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# Teaching Descriptive Geometry at the Faculty of Architecture

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**Abstract.** This paper presents a glimpse into how Descriptive Geometry is taught in Hannover. After 15 years of teaching experience one goal of this course is to bridge the gap between everyday experience and scientific methods. Descriptive Geometry for architects should provide basic information on the geometry of shapes as well as on projection methods. Lectures should not only address the brain but all senses.

## 1 Introduction

While teaching students of architecture for over 15 years, the author has observed a loss of connection between everyday experience and scientific methods. At times of visualisation by computer the goals of a curriculum in Descriptive Geometry are to provide both, basic information about essential concepts of geometry and an overview of projection methods. The audience will be well motivated when each topic is presented in different ways such that all senses are involved, not only the brain. For some colleagues the following might be a little bit too popular, but since I have been teaching in this way I never heard the question: "What is the use of that?"

## 2 Changes in teaching Descriptive Geometry

In architectural statics graphical methods have been completely replaced by numerical methods. Algorithms such as the construction of the axes of an ellipse by Rytz are obsolete at times of computer-generated perspectives. The prophets of the new age praise the possibilities of cyberspace. Computers will go on solving problems that were meant to be solvable by human intuition only. Computers enable us to visualize complex connections in a new and better way. Will the traditional drawing techniques partly or wholly disappear?

On the other hand human beings will still live in real spaces and architects have to consider the effects of real spaces, rooms and surfaces on the behavior of human beings. We will still eat apples and not the output of an apple machine. Our interfaces will still be eyes and ears.

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Solving problems with the computer will not completely replace Descriptive Geometry. Two periods in life have to be considered here: Times of education and study on the one hand and times of practice on the other. The goals of education are: Basic information as well as an overall view of the problems the future profession will bring about and the most appropriate methods. Further steps are to get more experience and increase the number of tools. In order to get best results in a curriculum not only the brain but all the senses have to be involved. This leads to the following remarks:

# 3 Proposals for a curriculum

## 3.1 Pythagoras' monochord

The three-dimensional world and the objects that surround us can be described with a system of coordinates. A pretty good way to experience this fundamental realisation of a transfer from quality into quantity and backwards is shown by Kükelhaus [4] with Pythagoras' monochord (Fig. 1). Students are very impressed when they learn that the midpoint of a line segment can easier be found by using the ear than the eye.

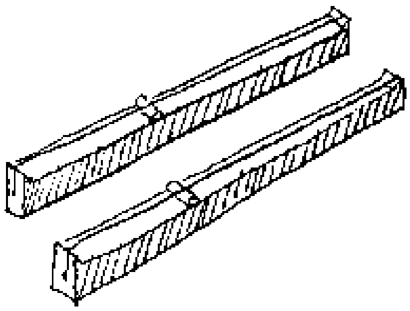

Figure 1: Pythagoras' monochord

## 3.2 Projections

The knowledge of the most frequently used projection methods (orthographic multiview drawing, axonometric and perspective), their different qualities and their useful application can be shown best in comparison. It is useful to present results of the different methods at the beginning of a curriculum. Then these methods should be trained one after the other, sometimes looking for a solution in a different method. At the end of the curriculum student should remember the different qualities in exercise sheets drawn by the students.

## 3.3 Fundamental operations

There are two fundamental operations to analyse problems of three-dimensional objects:

- to *cut* in order to have an inner view and
- to *rotate* in order to see the real extension of an object or of parts of the object.

One can realise that these fundamental operations are used in other fields of research, e.g. in brain research by cutting a frozen brain to get information for a computer model.

### 3.4 Transfer of strategies to different tasks

In order to avoid the question "what is the use of that?", a look at the great variety of ways of applying well-tried strategies, e.g. collineation (Fig. 2) is helpful.

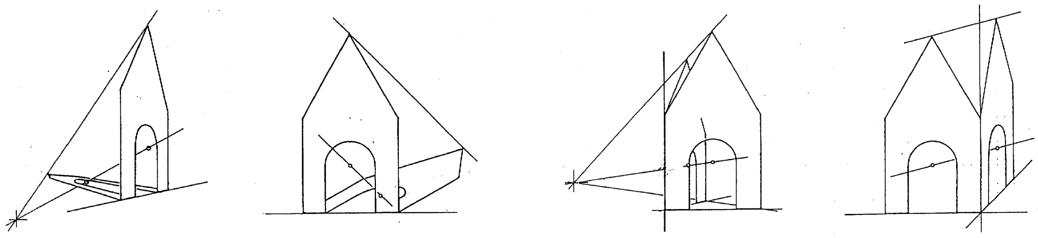

Figure 2: Different use of collineations

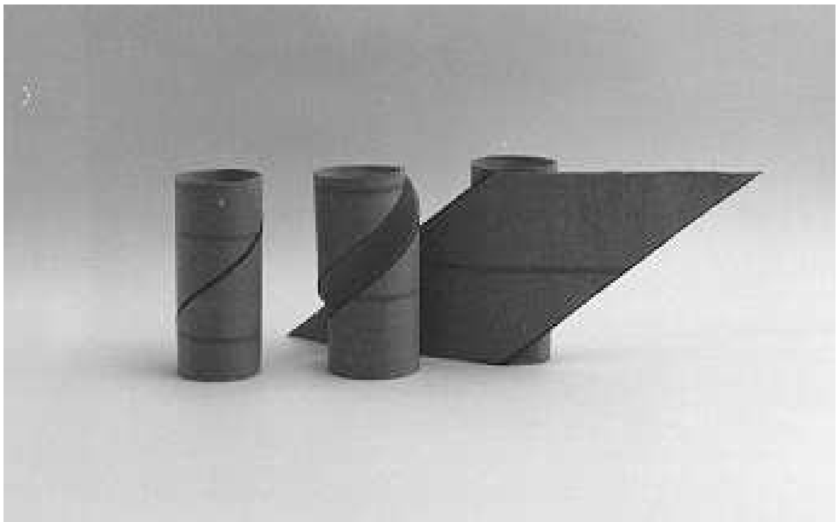

Figure 3: Helical line on a cylinder (toilet roll), developed cylinder

### 3.5 Information interchange and perception

The two main goals of drawing in architecture are to visualize ideas and to achieve better perception. Freehand sketching is the best way to improve perception capabilities. In order to give the drawing the right place in a world of multimedia, one has to consider the fact that every drawing is an abstraction. To draw means to express a particular meaning. A photograph always shows the whole and that is not best for every purpose.

## 4 Examples

### 4.1 Helical lines and staircases

Introducing the helical line with an empty toilet roll (Fig. 3) will make the students think about that topic at later times in their life. The developed helical line on the developed

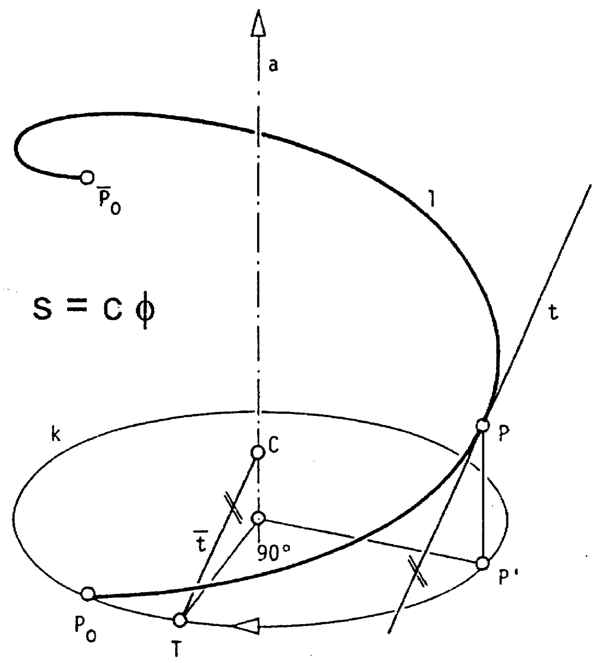


Figure 4: Equation and construction of the tangent at a given point on the helical line.

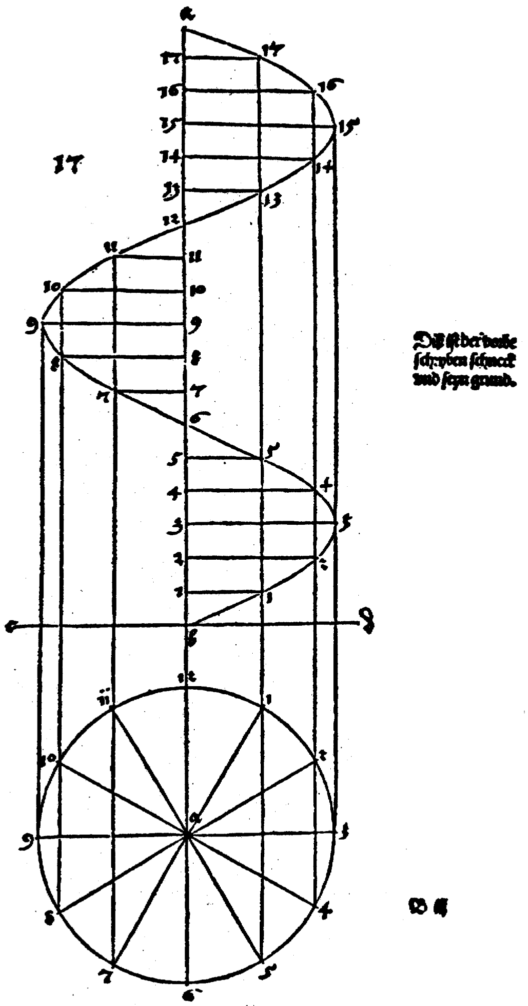

Figure 5: Albrecht DÜRER's construction of a helical line in plan and front view

cylinder is obviously a straight line with a constant gradient at all points, an important property for designing and manufacturing a winded staircase (Fig. 10).

With a clockwise corkscrew and an anti-clockwise (Fig. 6) for left-handed people it is easy to show the possible two types of a helical line. A special Bavarian manner of cutting a radish (Fig. 7) reveals that the helical line is obtained by the composition of two motions, the translation along and the rotation about the axis.

The application of helical lines and surfaces in architecture can be very curious (Fig. 9). Bricklayers perhaps have been happy to finish their job on a medieval house in Hamburg. So they also finished that boring laying brick over brick and discovered the beauty of a helix. Their colleagues in St. Moritz, Switzerland, did the same at the local museum. Staircases are the applications of helical lines and surfaces in architecture. The difference between winding staircases (without a material axis) and spiral staircases (with a material axis) can be discussed.

DÜRER's drawing from the year 1525 (Fig. 10) cannot be improved to explain the construction of a helical line in plan and front view and places the topic in an historical context.

One never gets really involved in a topic as long as one does not practise, even after an extremely clear lecture. So students have to do some exercise sheets (see e.g. Fig. 8).

Figure 6: Clockwise and anti clockwise corkscrew

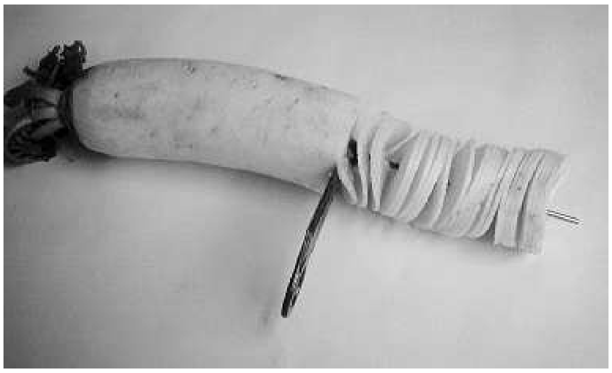

Figure 7: Cutting a radish by screwing a knife around a metal axes

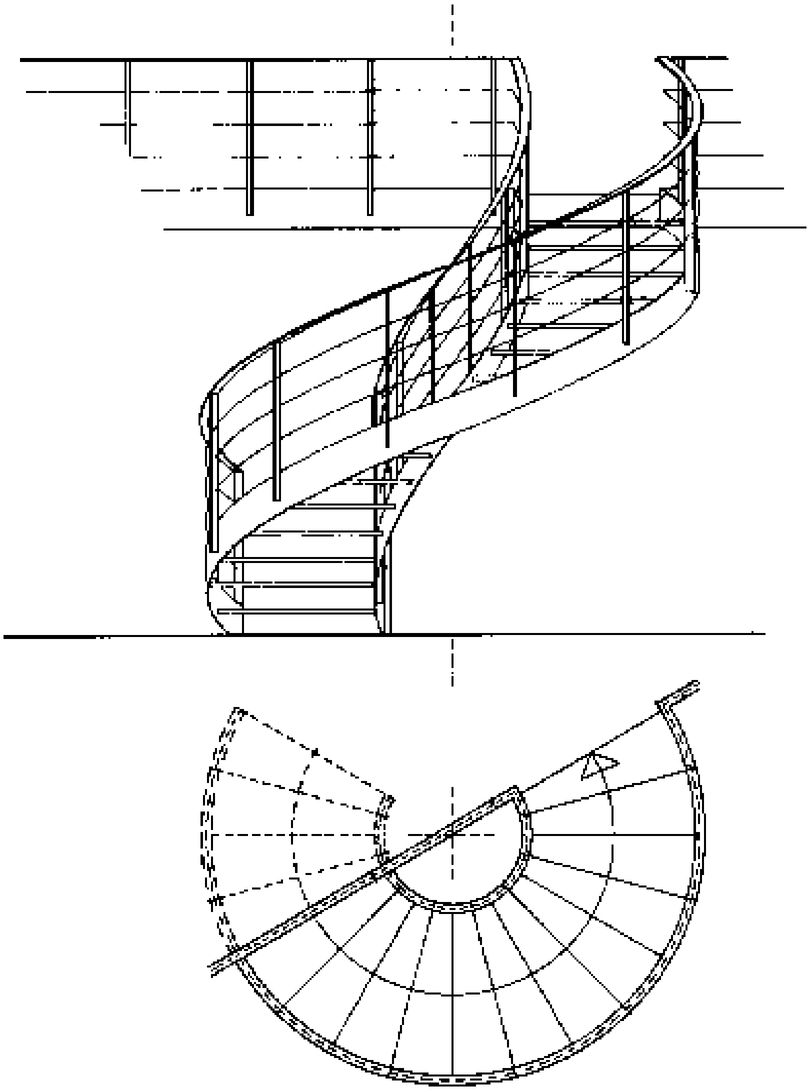

Figure 8: Student's work at the end of the first semester

Figure 9: Screwed chimneys in Hamburg, Germany

Figure 10: Winding staircase, Zoological Collection, Munich, Germany

### 4.2 Spheres in architecture

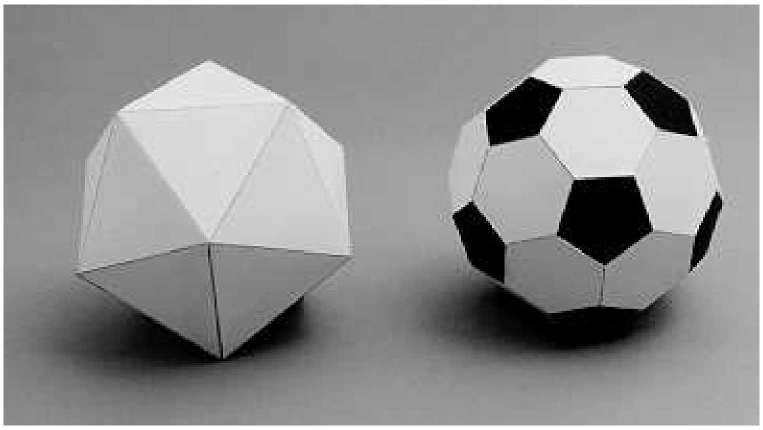

Figure 11: Dodecahedron, football

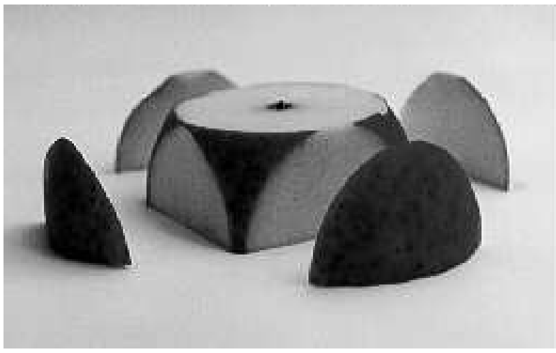

Figure 12: (a) Apple, cut to fit into a half-cube, (b) Cut apple, turned

WITTMANN shows in [5] the way from an dodecahedron to a soccer football by cutting the edges. PLATO's solids like the dodecahedron are used as a framework in architecture. With an apple and a knife it is easy demonstrate clearly the different circular sections of a sphere (Fig. 12). This particular form of a spherical vault can also be found at a dice.

Turning the cut apple reveals that the geometric shape of the Hagia Sophia (Fig. 13) is the same as that of a roman capital (Fig. 14). It is not obvious for all students that geometrical knowledge ranges over all scales. At the cut apple the pips form a pentagon, a good illustration of proportions and the golden rule in nature.

## 5 Conclusion

In order to train the capability of criticism against the overflow of pictures, it is necessary to combine everyday experiences with a geometrical analysis as well as with descriptive and constructive methods. It will be helpful to compare traditional and new presentation methods. The knowledge of various methods (traditional and new) gives the chance to select the most suitable one. Instead of presenting a large number of finished solutions it is recommendable to reduce the number of treated problems and to solve them step by step. This produces more independence, improves the sense of orientation and the problem solving strategies. And it provides more description methods and increases the ability to judge.

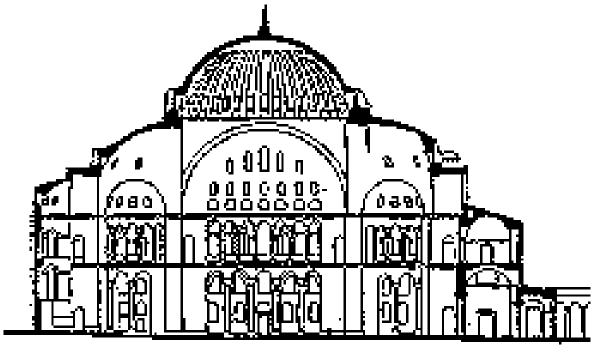

Figure 13: Hagia Sophia, spherical vault

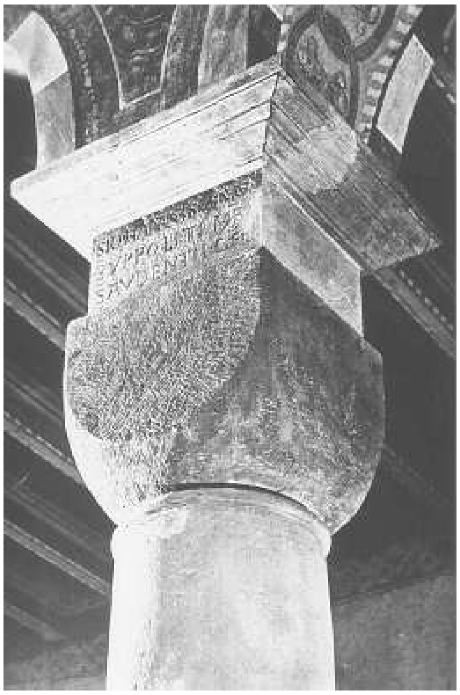

Figure 14: Roman capital

Drawing does not only train the capabilities for presentation. Specially freehand sketching can lay open the creative possibilities of our brain as mentioned by Edwards [2]. This aspect is becoming more and more important at times when the computer is taking over visualisation and information interchange. Ferguson [3] describes the connection between picture and idea, imagination and reasoning. I think that it would do no harm, if curricula in Descriptive Geometry dealt more with graphics.

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