

# Transformations of descriptive geometry education for architecture students at Gdańsk University of Technology, Poland

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**ABSTRACT:** In this article, the authors analyse the evolution of teaching descriptive geometry for architecture students at Gdańsk University of Technology (Gdańsk Tech), Poland. The study traces changes in the curriculum in terms of teaching hours, considering also practices at Politechnika Lwowska (Lwów Polytechnic) and the Technische Hochschule Danzig (Technical University of Gdańsk), before World War II. The article identifies key historical periods during which changes in the teaching of descriptive geometry were examined. The analysis indicates a significant reduction in the number of teaching hours dedicated to descriptive geometry and a simultaneous increase in the importance of using computer-aided design (CAD) tools and three-dimensional parametric modelling. The importance of spatial understanding and imagination, fostered by geometric education, is discussed. The article advocates for a curriculum that integrates geometric concepts within broader contexts of architectural and digital design, ensuring the development of essential spatial skills among future architects.

## INTRODUCTION

Since the inception of technical universities, descriptive geometry has played a significant role in educating students. It was helping to understand spatial correlation between solids and expand spatial understanding. However, it is a discipline that is recently becoming less and less crucial in traditional form due to digital technologies development. In this article, the authors focus on analysing the amount of teaching hours of geometry education at Gdańsk University of Technology (Gdańsk Tech), Poland. The beginnings of the teaching system developed prior to World War II at Lwów Polytechnic and at the German Technische Hochschule Danzig (predecessor of Gdańsk Tech) are also covered, presenting how the curriculum gradually evolved through the years and what prompted these changes.

### Recent Studies of Descriptive Geometry Education

The issue of the obsolescence of the descriptive geometry course is a common problem across many universities. Since the early 21st century, with the increasing prevalence of digital technologies, there has been a departure from traditional teaching methods in descriptive geometry. Many universities have faced the same dilemma: questioning whether descriptive geometry is still necessary given that computer programs now handle all constructions [1]. The gradual reduction in hours allocated to descriptive geometry has caused an immediate decline in the subject's prominence, yet it has never prompted a remodel, reconsideration or update.

Some universities have completely eliminated the course, replaced by a training in the use of computer-aided design (CAD) software, which mainly has a technical character [2]. Other universities have significantly reformed the course initiating teaching innovation projects for geometry. The objectives were generally to engage students dynamically, integrate new technologies and revise the syllabus for a more pragmatic approach to real architecture. Universities began focusing on reducing the complexity of the subject to make it more approachable for students. It emphasised the importance of student involvement by bringing the abstraction of geometry closer to real-world architecture. It aimed to enhance student understanding and engagement and improved student understanding of the subject matter [3].

Another interesting approach to changing teaching methods in descriptive geometry was the introduction of the GeoGebra software and the way it enhanced the learning process [4-6]. The application was mostly used to create models of given exercise, allowing students to see the overall concept of their task [7]. The second most frequently mentioned method was the implementation of virtual reality and augmented reality. The first attempts appeared in 2005, marking it the approximate beginning in research towards changing descriptive geometry teaching methods and curriculum [8]. As time progressed, more similar studies appeared [5], as well as the development of immersive reality tools [9][10]. What was peculiar for latter studies, was the application of modern technologies, such as virtual reality (VR) goggles and augmented reality (AR) software [7]. Another interesting approach was testing students' knowledge

by giving them mental cutting tests at the beginning and at the end of the course of geometry [11-14]. Most of the tested students stated that the descriptive geometry course expanded their spatial thinking skills [12], especially mental rotation and manipulation [14], which helps with solving spatial problems.

#### History of Technical Universities in Gdańsk and Lwów/Lviv

Gdańsk University of Technology began its functioning under the German Empire's governance in 1904, as the Königlische Technische Hochschule zu Danzig, with facilities for students from West Prussia and Pomerania. It initially had six faculties, including the Faculty of Architecture, where descriptive geometry was taught. In 1921, it was renamed to the Technische Hochschule der Freien Stadt Danzig (Free City of Gdańsk). Later it was renamed to Technische Hochschule Danzig (1939-1941) and Reich Hochschule Danzig (1941-1945). Simultaneously, the name Politechnika Gdańska was in use, and it has been officially called in this way since 1945 [15].

The technical school in Lwów/Lviv commenced its functioning under the Austro-Hungarian Empire in 1817 as a secondary school, becoming the Imperial-Royal Technical University in 1844, and later the Polytechnic School in 1877. It was renamed to Lwów Polytechnic under the Polish jurisdiction in 1920. In 1939, due to the Soviet takeover of Lwów, the university had undergone another name change to Lviv Polytechnic Institute. Nowadays, since 1994, the institution has the status of national university in Ukraine, and became Lviv Polytechnic National University.

Descriptive geometry emerged as a separate subject in 1847/48, though a dedicated department of geometry was not established until 1870, previously having been part of the Department of Mechanics and Descriptive Geometry. Under the Austro-Hungarian Empire, until 1918, the curriculum had evolved significantly. Activities ceased in July 1941 when the Germans occupied Lviv [16].

After World War II, Gdańsk University of Technology was rebuilt by the new Polish government [17]. In October 1945, the University resumed educational activities, establishing a descriptive geometry department led by Franciszek Otto, a former assistant at Lwów Polytechnic. He contributed to the transfer of educational programmes developed at Lwów Polytechnic to Gdańsk [16]. Methods implemented by Professor Otto became a tradition in teaching geometry and have become permanently ingrained in the teaching of descriptive geometry in the Faculty of Architecture at Gdańsk Tech.

#### Recent Geometry Teaching at Gdańsk University of Technology

The recent teaching of descriptive geometry in the Faculty of Architecture at Gdańsk Tech is a continuation of the work of professors and lecturers active in the first half of the 20th century. However, the historical programme and historical teaching methods have undergone more and more far-reaching changes and innovations. Around 1995, experiments began with the introduction of exercises using tools based on CAD systems.

In the second decade of the 21st century, the range of tools used during classes was also expanded to include tools for three-dimensional parametric modelling. At the same time, the use of advanced geometric constructions during classes has been constantly reduced. In recent years, the teaching methods themselves have also been transformed. The blended learning method was introduced with the use of an on-line course on the eLearning platform.

In the 2023-2024 academic year, traditional lectures using blackboard drawing were eliminated and replaced by on-line lectures in the form of videos and interactive presentations supplemented by discussions, held in the form of remote meetings. The experimental field for the reforms described above was the remote teaching introduced during the Covid-19 pandemic.

The following sections of the article are focused on analysing the changes that have occurred over the years in the education of descriptive geometry on the example of Gdańsk Tech, and on determining the future of this field in architectural education. The authors anticipate that the study will identify the direction of its further development, thereby encouraging future researchers to continue advancing this field of knowledge.

#### METHODOLOGY

The authors began by identifying the directions of changes in the teaching of descriptive geometry and determining trends, which were presented through a comparative analysis of the number of hours dedicated to education. The greatest emphasis was placed on comparing how the implementation of new digital technologies has influenced traditional approaches to teaching geometry. The study examined how the new system of geometry education could, more effectively achieve the intended goals and learning outcomes.

To conduct the analysis, the timeline was divided into five periods in the history of geometry, based on pivotal changes in teaching hours.

- 1921-1940 - Period I of teaching of geometry at Lwów Polytechnic and Lviv Polytechnic Institute [18];
- 1907-1945 - Period II of teaching of geometry at the Technische Hochschule Danzig [19];

- 1945-1965 - Period III of post-war practices at Gdańsk University of Technology [20];
- 1965-2004 - Period IV of significant reduction in hours [20];
- 2004-2024 - Period V of reduction in hours and broader implementation of new computer technologies [20].

To analyse changes in the teaching hours of descriptive geometry, the authors examined the study programmes of Lwów Polytechnic and Lviv Polytechnic Institute from 1920-1940, the study programmes of the Technische Hochschule Danzig from 1907-1945 and enrolment records, as well as study programmes of Gdańsk Tech from 1945-2024. The subjects taught in the given academic years were analysed, and those directly related to descriptive geometry were selected. The obtained data were compiled into tables (Table 1, Table 2 and Table 3) showing the weekly teaching hours of subjects related to descriptive geometry over the years. Finally, the number of hours devoted to teaching descriptive geometry in a traditional way was counted and compared with the number of hours during which digital technologies are used in teaching at Gdańsk Tech during the current academic year 2023-2024.

## RESULTS

From the subjects taught in various years at the selected universities, the following were considered:

- At Lwów Polytechnic and Lviv Polytechnic Institute (Table 1):
  - Lectures: Descriptive Geometry, Introduction to Descriptive Geometry, Painting Perspective;
  - Exercises: Drawings in Descriptive Geometry, Exercises in Descriptive Geometry, Drawings in Painting Perspective.
- At the Technische Hochschule Danzig (Table 2):
  - Lectures: Descriptive Geometry, Descriptive Geometry I, Descriptive Geometry II, Painting Perspective and Photogrammetry;
  - Exercises: Descriptive Geometry, Descriptive Geometry Ia, Descriptive Geometry IIa, Painting Perspective and Photogrammetry.
- At Gdańsk University of Technology (Table 3):
  - Lectures: Descriptive Geometry, Geometry for Architects;
  - Exercises: Descriptive Geometry, Geometry for Architects.

Table 1: Weekly teaching hours of descriptive geometry at Lwów Polytechnic in 1921-1939 and Lviv Polytechnic Institute in 1939-1940.

Per.	Academic year	Lec. (h) I sem.	Ex. (h) I sem.	Lec. (h) II sem.	Ex. (h) II sem.	Lec. (h) III sem.	Ex. (h) III sem.	Lec. (h) IV sem.	Ex. (h) IV sem.
I	1921/22-1924/25	4	6+2e	4	6+2e	2		2	4
	1925/26-1930/31	4	8	3	8	3			4
	1932/33	5	-	4	8	3	8	3	4
	1934/35-1939/40	5	6+2e	3	6+2e			2	4

\*Note: Legend: Per. - period, Lec. - lectures, Ex. - exercises, sem. - semester, e. - extra classes

Table 2: Weekly teaching hours of descriptive geometry at the Technische Hochschule Danzig from 1907-1945.

Per.	Academic year	Lec. (h) I sem.	Ex. (h) I sem.	Lec. (h) II sem.	Ex. (h) II sem.	Lec. (h) III sem.	Ex. (h) III sem.	Lec. (h) IV sem.	Ex. (h) IV sem.
II	1907/08-1918/19	3	5	3	4	-	-	-	-
	1925/26-1926/27	4	5	-	-	-	-	-	-
	1927/28-1933/34	4	5	1	2	-	-	1	2
	1934/35-1940/41	2	2	2	2	-	-	-	-
	1941/42-1943/44	-	-	2	2	1	3	-	-

\*Note: Legend: Per. - period, Lec. - lectures, Ex. - exercises, sem. - semester

Table 3: Weekly teaching hours of descriptive geometry at Gdańsk Tech from 1945-2024.

Per.	Academic year	Lec. (h) I sem.	Ex. (h) I sem.	Lec. (h) II sem.	Ex. (h) II sem.	Lec. (h) III sem.	Ex. (h) III sem.
III	1945/46-1947/48	4	3	3	6	1	3
	1948/49-1956/57	4	3	3	3	1	3
	1957/58-1963/64	3	3	2	2	1	2
IV	1964/65-1971/72	2	2	2	2	1	2
	1973/74	2	2	2	2	2	3
	1975/76-1990/91	2	2	2	2	-	2
	1991/92-2003/04	2	2	2	2	-	-
V	2004/05-2018/19	2	1	2	1	-	-
	2019/20-2023/24	2	1	1	1	-	-

\*Note: Legend: Per - period, Lec. - lectures, Ex. - exercises, sem. - semester

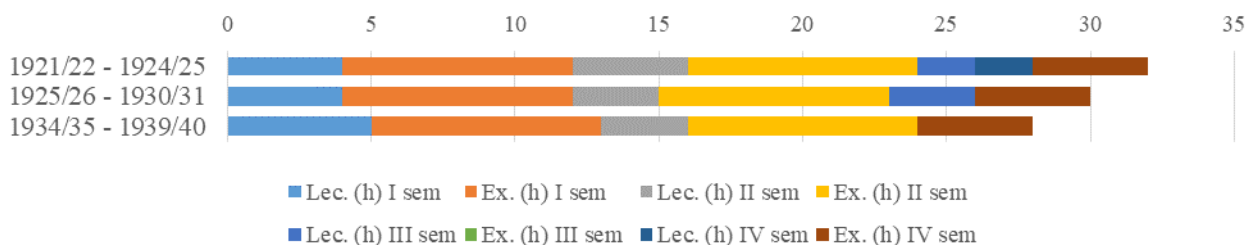


Figure 1: Weekly teaching hours of descriptive geometry at Lwów Polytechnic in 1921-1939 and Lviv Polytechnic Institute from 1939-1940 (Lec. - lectures, Ex. - exercises, sem. - semester).

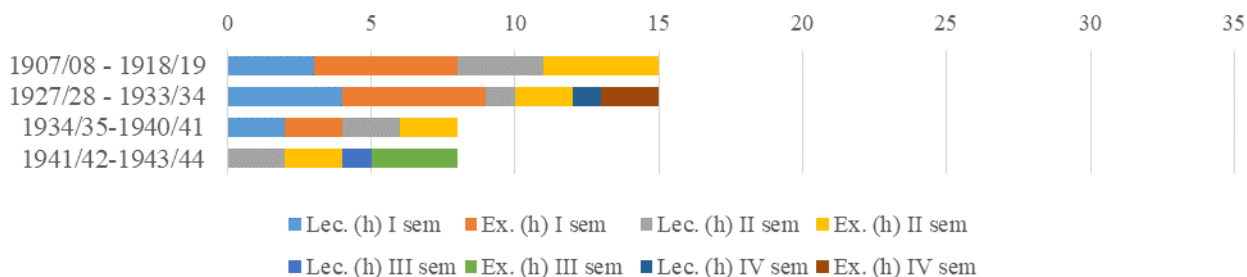


Figure 2: Weekly teaching hours of descriptive geometry at the Technische Hochschule Danzig from 1907-1945 (Lec. - lectures, Ex. - exercises, sem. - semester).

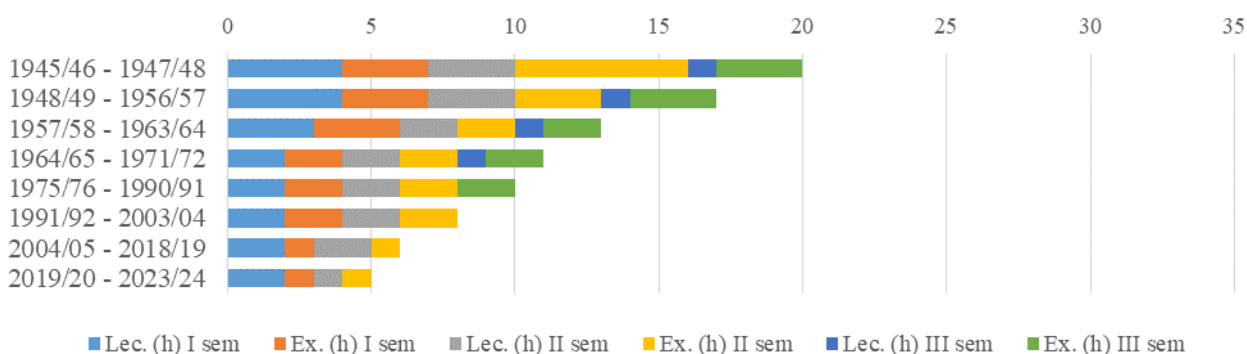


Figure 3: Weekly teaching hours of descriptive geometry at Gdańsk Tech from 1945-2024 (Lec. - lectures, Ex. - exercises, sem. - semester).

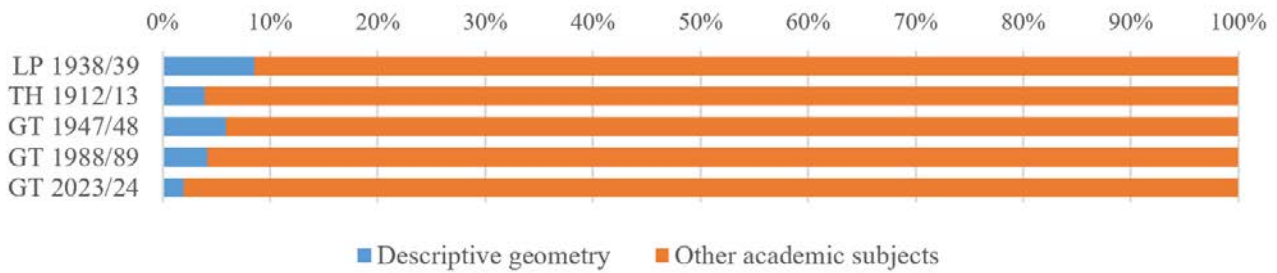


Figure 4: Comparison of the percentage of descriptive geometry hours in relation to the total number of teaching hours during the entire architectural education (LP - Lwów Polytechnic, TH - the Technische Hochschule Danzig, GT - Gdańsk Tech).

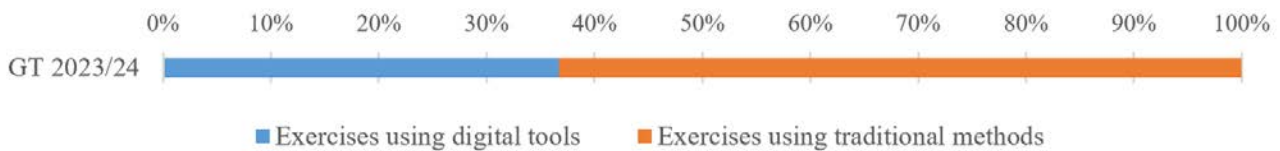


Figure 5: Comparison of current descriptive geometry exercise hours dedicated to learning using traditional and digital tools at Gdańsk Tech.

#### Lwów Polytechnic, 1921-1939 and Lviv Polytechnic Institute, 1939-1940

Geometry at Lwów Polytechnic was taught from the first semester and continued until the end of the fourth semester. A substantial number of hours were dedicated to this subject, ranging between 28 and 30 instructional hours per week over the course of four semesters (Figure 1). The number of hours allocated for exercises was greater than for lectures [18].

#### Technische Hochschule Danzig, 1907-1945

Descriptive geometry at the Technische Hochschule Danzig was taught during the first two semesters. The number of hours dedicated to this subject, compared to the total number of hours allocated for the architectural education (Figure 2), is not high in comparison to Lwów, even considering the relatively shorter duration of technical education - four academic years. The number of hours dedicated to exercises exceeded the number of hours dedicated to lectures [19].

#### Gdańsk University of Technology, 1945-1965

The third period is Gdańsk Tech after World War II. During this time, Gdańsk Tech began its activities under Polish jurisdiction, which mainly led to education reform in the geometry curriculum. The number of hours increased compared to the German School, but did not reach the same level as in Lwów (Table 3). This is also evident in relation to the overall architectural education (Figure 3) [20].

#### Gdańsk University of Technology, 1965-2004

Descriptive geometry at Gdańsk Tech in the subsequent period continued to be taught during the first three semesters; however, the number of hours allocated for teaching was significantly reduced compared to the years immediately following the war. The time dedicated to lectures and exercises was comparable, as some tasks were transferred to students as homework. Comparing this number to the total number of hours devoted to the architectural education (Figure 4.), it can be noted that the significance of geometry noticeably decreased [20].

#### Gdańsk University of Technology, 2004-2024

In the last period analysed, descriptive geometry at Gdańsk Tech was taught only during the first two semesters, and once again, the number of hours allocated for teaching was significantly reduced. Remarkably, the time dedicated to lectures was greater than the time for exercises (Table 3). Additionally, during this period, teaching of descriptive geometry using digital tools was introduced. Their use is constantly growing and currently their number is only slightly smaller than the number of traditional classes during the entire academic year (Figure 5). This is due to the fact that the entire first semester is devoted to theoretical preparation using traditional methods and all digital tools are used in the second semester [20].

## DISCUSSION AND CONCLUSIONS

An analysis of the hourly grids clearly shows that since the middle of the 20th century, the study plans of the Faculty of Architecture at Gdańsk Tech have devoted less and less time to drafting geometry. It is, therefore, not surprising that the programme of the subject is also being reduced from year to year.

The current programme for the first semester has undergone a complete educational reform. During the classes, only the simplest geometric constructions are introduced to the smallest extent possible to understand their principle. The most significant recent change is the simultaneous introduction of Mongean projections and axonometry, allowing students to analyse constructions from both perspectives concurrently. This approach enhances spatial understanding and imagination.

In the second semester, traditional shadow constructions have been discontinued. While perspective assignments remain largely unchanged, topographic projection tasks have been significantly transformed and expanded to include topics previously covered in Mongean projections. Those topics are mainly geometry of roofs and site plan exercises, including rainwater management and building shading. This change has been introduced to reflect current architectural practice and emphasise practical applications.

The analysis conducted on the transformation in descriptive geometry education clearly indicates a significant reduction in teaching hours and a shift towards the use of digital tools. This state of affairs naturally reflects the declining role of traditional drawing in design. However, it raises huge problems in building advanced spatial imagination among students, which, by solving complex geometric problems, stimulated its development.

The reduction in the number of hours (absolutely and also relatively to the total number of hours provided in the curriculum) reduces the chances of students to develop this imagination. It should also be mentioned that the typically engineering role of geometry in teaching students traditional geometric constructions, although to a lesser extent, is still important.

Geometry is also a contemporary theoretical introduction to three-dimensional modelling. The authors are, therefore, faced with a greater dispersion of the roles of drafting geometry as a teaching activity in the Faculty of Architecture at Gdańsk Tech. This dispersion should, in the authors' opinion, be reflected in the curriculum as well. Weaving the individual hours of classes taught by didacticisms associated with the subject of Descriptive Geometry into the framework of classes, such as computer techniques or architectural design, would allow these dispersed roles of the subject to be better realised. At the same time, it would make it possible to focus the main course hours on the currently guiding role of developing spatial imagination.

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