UDC 004.94

ENGINEERING AND COMPUTER GRAPHICS AS A FOUNDATION OF STEAM-ORIENTED TECHNICAL EDUCATION

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Abstract *This article investigates the implementation of STEAM (Science, Technology, Engineering, Art, and Mathematics) principles in the academic discipline "Engineering Graphics" and "Technical Drawing and Computer Graphics". The subject is presented as an integrative educational tool that connects analytical thinking, spatial visualization, and technological proficiency. By incorporating tasks such as technical drawing, parametric modelling, and object visualization, the course provides a platform for developing students' creativity, engineering literacy, and multidisciplinary problem-solving skills. Practical examples of STEAM-oriented assignments are discussed.*

Keywords *STEAM education, engineering graphics, spatial thinking, creativity, technical drawing, 3D modelling, educational tasks, engineering training.*

Problem statement. Modern higher technical education requires innovative approaches to developing engineering competencies that integrate analytical thinking, creativity, spatial reasoning, and digital literacy. The disciplines "Engineering Graphics" and "Technical Drawing and Computer Graphics" have traditionally been viewed as tools for mastering the graphical language of engineering, primarily focused on adherence to standards and the preparation of technical documentation. However, with the emergence of the STEAM education paradigm, there is an increasing need to reconsider the content, instructional strategies, and integrative potential of these courses. It is now relevant to explore how these disciplines can serve as a foundation for combining science, technology, and engineering in the education of future professionals.

Analysis of Recent Research. Modern technical education increasingly demands a rethinking of the role of creativity, visual literacy, and interdisciplinary integration. The STEAM framework – an extension of STEM through the inclusion of the arts and cultural components – has received significant attention in recent educational discourse. It is based on the recognition that innovation and creative solutions often arise at the intersection of disciplines and in response to real human needs [1]. Within this approach, the arts are not secondary to science and engineering but are equal contributors to the development of flexible, imaginative, and socially responsive thinking (Table 1).

This integrative vision has important implications for educational practice. Preparing professionals for the challenges of the 21st century requires more than technical accuracy and analytical reasoning; it also calls for the development of design-based problem solving, visual communication skills, and cultural awareness [2]. In the digital era – where the lines between technology, media, and design are increasingly blurred – the traditional division between technical and creative competencies is no longer valid.

Formulation of Goals. The goal of this study is to show how engineering graphics can support STEAM education by combining technical precision with creativity and spatial thinking. The study proposes ways to integrate visual, digital, and interdisciplinary tasks into the curriculum to better prepare students for modern engineering challenges.

The main part. This shift opens new perspectives for traditionally technical disciplines such as Engineering Graphics and Technical Drawing and Computer Graphics. These subjects can serve as effective platforms for implementing STEAM principles, as they combine graphical precision, digital modelling, and creative expression. Furthermore, the integration of digital tools into educational ecosystems enhances interdisciplinary connections and supports flexible, learner-centred approaches that meet the demands of contemporary technical education.

Table 1. Key Differences Between STEM and STEAM Approaches in Education

Characteristic	**STEM**	**STEAM**
Focus Areas	Science, Technology, Engineering, Math	+ Art, Creativity, Design
Type of Thinking	Analytical	+ Integrative, Creative
Problem Approach	Technological solution	+ Human-centred, aesthetic and functional
Application Examples	Technical drawings, calculations	+ Form modelling, product casing, visualization

The disciplines of Engineering Graphics and Technical Drawing and Computer Graphics play a central role in implementing the STEAM approach by combining the precision of technical reasoning with the creative potential of art. Studying projections, constructing drawings, and developing 3D models foster spatial imagination, geometric intuition, and aesthetic perception of form.

Example 1. Within the engineering graphics course, students complete tasks involving axonometric projection, which require precise calculations while enhancing their understanding of the relationship between two-dimensional and three-dimensional object representations. This approach simultaneously cultivates analytical skills and spatial visualization.

Example 2. In the technical drawing and computer graphics course, students design 3D models using software such as AutoCAD. After constructing the basic geometry of a component (e.g., a shaft using a revolve operation), they refine the model by applying ergonomic and functional improvements – adding chamfers, fillets, or structural features. This encourages a shift from mechanical modeling to thoughtful, design-oriented technical creation.

One of the key competencies formed through graphical training is visual literacy – the ability to "read" and "generate" graphical information according to national standards that are standardized and universally applied in engineering practice. Technical drawing serves as the universal language of engineers; however, mastering it requires not only knowledge of rules for presenting and formatting graphic content but also strong spatial imagination, abstraction skills, and the ability to visually structure objects.

Example 3. Students analyse working drawings of mechanical parts based on 2D projections and construct corresponding 3D models. This exercise deepens their understanding of projection principles and their connection to real object geometry.

In Fig. 1, a solid model of a mechanical part is presented alongside a brief design specification, which serves as the starting point for the laboratory task. Students use the provided geometry and dimensions to reconstruct the model in a CAD environment, applying parametric and spatial modelling tools.

In Fig. 2, a projection drawing is shown, generated directly from the 3D model. The drawing includes standard views (front, top, and left), visible and hidden edges, dimensioning, and tolerancing — all according to technical drawing norms. This example demonstrates how engineering graphics enables bidirectional conversion between 2D and 3D formats and strengthens students' skills in both interpreting and producing documentation.

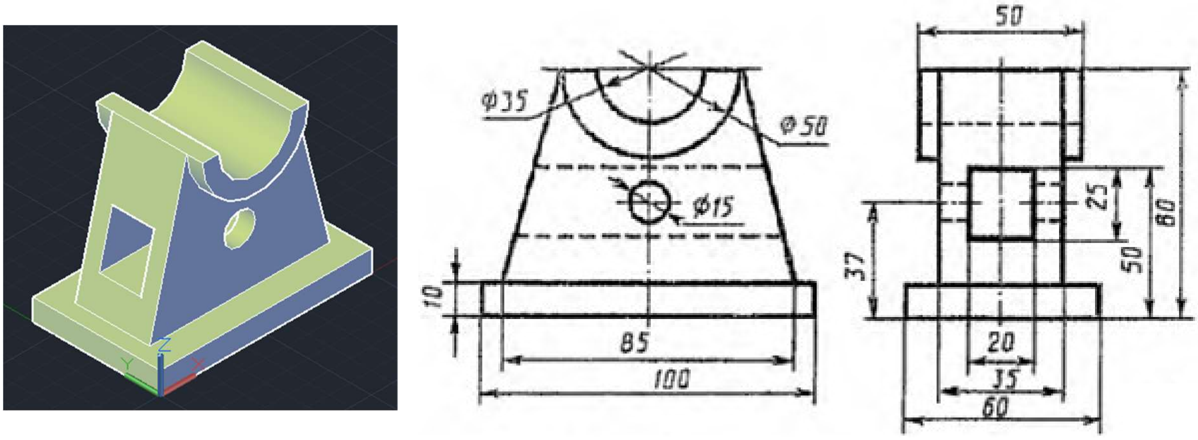

Fig. 1. Solid model and initial task for the laboratory assignment

Example 4. In practical assignments, students are given the reverse task: to create complete working drawings based on 3D models. This develops their ability to accurately and logically represent the shape, dimensions, and functional characteristics of a technical object using engineering graphics. The presence of various constructive elements (e.g., holes, chamfers, grooves) provides opportunities to practice dimensioning, view selection, the use of sections, and the specification of technical requirements.

3D modelling serves as a powerful tool in STEAM education, enabling students to combine engineering knowledge with creative problem-solving approaches. Utilizing 3D modelling software such as AutoCAD, SolidWorks, or Blender fosters the development of spatial reasoning, technical skills, and aesthetic sensibility.

Parametric modelling is one of the key digital technologies that vividly demonstrates the integration of mathematical, engineering, and visual components. Working with parameters helps students not only build precise digital models but also develop design-oriented thinking – by analysing how dimensions and form affect functionality and appearance. Therefore, educational tasks involving parametric modelling naturally support the interdisciplinary logic of the STEAM approach.

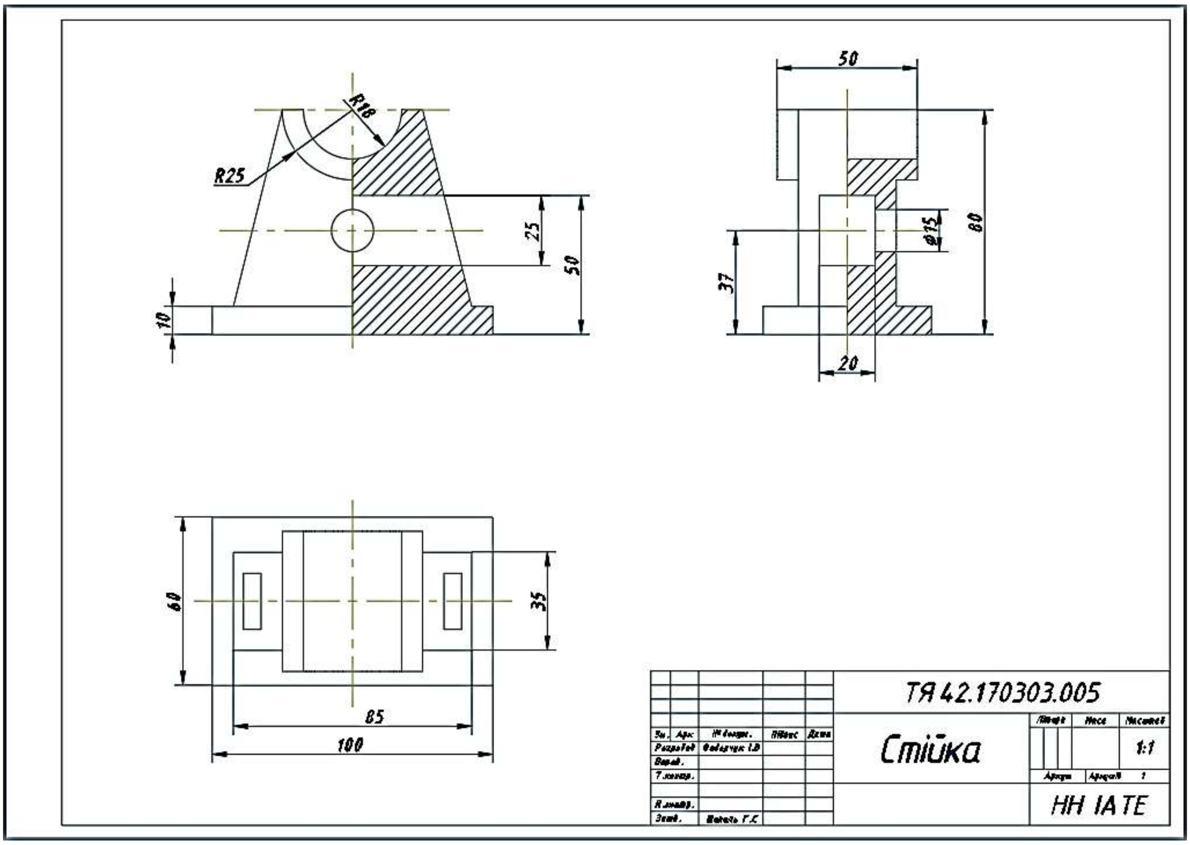

Fig. 2. Projection drawing generated from the solid model in Fig. 1

Example 5. In the computer graphics course, students create flat geometric profiles with variable parameters – such as side lengths, fillet radii, and the number of holes. The model automatically updates when the values are changed, allowing them to explore various design configurations. This approach fosters adaptive digital design skills that are essential in engineering, product development, and modern customizable manufacturing.

Example 6. Another example of implementing the STEAM approach is the task of restoring or repurposing existing technical devices using 3D modelling and printing tools. In the study [3], a broken DEWALT DCF610S2 screwdriver was redesigned by students and transformed into a testing device for car window lifting mechanisms. As part of the project, a new 3D model of the casing was created with geometry adapted to the altered function.

This case illustrates not only proficiency in digital tools, but also the application of design thinking, ecological awareness, and engineering creativity. It demonstrates how STEAM-oriented education empowers students to generate innovative solutions that extend the product lifecycle and reduce waste.

One of the promising directions for implementing the STEAM approach in courses such as Engineering Graphics and Technical Drawing and Computer Graphics is the introduction of project-based tasks that combine technical reasoning, visual literacy, aesthetics, and applied engineering. These tasks can simulate real-world scenarios and help students develop interdisciplinary skills.

The practical application of STEAM-based approaches in graphical disciplines is further demonstrated through real examples of student assignments. Samples of work produced within the Engineering Graphics and Technical Drawing and Computer Graphics courses are available on the website of the Department of Descriptive Geometry, Engineering and Computer Graphics at Igor Sikorsky Kyiv Polytechnic Institute [4].

Idea 1. Designing a device casing optimized for 3D printing. Students can be tasked with designing a protective casing for a conceptual electronic module, considering structural, ergonomic, and aesthetic requirements. The model would be created as a parametric sketch using CAD software, adapted for 3D printing, and supplemented with graphical documentation. The theme can be adapted – for instance, a casing for a mobile sensor, mini fan, or battery pack.

Idea 2. Redesigning a household or technical object for use in crisis conditions. As part of a learning project, students may be assigned the task of selecting or being provided with a basic household item (e.g., a handle, container, mount, or connector) and redesigning it to improve its usability under specific conditions such as limited mobility or emergency settings. Special attention should be given to accessibility for people with disabilities. The assignment encourages adaptation to real-life constraints – minimum material use, ease of production, user-friendliness, and modularity.

Idea 3. Microproject "One Object – Three Use Scenarios". Students may be assigned the task of selecting a basic household item (e.g., a pen, spoon, lamp, or hanger) and designing three versions of it: one for a typical user, one for a child or elderly person, and one for a person with a disability. The project involves adapting the form, dimensions, and functionality based on anatomical, sensory, and motor characteristics of different users. This type of assignment fosters critical thinking, empathy, and the ability to design human-centred engineering solutions.

Conclusions. The implementation of STEAM principles in courses such as Engineering Graphics and Technical Drawing and Computer Graphics opens new opportunities for developing interdisciplinary thinking among students of technical disciplines. By combining technical precision with a creative approach to form, function, and visualization, these courses can serve as effective tools for shaping modern engineering culture.

Project-based tasks, the integration of digital technologies (CAD/3D modelling), and the inclusion of human-centred design foster spatial reasoning, design sensitivity, and real-world problem-solving skills. The STEAM approach enables the transformation of traditional graphics education into a dynamic, meaningful, and relevant practice.

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