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Abstract

This article looks back at the unclear history of city planning education in Spain and examines its relationship with the educational history of architects. Spain is a country that has developed the most urban planning experts including hundreds of town construction cases of colonial towns in the history of city planning since the Age of Exploration. Today, city planning and/or urban design education in Spain is part of the architectural education, which is generally incorporated in the superior technical school of architecture in technical university or general universities.

City planning experts have historically been equal to military engineers or architects, but it is quite unclear how the education of city planning was started and developed. This paper organizes the basic history of city planning education in 18th-century Spain especially focusing on one of the important academies of related fields, the Royal Military Academy of Mathematics of Barcelona (*La Real Academia Militar de Matemáticas en Barcelona*) which produced many military engineers and was responsible for the education of city fortification also. The paper tells that the educational content of military academy such as above was also linked to urban space improvement what would be civil town planning.

The case study of the Royal Military Academy of Mathematics of Barcelona, observing the composition of the academy, its curriculum, instructors' backgrounds, students' notes, and so on, tells us that mathematics and geometry were deeply linked with military engineering and architecture. The education of mathematics, especially of geometry, was a basic knowledge to create reasonable and well-ordered construction of fortifications for engineers. The engineers related to the Academy played an important role on the fortification design of not only the Spanish colonial towns but also some important fortification projects of the towns in Spain. Moreover, as those engineers were also involved in urban public space development, it is obvious that the education on mathematics and geometry for engineers in the military academy played an important role on the development of not only military urban and architectural projects but also civil planning projects.

Keywords: Royal Academy of Mathematics of Barcelona, City Planning Education, Spain, Military Engineers, Architects, 18th century

Introduction

It is important to understand the historic formation of town planning education in early modern Spain, where a large amount of town planning was practiced in an era when the modern concept of “urban planning” had not yet been established. This paper aims to show the historical formation process of town planning education, looking at the academies that produced experts who were in charge of city planning enterprises, in the context of architectural education.

The principal institution for architects and engineers in 18th-century Spain was the academy, not in Madrid, however, but in Barcelona. The Royal Academy of Fine Arts of San Fernando was established in the mid-18th century, but before that, the Royal Military Academy of Mathematics of Barcelona had been established as an educational institute for military engineers in the 1720s.

The historical development of architectural education is important not only from the viewpoint of fine art education but also from the viewpoint of the architectural education of engineers. It is impossible to separate the basic concept of architectural education from the aspect of city improvement measures such as the civil engineering and urban aesthetic, that is, city planning education. The profession of architect, in addition to including the design of buildings, involved the restoration of buildings and the beauty of cities. Additionally, as seen in Spain and its colonial urban development projects, architects and technicians were experts responsible for the fortification design in the planning of roads, bridges, and plazas.

The 17th and 18th centuries were times when the modern concept of “urban planning” had not yet been established, but after the Renaissance, architects had treated knowledge of city planning as part of architectural theory, and architects had received such an education. The education process of architecture and city planning is not clearly understood; it is relatively easier to capture the education history of city planning by paying attention to expert educational institutions for professionals of military projects.

This paper focuses on the composition of the Royal Military Academy of Mathematics of Barcelona, which was established as a constructional educational institution for military engineers in the 18th century; it further summarizes the basic knowledge of the historical development of city planning education for architects.

Engineers in their home country and colonial cities

Urban drawings created in the Spanish colonial period that show town space composition often include information about the related engineers, including names. The personal history of the engineers, upon examination, shows hints about how they absorbed the knowledge of drawing urban plans. For instance, the engineer Agustín Crame y Mañenas (1730-1780), who drew the urban image of Campeche [Fig.1], was a military engineer and was also a professor at the Royal Military Academy of Mathematics of Barcelona.¹⁾ As another example, Juan Martín

1) ———— MUÑOZ CORBALÁN, Juan Miguel (coord.): *LA ACADEMIA DE MATEMÁTICAS DE BARCELONA, El legado de los ingenieros militares*, Ministerio de Defensa, 2004, p.185.



Fig.1 Urban image of Campeche, 1772 (MUÑOZ, 2004, p.178.)

Zermeño (1700-1773), an engineer known for the Royal Fortress of San Fernando on the outskirts of Figueras, Spain, is also known for his success in colonial Cuban and Chilean cities.

Military engineers who were active in urban planning and urban improvement projects in both their home country and the colonial cities were high-ranking engineers called, among other titles, Ordinary Engineer, Extraordinary Engineer, Chief Engineer, etc. It is known that they were engaged

in education at the Royal Military Academy of Mathematics of Barcelona or that, in many cases, they commonly were educated as an engineer at this academy and they were, so to speak, selected engineers. The Royal Military Academy of Mathematics of Barcelona was expanding education in various fields, which will be explained in a later paper, but in this paper, we are focusing on the characteristics of educational institutions that are especially related to city planning.

City planning academies in Spain

Some improvements to educational institutions of architecture and city planning in early modern Spain took place in the era of King Philip II. The first notable example would be *La Academia Real Mathematica* (the Royal Academy of Mathematics), founded in Madrid in 1582 under the direction of Spanish architect Juan de Herrera and Italian military engineer Tiburzio Spanocchi (1541-1606). This institution imparted knowledge necessary for the planning of military facilities such as Euclidean geometry, navigation technique, and fortification, and it is thought that it also included education related to city planning. However, this institution did not last long and closed around 1625.

In 17th-century Europe, fortification theory by French engineer Sébastien Le Prestre de Vauban (1633-1707) was remarkable. An outstanding example of a Spanish educational institution is the Spanish military academy in Brussels. However, this academy lost its function at the beginning of the 18th century. During the same period, the Spanish Royal started to plan the establishment of an educational institution for military engineers in Barcelona: *La Real y Militar Academia de Matemáticas de Barcelona* (Royal Military Academy of Mathematics of Barcelona), that we focus on this paper.

Another institution, *La Real Academia de Bellas Artes de San Fernando* (Royal Academy of Fine Arts of San Fernando), was established in Madrid in 1752. There, under the influence of Italian education, expert education for arts, painting, sculpture, and architecture were started. In this style of architectural education, there was a basic concept of control of excessive baroque decorations and of reforms of ordinary architecture by the military architects²⁾.

2) ——— Antonio de Lizaur y de Utrilla, ed. *LA ILUSTRACIÓN EN CATALUÑA: La obra de los Ingenieros Militares*. Barcelona: Ministerio de Defensa, 2010, pp.150-164.

The Royal Academy of Fine Arts of San Fernando grew as an educational institution for architects and civil engineers. This academy played a vital role in producing important architects and military engineers related to public construction projects in that century.

The Royal Military Academy of Mathematics of Barcelona, on the other hand, was established before that of San Fernando in necessary under the situation of the city of Barcelona and Spanish Succession War, and academy in Barcelona was realized. In this institution, education for architects and military engineers was practiced not in terms of one of three representative arts, but from a viewpoint of architecture and city planning as science.

The formation of the Royal Military Academy of Mathematics of Barcelona and its background

Before the establishment of the Academy

In 16th-century Spain, when fortification projects were being undertaken frequently, an Italian engineer, Tiburzio Spanocchi (1541-1606), was appointed as the director of Spanish fortification engineering; thus, Spain was dependent on Italian tradition and engineering. Such fortification engineering was practiced not only in the home country of Spain but also in its colonies³⁾. Another example of Italian influence is another Italian engineer, Bautista Antonelli (1547-1616), who was engaged in the fortification project of the Strait of Magellan.

Spanocchi established *La Academia Real Mathematica* (Royal Academy of Mathematics) in Madrid in 1582, together with Juan de Herrera (1530-1597), an architect and also a mathematician, under the royal instruction of King Philip II. It was established as an educational institution for experts such as geographers, astronomers, architects, engineers, military experts, and other mathematical scientists. Later, the academy put more emphasis on practical education than theoretical education, adding cosmography and navigation; it began to function as an institution for training the young people of the court.

Outstanding academics in these fields were gathered as faculty members. Among them was military architect Cristóbal de Rojas (1555-1614)⁴⁾, who was a student of Spanocchi and also an assistant of Herrera, and another military engineer, Pedro Rodríguez de Muñiz, who specialized in math and the square root. Military architecture is a field centered on fortification, and it required knowledge of architecture and military technology. Mathematical knowledge such as geometry was also an indispensable factor for a rational architectural planning with high protection. *Academia Real* itself cooperated, in 1625, with *Colegio Imperial de Madrid* (Royal College of Madrid, or *Reales Estudios de San Isidro*), which was also founded in Madrid at the end of the 16th century, and was responsible for natural sciences education. *Academia Real* was

3) ————— In Spain, Spanocchi practices fortification projects in such as Jaca, Pamplona, Fuenterrabía, and in the American colonies in the fortification of the Magellan Strait. MUÑOZ CORBALÁN, Juan Miguel (coord.): *LA ACADEMIA DE MATEMÁTICAS DE BARCELONA, El legado de los ingenieros militares*, Ministerio de Defensa, 2004, p.173.

4) ————— CRISTÓBAL DE ROJAS wrote *La Teórica y práctica de fortificación* (Madrid, 1598), as one of the great achievements of *La Academia Real Matemática*. He had a concept that the most important thing as a military engineer was to fully understand geometry. Francisco Javier Sánchez Martín, *Estudio del léxico de la geometría aplicada a la técnica en el Renacimiento hispano*, Universidad de Salamanca, 2009, p.48.

at that time specializing in mathematical science, and collected educators from various specialized fields, but eventually closed in 1783 owing to a lack of facilities and management system.

The great development of artillery power in the 17th century made urban fortification more important than ever. Because of this, demands for strengthening educational systems of mathematics, military affairs, and architecture increased, and we can assume that the knowledge required by servicemen and engineers has been mixed. Military knowledge required by engineers that were engaged in urban improvement increased, as such military knowledge would be required for fortification projects in Spain as well as in its colonial cities.

In 1675, the *Academia Militar de Bruselas* (Military Academy of Brussels) was founded. It was an institution for professional education for artillerymen and engineers, established under the direction of military engineer Sebastián Fernández de Medrano (1646-1705). Many engineers were trained at this academy, and from this academy there were many dispatched to the colonial cities in America. The Royal Military Academy of Brussels was an important military academy in the Spanish fortification project, but when it fell to the French army in 1697, it declined, leading to its dissolution in 1706. However, this the academy directly influenced the organization and development of the Royal Military Academy of Mathematics of Barcelona in the 18th century.

Establishment of the Royal Military Academy of Mathematics of Barcelona

At the end of the 17th century, the Royal Academy of Mathematics in Madrid was set to relocate to Barcelona, and engineer Sebastián Fernández de Medrano was nominated as the general director; however, Medrano would pass away in 1705. Prior to his death, Medrano planned an outline of the future Academy of Mathematics of Barcelona and presented it to the king, and it was decided that the establishment of the Royal Military Academy of Mathematics of Barcelona would be established following a Royal Decree by King Charles II on January 22nd, 1700. The education would follow the same policy as Brussels' Academy under the guidance of general directors Francisco Larrando de Mauleón and José Mendoza y Sandoval, but the Academy's activities were temporarily canceled because of the Siege of Barcelona of 1705 for a short period of time.

After that, engineer, Jorge Próspero de Verboom⁵⁾ was appointed chief engineer on January 13, 1710, when the academy was started up again. As Verboom was one of the important disciple of Medrano in Brussels, Barcelona's Academy would follow the policy of Brussels' Academy.

Improvement of the educational environment

The academy did not open quickly, but Verboom arranged the educational environment with facilities such as the drawing room and faculty, student, and teacher's lodgings, which were important for receiving education in geometry, drafting, and fortification planning, and on June 22nd, 1720, the Royal Military Mathematics Academy of Barcelona was officially opened. At this time, the general director, Italian engineer Mateo Calabro (1720-38, term of office), was appointed. After that, it became an educational institution for engineers and infantry, and later

5) ————— Verboom was an engineer who was educated Medrano in Brussels.

only for engineers, lasting until its closing in 1803.

The academy developed and improved the teaching method for fortification planning and its appropriate scale, etc. The result was used in city planning of the Spanish colonies in America, and it is said that many of the architects on the new continent were produced in this academy. It is also said that Calabro promoted algebra, cosmography, astronomy, and navigation techniques, and made light of the practical contents such as fortification projects and drawings.

The directors who followed Calabro were engineer Pedro de Lucuze (1738-1779), then Miguel Sánchez Taramas (1779-1789), and Félix de Arriete (1789-1793). After 1724, the academy was located in a corner of the arsenal (weapons plant) of Barcelona's fortress, *Ciudadella*. The academy needed at least two large rooms and sufficient light. One of the two large rooms needed capacity as a classroom for 30 to 40 people to learn mathematics and geometry. The other was a classroom for drawing and fortification planning classes, which was calculated to be large enough for half of the students to be able to use.

The official rule of the Royal Military Academy of Mathematics of Barcelona, to be precise, was promulgated in 1739 as part of the Royal Ordinances. In addition to the nomination of one director and two assistants, it was also stated that one drawing director (overseeing all engineers) and a set of teaching materials and tools (two globes, a celestial globe, a protractor, a compass, a level, etc.) should be prepared. However, what is further remarkable is that the director was responsible for maintaining the level of the lessons, and for regulating the period and the contents of the lesson. In particular, the number of students was to be no more than 40; the age of the students had to be over 15 and under 30 years old, and they were to be endowed with aristocratic behavior and dignity. The Academy seemed to support those selected applicants to be able to get education in Barcelona to produce more excellent engineers.

Academy's educational program

The Brussels' Academy, the precedent similar institution, had a two-year educational program. The first year was dedicated to general fundamentals, and the second year to a program for engineers and artillerymen. However, in this Academy of Barcelona, it was enhanced to be a three-year program.

There were four courses, each one of which lasted 9 months. The first two courses were used to acquire the knowledge required as an officer's mission, and the other two courses to learn the requisite knowledge to be an engineer and an artilleryman. This program of 3 years total was aimed at learning all the pure mathematics, applied mathematics, culture for military personnel, and knowledge that was directly useful for engineers. The following table (Table 1) shows the eight categories of required subjects [Table. 1].

In this way, instructions to effectively impart the requisite knowledge for military engineers were laid out. However, as there were no materials to educate in the Castilian language, the leader was obliged to write the teaching content and the students were required to copy it. The general director was instructed to check the faculty's teaching notes and the beauty of the drawing to be used⁶⁾. For this reason, we can today see some of the lesson notes [Fig.2 and 3].

Subjects	Topics of study fields
1st Subject : Arithmetic	Integral number / Linear algorithm / Fraction and ratio / Principle of proportion / Power and roots, and progression.
2nd Subject: elementary geometry	Elements of Euclid / Rectangle and division by diagonals / Properties of circles and straight lines and diagonals / Ratio and the properties of plane figures / Rectangular prisms and parallelepipeds / Pyramids / Prisms / Cylinders / Spheres / Conical curves
3rd Subject: trigonometry	Trigonometry / Drawing of plane figures / Inscribing and circumscribing circles and other figures / Deformation of plane figures / Use of tools / Area measurement / Volume measurement / Level measurement
4th Subject: Fortification studies	Polygonal fortress / Irregular fortress / Effective fortification planning according to the terrain / Reinforcement of fortresses
5th Subject: Canon studies	Properties, composition, examination, and preservation of powder / Old and new cannons, drawings of mortars, canons, gun carriage, and other weapons / Battery of artillery and mortars / Landmines / Artificial fire, artillery equipment and fortress catalog
6th Subject: Space geography	Celestial sphere / Geography / Waterway / Navigation technique / Weather
7th Subject: Mechanics	Movement of objects with weight / Mechanical devices / Irrigation / General overview on optics / Projection drawing
8th Subject: Civil architecture	Decoration of buildings, beautiful appearance of building, strength and safety of construction

Table 1 Educational categories of the Academy

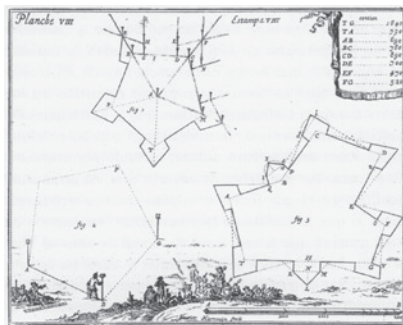


Fig.2 Explanation of the citadel plan shown in Medrano's book published in 1700⁷⁾.

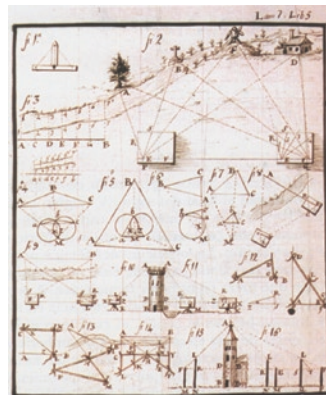


Fig.3 Note by a student at the Academy of Barcelona (MUÑOZ CORBALÁN, Juan Miguel (Coord.): *LA ACADEMI DE MATEMÁTICAS DE BARCELONA, El legado de los ingenieros militares*, Ministerio de Defensa, 2004, p.80.)

- 6) ——— The Ordinances of 1739 said that students were obliged to participate in the classes “with paper, ink, and pencils to copy down the classes”.
- 7) ——— Medrano published his book in 1700 in “El architect perfecto en el arte military” and was very effective in the education of the academies. Alicia Cámara (coord.), *Los Ingenieros Militares de la Monarquía Hispánica en los Siglos XVII y XVIII*, Ministerio de Defensa, Madrid, 2005, p.128. Verboom, the invited director of the Barcelona Academy was a disciple of Medrano during his Brussels Academy era and worked on Medrano's publication of that book.

Academy's education and city planning

Influence

In military education, technology and tools for attacks and defenses against cities, and related knowledge of the natural sciences, were required for military engineers. The greatest challenge that used such knowledge was the design of fortresses and fortified cities. There, not only were rational planning techniques of the walls planned, but also the urban space within the fortification were planned.

Many military engineers that studied in the Academy of Barcelona worked on city planning in the Spanish colonial cities in the Americas, such as the planning of Argentina city and Campeche. Many that studied in the Academy of Barcelona also did planning of fortifications in Spain itself, such as the Fortress of Figueres. Thus, the Academy of Barcelona was a very important institution for the education of city planning in 18th-century Spain.

Military and architectural projects



Fig.4 The town planning of the Barceloneta district in Barcelona



Fig.5 The Fortification of Figueres planned by Juan Martín Zermeno (Plaza de San Fernando por Pedro Martín Zermeno, 1756 (Instituto de Historia y Cultura Militar. Ref.:GE-5/13)

Graduates from the Academy were not simply involved in polygonal fortification planning, but also played an important role in creating domestic urban space development projects. The district of Barceloneta is one such remarkable example [Fig.4].

Barceloneta was an urban planning project, not a fortification project. After the Spanish Succession War, a fortress, Ciutadella, was to be constructed outside the walls of Barcelona and Barcelona citizens across a wide area of its construction site were expelled. A newly developed collective residential district was to be developed for those who were ordered to leave. Verboom, who originally came from Brussels, was responsible for the planning, but it was not brought to realization. Later, Juan Martín Zermeno was appointed to draw a different planning based on Verboom's idea. Blocks were arranged in a rectangular coordinate system, and street blocks are slender. The basis of today's Barceloneta's urban space was illustrated using these concepts, and its construction started in 1753.

On the military side, Zermeno planned the fortification of Figueres [Fig.5], and its construction also started in 1753. This is a fortress of



Fig.6 San Miguel del Puerto, a church designed by military engineer Pedro Martín Zermelo in Barceloneta

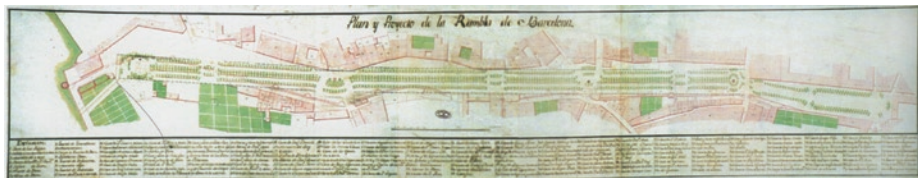


Fig.7 Planning of Ramblas in Barcelona, 18th century. (Archivo General de Simancas, Mapas, Planos y Dibujos, IX-106)

a huge scale, a representative fortress project of Catalonia; Zermelo's son, Pedro Martín Zermelo, also took over his father's work. Thus, we can recognize that Juan Martín Zermelo did both military and civil architectural works.

Juan's son, Pedro (1722-1790), was a military engineer, but one of his works is also a church, San Miguel del Puerto, in Barceloneta, showing his skills as a general or a civil architect [Fig.6].

Pedro also made the plans for Barcelona's Ramblas [Fig.7]. This project also was planned around 1766 by Pedro Martín Zermelo, a military engineer, but it is a green area plan for citizens. This is an ideal urban space planning for civil society rather than a military project.

Thus, in addition to the fortification projects, military engineers naturally engaged in designing various urban development projects, public facilities, and general architecture as needed. Military engineers were familiar not only with the military projects, but also with the knowledge necessary for general urban planning. From these circumstances, we can infer that an education received at the Academy of Barcelona contributed to many of these areas.

The Academy of Barcelona produced engineers who were capable of undertaking all kinds of construction projects, including military facilities, urban planning, and general construction in Catalonia. What these have in common is the requisite knowledge for the realization of necessary order and safety in consideration of social space needs. Thus, we can assume that the Academy of Barcelona provided not just general but also professional knowledge and technique for engineers.

Conclusion

This paper looks at the Spanish institutions of the 18th century that provided city planning education; the focus is on the background of the establishment and educational contents of the most remarkable institution of the time, the Royal Military Academy of Mathematics of Barcelona.

The Royal Military Academy of Mathematics of Barcelona was an educational institution to train military engineers with various fields of education such as arithmetic, geometry, fortification, algebra, cosmography, astronomy, navigation, etc. Among those fields, the education of arithmetic, geometry, and fortification were particularly important and related to one another. The students' notes of the Academy show that knowledge of geometry is directly linked to the design of city fortification from the viewpoint of military defense and reasonable construction.

In addition, this paper also looked at the remarkable success of military engineers who engaged in the education of this academy and the military engineers who learned and graduated there. They played an important role in the construction of military facilities such as fortification projects in not only the Spanish colonial towns but also some important towns in Spain. It is also noteworthy that military engineers applied mathematical and geometrical knowledge to urban space development which is civil urban planning.

A further understanding of the progress of the educational environment on city planning in 18th-century Spain would be important to compare with the educational institutions of architects, and it will give us more details on the historic relationship between mathematical education and city planning education and architectural education. It will also be necessary to study the educational contents of related academies from the viewpoint of fine arts, such as the San Fernando Academy in Madrid, following these precedent military academies of mathematics.

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