

Introduction to Computer Aided Design — Concept of a Didactically Founded Course

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Abstract. When approaching computer aided design, the drawing contents are of secondary importance at the beginning; on the contrary, in the first learning phase an overwhelming number of software related terms and input requests have to be coped with. Only after this phase has been completed, full concentration can be laid on geometric and other superordinated problems. Based on the Living Learning idea and the model of Theme-Centered Interaction, we have developed a specific methodological course concept which enables a rapid and efficient approach to CAD. Characteristic features of the concept are the principle of a strong guidance and the method of coloured drawing. A detailed script documents and explains the design steps which have to be carried out for the creation of the selected architecture examples. It forms the basis and the guideline for passing through a 3-step course program: lecture, exercise and task. The presented methods enable a large number of students to pass on a maximum of syllabus in short time.

Key words: Descriptive Geometry courses, architecture, Computer Aided Design.
MSC 2000: 51N05

1. Introduction

It is the task of our institute to train spatial thinking as well as drawing and design of three-dimensional objects in the course of the vocational training of architects. The ideal medium is Descriptive Geometry (DG) with its analytic and systematic spatial thinking. However, DG and manual design are more and more questioned generally by making reference to the computer and common software. Experience shows that this critical judgement primarily is made by people who do not concern themselves with the training of spatial ability. However, we assume that it is specifically the competence of DG which is a sound basis for a differentiated concept of a CAD course. We have developed a concept for our institute that offers an introduction to computer aided design by taking particularly geometric contents into account. Though, the CAD course shall not replace the DG lecture within the vocational training of architects but it shall supplement it.

2. Our task

The aim of our CAD course is a quick and practical introduction to computer aided design by taking particularly geometric aspects into account. The original drawing contents are not the focus of interest when dealing with CAD software for the first time; in the first learning phase the basic problem of the student is the overwhelming number of instructions, input requests, names, symbols, settings etc. The solution of exactly this problem with suitable methods is an important didactical challenge for a basic course in computer aided design.

3. Didactical principles

The didactical concept of the course is oriented towards the idea of Living Learning developed by Ruth COHN. Her model of ‘*Theme-Centered Interaction*’ (TCI) integrates the interests of the individual (“I”), the group interaction (“We”) and the special task (“It”) while taking the environment (“Globe”) into account. It supplies impulses for the connection between humanity and performance in the teaching program. The aim is to create an atmosphere that provides optimum learning conditions for each student.

4. The methodical concept

On the basis of this central didactical theme, we have developed a concept consisting of a *script* and a *3-step course program*. Here, the script is the basis as well as the guideline for passing through three steps: *lecture*, *exercise* and *task*. Characteristic features of this course concept are the principle of a strong guidance and the method of coloured drawing. The content of the course is structured by a systematic sequence of lessons using different examples from architecture. To find the optimum time for dealing with instructions during the course different aspects are taken into account: On the one hand the structures connected to the drawing program and on the other hand the learning-theoretic principle of learning in sensible contexts.

4.1. The script of the course

The script has been developed and designed in such a way that an optimum utilization of teaching lessons during all three levels of the course program is possible. The individual steps of the *exercise* are exactly prepared in the script with texts and pictures while considering different didactical aspects. First of all, the script serves as basis of work for the *lecture*, in which important information are supplemented by coloured entries and graphically highlighted at the same time. As coloured, detailed and completed guideline, the script stepwise leads through the *exercise* at the computer. In addition, continued and deepened information form the basis for independently treating the *tasks* issued by us. Finally, the specific information density of the treated script enables a well-directed memorization of facts after the course has been completed or to repeat the course independently in order to brush up knowledge at any time.

4.1.1. Detailed guidance

In the course, a solution path that is always clearly prescribed and structured is followed in order to enable a quick familiarization, memorization and application of many functions and

Schritt 1:
Die erste Eingabe: **LINE** -
Spannen Sie eine Linie zwischen zwei Punkten, die auf dem Bildschirm frei zu wählen sind, auf.

Ü01 starten

Befehl: `line`

Ersten Punkt angeben: \hat{p}_1

Nächsten Punkt angeben oder [Zurück]: \hat{p}_2

Nächsten Punkt angeben oder [Zurück]:

Befehl:

Schritt 2:
Fügen Sie durch wiederholtes Fixieren von Punkten auf dem Bildschirm an die erste Linie drei weitere an, und ergänzen Sie sie zu einem Quadrat.

Befehl: `_line`

Ersten Punkt angeben: \hat{p}_1

Nächsten Punkt angeben oder [Zurück]: \hat{p}_2

Nächsten Punkt angeben oder [Schließen/Zurück]: \hat{p}_3

... (vorherige Zeile 1x wiederholen)

Nächsten Punkt angeben oder [Schließen/Zurück]:

Befehl:

Schritt 3:
Wiederholen Sie die ersten Schritte, um ein zweites Quadrat zu erstellen - mit dem Unterschied allerdings, dass Sie dieses Mal mit genauen Maßen arbeiten: Das zweite Quadrat soll eine Kantenlänge von 2 cm haben; es wird der erste Bauer aus dem Schachfigurenkabinett sein.
Zoomen Sie das Bild zunächst etwas kleiner, um genügend Platz auf dem Bildschirm zu haben.

Befehl: `'_zoom`

Fensterecke angeben, Skalierfaktor eingeben (nX oder nXP) oder
[Alles/Mitte/Dynamisch/Grenzen/Vorher/Faktor/Fenster] <Echtzeit>: `.5x`

Befehl:

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Figure 1: The script serves as basis of work for *lecture*, *exercise* and *task*

instructions. This strong guidance principle enables a persistent passing on of large material volumes even under the existing frame conditions at the college (limited time resources and computer capacities, high number of participants).

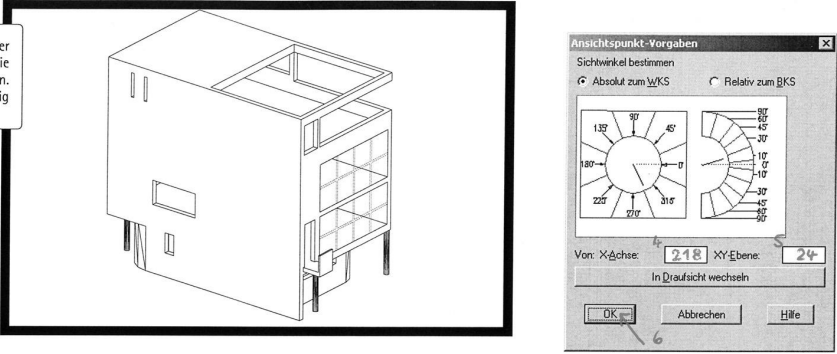
The guidance is put in concrete terms in different ways depending on the particular nature of the learned material: at the beginning of the course, the guidance consists of the detailed information of all required keyboard entries and mouse clicks; all starting difficulties which are typical for computer courses (seeking for the buttons, missing keypresses) are ideally solved that way. Frustration and unproductive helplessness at unimportant positions are avoided. At later stages, the guidance helps e.g. when complex menu structures are passed through. The guidelines of solution paths that have been developed the best possible way additionally enable the students to concern themselves with the structured creation of drawings at a superordinated level.

Due to this guided procedure, the course can be planned with all its aspects. Moreover, each position can accurately be influenced: Thus a precise selection of the level of difficulty is possible, the course of suspension during a 90-minutes *lecture* can be determined in detail and the change of different learning phases can be controlled as well as guaranteed feelings of achievement can accurately be placed. This conceptional procedure enables an easy and accurate implementation of experiences achieved during the course as well as feedbacks of the participants.

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Bestimmen Sie verschiedene Axonometrien über Ansichtpunkt-Vorgaben, und rekonstruieren Sie die Kennwerte der drei unten abgebildeten Axonometrien. Speichern Sie mindestens drei Ihnen günstig erscheinende Ausschnitte.



Speichern Sie Ihnen günstig erscheinende Ausschnitte

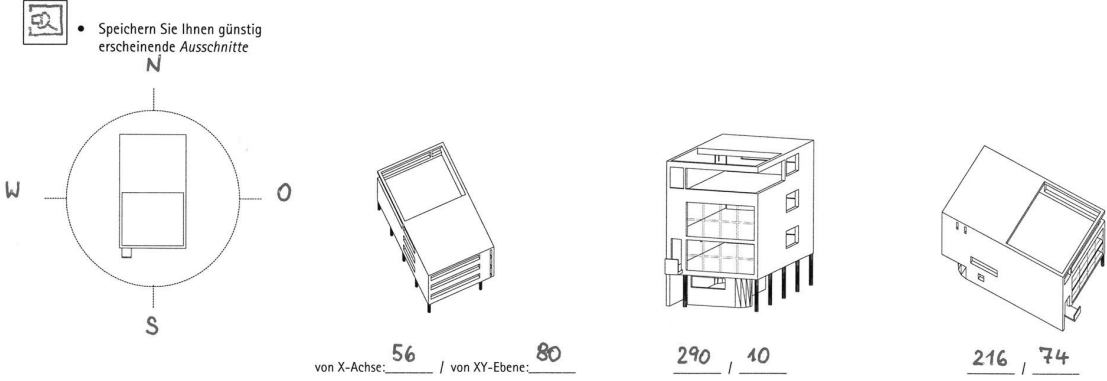


Figure 2: Detailed guidance avoids frustrations and unproductive helplessness at unimportant positions

4.1.2. Coloured drawing



Figure 3: Coloured drawing during the *lecture* increases information density and attention

Coloured drawing is a method which increases not only the absorption of information by making individual additions to the script but also enhances the attention of the listeners during the *lecture*. For this purpose all the important places in the script are either marked or left open. The coloured additions in the minutes cover the labelling of instructions, explaining sketches as well as the accurate marking of the design course. In each phase of the course,

the coloured drawing is of significant importance for the student.

- The colourfulness increases the information density and clarity of the *script*; essential elements are highlighted, texts and pictures are allocated to each other and the chronology of the process is visualized by varying the colours.
- For the *lecture*, the activity of drawing requires a minimum of activity and attention of the participants that always has to be maintained. The independent drawing increases concentration, supports the identification with the working material and is of benefit for memorization.
- It becomes noticeable during the *exercise* that colouring makes the script very clear. The sequence of steps can quickly be read, recognized and implemented and the central contents become an eye-catcher.
- Furthermore, the benefits of the coloured minutes become effective when the *tasks* are treated but also for the different forms of independent reworking, even after longer periods of time.

When determining which parts have to be supplemented in colour, the importance of the content and the continuity of the active participation are taken into account. On the other hand, the quantity of additions has been selected in a way to support perfectly the remarks of the tutor during the *lecture*. The fact that the script may only be used after it has been treated independently avoids that the working material makes the attendance of the *lecture* superfluous.

4.1.3. Exercise examples

The course is structured by a systematic sequence of 10 lessons using four different examples from architecture. For the selection of the *exercise* examples, different aspects were considered: On the one hand, the use of examples from architecture that can easily be remembered supports the motivation to participate — significant buildings promote recognition and thus favour the finding and memorizing of instructions treated in this connection. On the other hand, the used examples have to be simple enough to realise them graphically during the *exercise*, but also complex enough that the problems arising in the particular lesson can be treated sensibly.

- The *Bauhaus chessboard* (Example 1) consists of very simple basic spatial elements and serves as an introduction to simple basic operations for drawing and processing of lines.
- The *College Life Insurance Building* (Example 2) consists of only a few thrilling elements with partly inclined planes; it introduces the working with layers as well as the three dimensional rotation and mirroring of objects.
- The plastic architecture of LE CORBUSIER (Example 3) is well suited for working with volumes. Solid objects are introduced and the presentation by means of different axonometrics and shadowing is treated with the example of *House 13 of the Weissenhof-siedlung*.
- The *National Gallery* of MIES VAN DER ROHE (Example 4) as simple steel skeleton building is composed of only a few steel profile elements; it is suitable for the introduction to working with blocks and for training the structural composition of drawings.

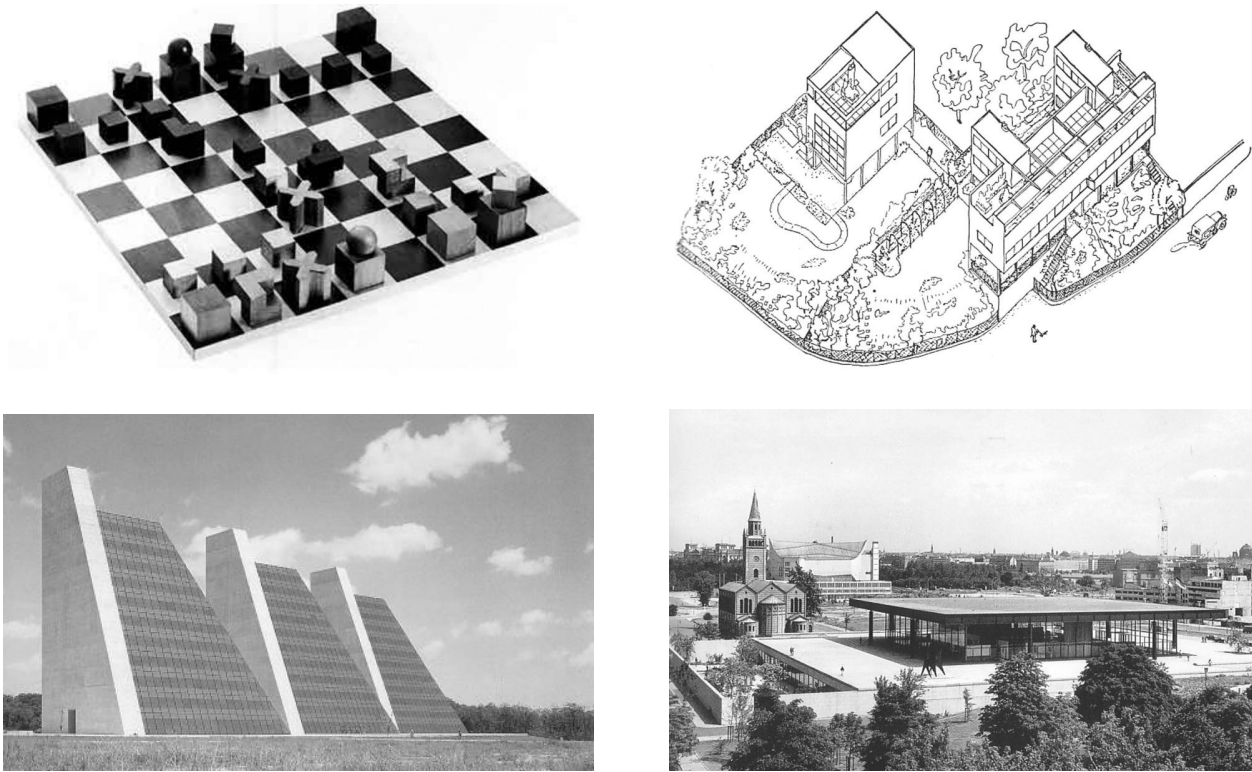


Figure 4: The four examples — The Bauhaus Chessboard, the College Life-Insurance Building, House 13 of the Weissenhofsiedlung, the National Gallery Berlin

4.1.4. Instructions and functions

One of the major challenges for drawing up the concept of a computer course is the variety of instructions and functions which are required for the treatment of even the simplest tasks. Due to learning-theoretic reasons, the instructions are informally introduced at any suitable position when practical examples are treated. On the one hand, the exact time for treating instructions during the course is performed by considering the structures related to the drawing program and on the other hand, the principle of learning within sensible contexts is also taken into account. The course starts with the practical application of simple drawing instructions — without any theoretical provisions. In order to achieve motivating success at an early stage, more complex instructions are deliberately postponed to later sections, and to this end simple solution paths are sometimes pursued and trained. With an increasing mastery of the basic functions more economic and intelligent alternatives can be passed on and in addition superordinated problems can be treated.

In order to support visual learning, the instructions are called by icons; the corresponding keyboard entries and shortcuts are presented but their use is avoided as far as possible. The easy comprehensibility of many symbols supports intuitive working; the reproduction of the symbols in the script increases their memorization. While drawing, the different drawing instructions of the CAD program are combined in groups with different colours and thus can easily be remembered. In order to facilitate the direct introduction to the program, prepared start files with favourable pre-settings for the working environment and specifically designed tool boxes are made available to the student.

- For the first lesson, simple instructions such as line, offset, copy, mirror (basic instructions for the creation of objects), delete, fillet, move (basic instructions for the process-

ing of objects) and simple zoom instructions are sufficient. The first exercise example (chessboard) is completed with the second lesson by using the functions circle, trim, properties, 2D rotation and hatching.

- Exercise Example 2 (Life Insurance Building, lessons 3–5) mainly introduces the functions array, object snap, stretch, 3D rotation, coordinate systems and 3D surface.
- Exercise Example 3 (House 13 of the Weissenhofsiedlung, lessons 6+7) treats solids and Boolean operations, polylines, functions for the projections setting, presentation modes and a consolidation of the coordinate systems.
- Exercise Example 4 (National Gallery, lessons 8–10) focuses on the working with blocks and moreover the editing of texts, the set-up of layouts and printing.

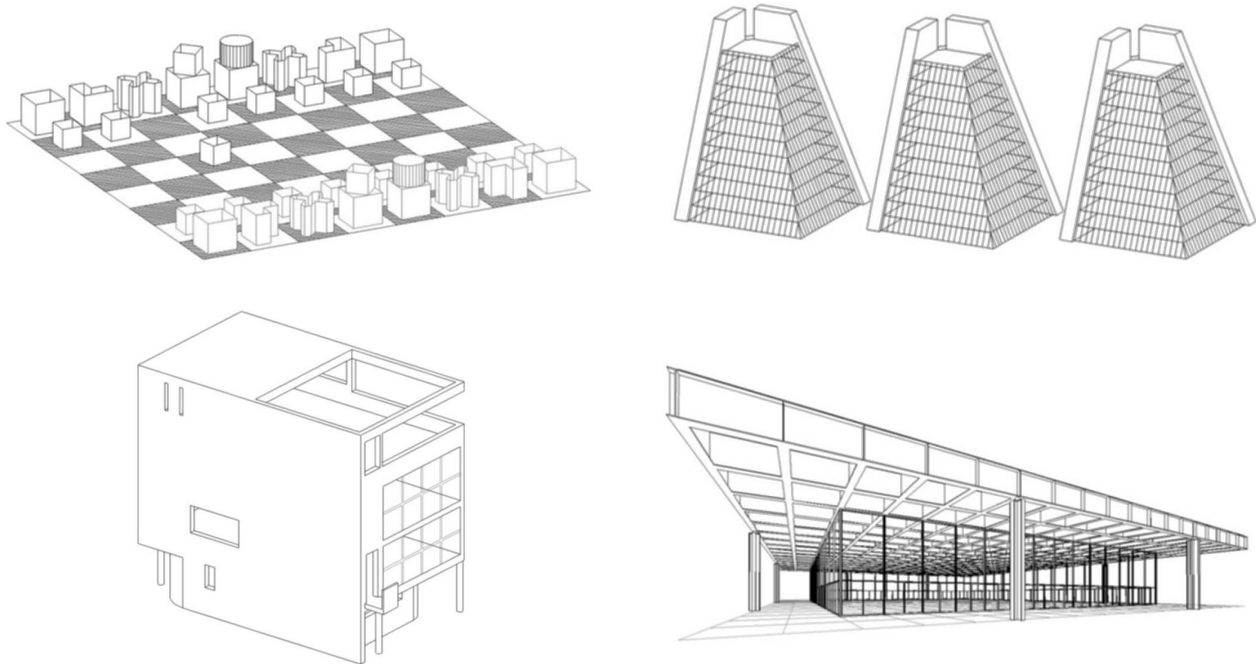


Figure 5: The four examples — every student will master these CAD-drawings

4.2. The three-step syllabus

The classes consist of a three-step syllabus such as

- *lecture* in the lecture hall (90 minutes),
- *exercise* in the computer room. Here, the preparations of the *lecture* are realised at the computer in small groups (60 minutes) and
- final treatment of an unprepared *task* (30 minutes).

The classes change between frontal teaching, teamwork and working in couples or alone; this enables a differentiated passing on of knowledge and a dynamic supervision of each individual student.

4.2.1. Lecture

The *lecture* shall pass on knowledge to all participants at the same time and takes place in the lecture hall with a very high number of participants. First of all the teaching material shall be treated and explained independently of the computer.

The design progression prepared in the script is explained during the *lecture*. For this purpose the lecturer performs the coloured additions to the documentation at the overhead projector step by step. Thus, the design progression serves as a central theme in the *lecture*. At suitable positions, central principles of the work at the computer are explained, contents are classified into superordinated contexts and geometric aspects are presented which go beyond the specific drawing program. In each case, the process of concerning the student with the subject of the *lecture* is introduced by the coloured drawing.

- Coloured drawing forces the student to become active. Thus attention and concrete individual action is created.
- While drawing the students listen and already absorb important connections in this first phase of communicating knowledge.
- The drawing action which is continuously required from the students provides a minimum of activity and concentration that always has to be maintained; moreover, a pure consuming attitude is avoided by this.
- Additional motivation is supplied by the prospect of the practical realization of the learned subjects which will directly take place in the computer room after the *lecture*.
- The high degree of concentration achieved by this also allows the efficient absorption of more complex contents, even if these cannot be realized in concrete terms within the current exercise.

This step concept considers the fact that the receptivity of the audience of a *lecture* varies: One student restricts himself to the coloured documentation of the design steps whereas another student has a greater benefit because he also absorbs the all-embracing contents. This kind of lecture technique enables an optimum of passing on knowledge and guarantees a minimum of knowledge reception.

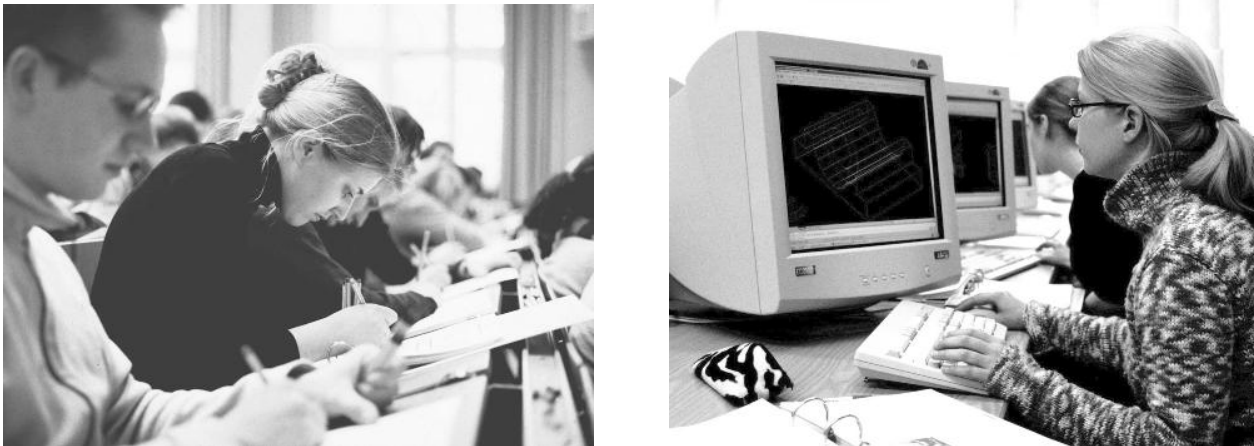


Figure 6: Coloured drawing during the *lecture* and independent working during the *exercise*

4.2.2. Exercise

During the *exercise*, the architecture examples are drawn in the computer room. A central concern when drawing up the concept of the *exercise*, is the creation of a helpful atmosphere. To this end, the participants are divided in large groups of 24 participants. Sufficient time in the computer room is available for these groups. These large groups are then divided in

learning groups of four students each. Each individual student enters the presented design individually into the computer. In his script, he finds the following help:

- his own documentation of the instructions to be carried out,
- the coloured evolution of the drawings,
- the selected required mouse clicks in the menu as well as
- the essential aspects highlighted in the explanatory texts.

Due to this detailed support, only a few students still have problems with the treatment. In this case, they consult the other members of their learning group. Only if the entire learning group is not able to solve a problem, the specific action of the tutor becomes necessary. As a rule, each student is supervised as much as required by this procedure.

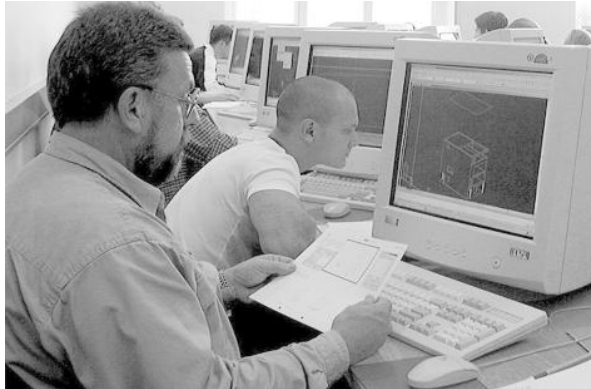


Figure 7: The student finds support in his own script, in his learning group and — seldom necessary — in his tutor

4.2.3. Task

Each lesson is supplemented and completed by a *task* lesson. The focus is laid on the individual solution of a problem, which the student has to develop by himself. Therefore in contrast to the *exercise*, no detailed solution steps are provided in this learning phase. However, a few proposals for interim results shall enable a mutual help of the students among themselves.

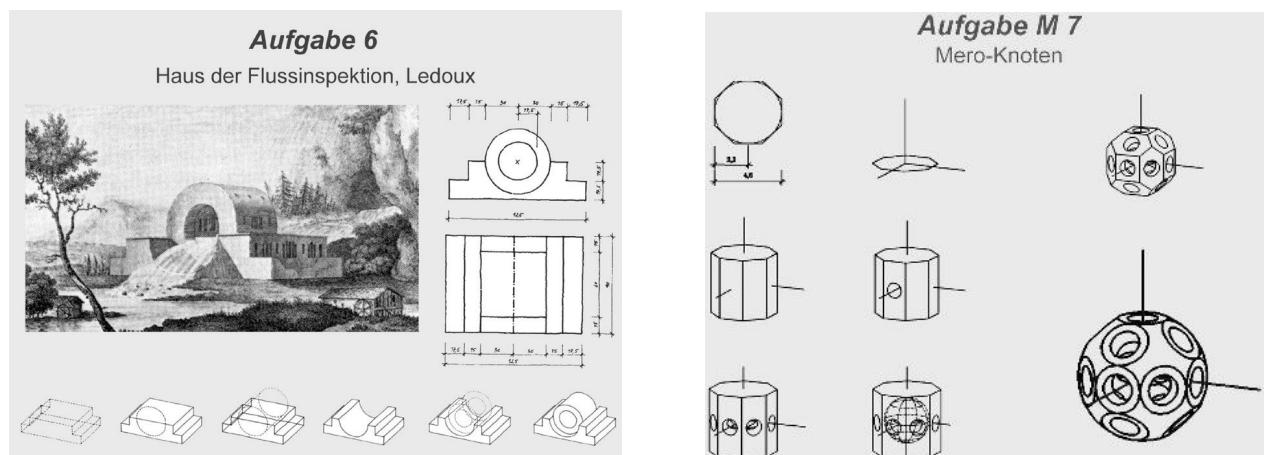


Figure 8: In addition to each exercise the student has to solve a *task* individually

Furthermore, the *tasks* are designed in such a way that the aspects used in the *lecture* and the *exercise* are repeated once more and applied in another context. By drawing up and pursuing an individual solution path, the skills of each student are examined and their knowledges will be deepened and validated.

We have observed with pleasure that all participants managed to perform this further transfer successfully. In particular the coping with a free *task* provides a special experience of success for the student because it completes the corresponding lesson with the experience that everything learned so far has been understood and can also be applied individually.

5. Evaluation

Regular evaluations among the students reveal that this concept is accepted very well. The students report that they have learned a lot in a short period of time, the supervision was good and sufficient and it was fun to carry out the exercises.

6. Conclusion

Due to the intense and strong guidance, many students can be taught intensively and efficiently at the same time with the presented learning concept; thanks to the detailed script only a minimum of supervision has to be performed. The guided stepwise drawing up of complex architecture drawings enables a high degree of experience of success for the participants.

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