1. The knowledge acquired in the Descriptive Geometry discipline is necessary for the engineering profession, forming the basis of technical and scientific activity.

2. It has been established that one of the basic problems in teaching Descriptive Geometry is the lack of spatial imagination in students and as a result, problem solving is reduced to the application of graphic algorithms without understanding the essence, which leads to the inability of students to solve complex problems. To compensate for this disadvantage, it is proposed to supplement flat drawings with interactive spatial models that can be rotated to be examined directly on the textbook page.

3. The chapters of the textbook were proposed as teaching support for first-year students of the Technical University of Moldova (TUM), the creation method being appreciated by students and teachers.

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