ABD: an auxiliary tool to design brick walls

Benedetto Colajanni, Daniela Faconti, Giuseppe Pellitteri

Dipartimento di Progetto e Costruzione Edilizia

Università di Palermo

Viale delle Scienze, 90128 Palermo, Italy

Tel. +39 91 234100 Fax + 39 91 488562 E-mail: bcolajan@unipa.it,

A hypertext is presented thought as an aid to design brick walls but also as a didactic tool aimed at understanding the different ways in which the brickwork can be dealt with: history, production, technology. The hypertext allows designing and drawing external walls according to the most traditional bonds, controlling the reciprocal consistency of the dimensions of the elements constituting the wall of a building perimeter.

Introduction

Teaching Architecture has two faces: the first one, teaching the creative aspect and the way to acquire and maintain the necessary cultural knowledge; the second one, teaching the practicalities, the technological machinery that gives a physical body to the architectural ideas. Of course the first is nobler, but the second cannot however be neglected. According to this point of view, also small tools dealing with current practical situations can be of a certain usefulness, specially when in symbiosis with big software tools. This can be the case of a hypertext on brickwork in which one tries to present the actual way of building brick walls in a frame comprising some historical examples and quotations from treatises of the architectural theorists.

The hypertext is structured in five sections presenting many reciprocal links: treatises and handbooks, examples, production, technology and standards. It is thought for Italian students and this orientates the choice of the items incorporated in the hypertext, as well as the names of the bonds.

The structure of the hypertext

The first section takes into consideration three periods: the roman era, the period from the XV to the XVIII century, that is the period of the treatises, and from the XVIII up to now that can be considered the period of the handbooks. Of each mentioned author the main texts dealing with brickwork are quoted. As an example a passage from Vitruvius's De Architectura, which is the only text of the first period, is quoted hereunder:

"Con questi mattoni si fanno i muri semilaterj, nel costruire i quali da una parte si pongono a file ordinate mattoni interi, dall'altra mezzi mattoni: perciò quando si fabbricano a perpendicolo i muri si collegano da una parte e dall'altra colla scambievole superficie: e i mezzi mattoni collocati sopra le commessure producono d'ambe le parti solidità ed aspetto elegante".

A second example is from Alberti's De Re Aedificatoria (see figure 2).

Figure 1. Initial page of the hypertext.

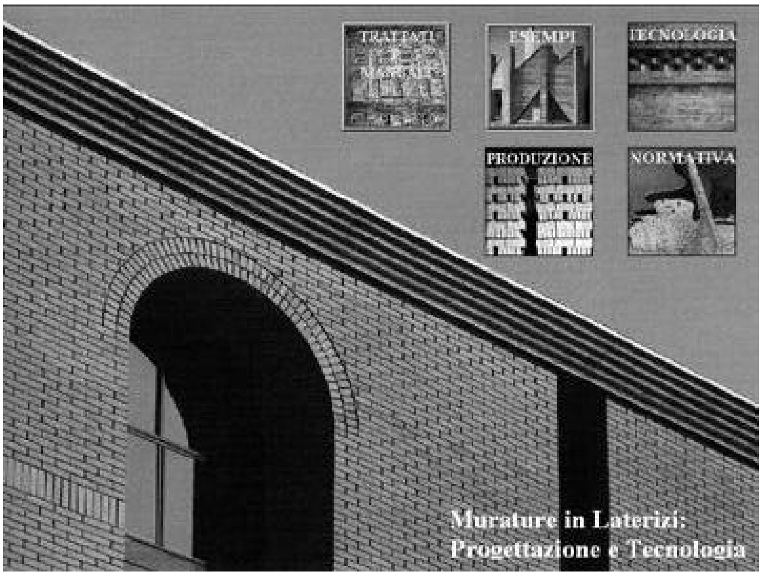
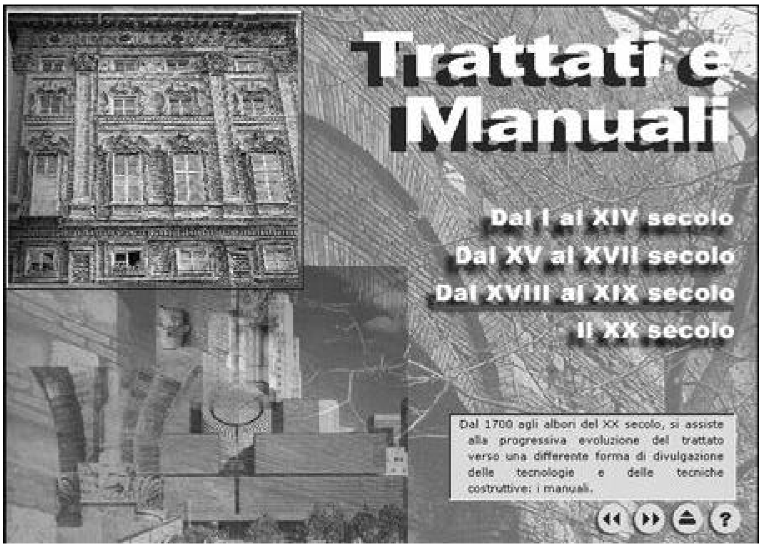


Figure 2. Initial page of the first section.



It is worthy remarking the passage from the age of the treatises to the age of the handbooks, from empirical experience to science as the basis of technique.

The practical examples in the second section of the hypertext are related to the other sections of which they constitute an illustration. They are, as yet rather limited in number but of course searching and adding new examples can be a didactic task.

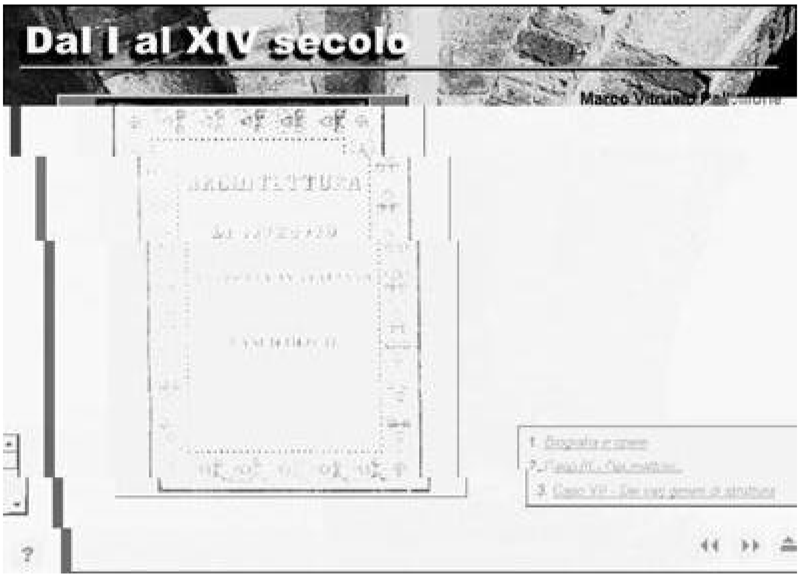


Figure 3. Initial page of Vitruvius's treatise quotation.

Figure 4. An Alberti's treatise page.

The technological section is as yet limited to the traditional bonds that will be quoted later.

The following section comprises only the Italian standard concerning the full bricks.

The practical section of the hypertext allows designing and drawing brick walls two headers and three headers thick according to the different bonds. These include *stretching* bond, *heading* bond, *block* bond, *cross* bond, *Gothic* bond and *Flemish* bond (the names are the ones employed in the Italian treatises and handbooks). All those bonds are shown in figure 5.

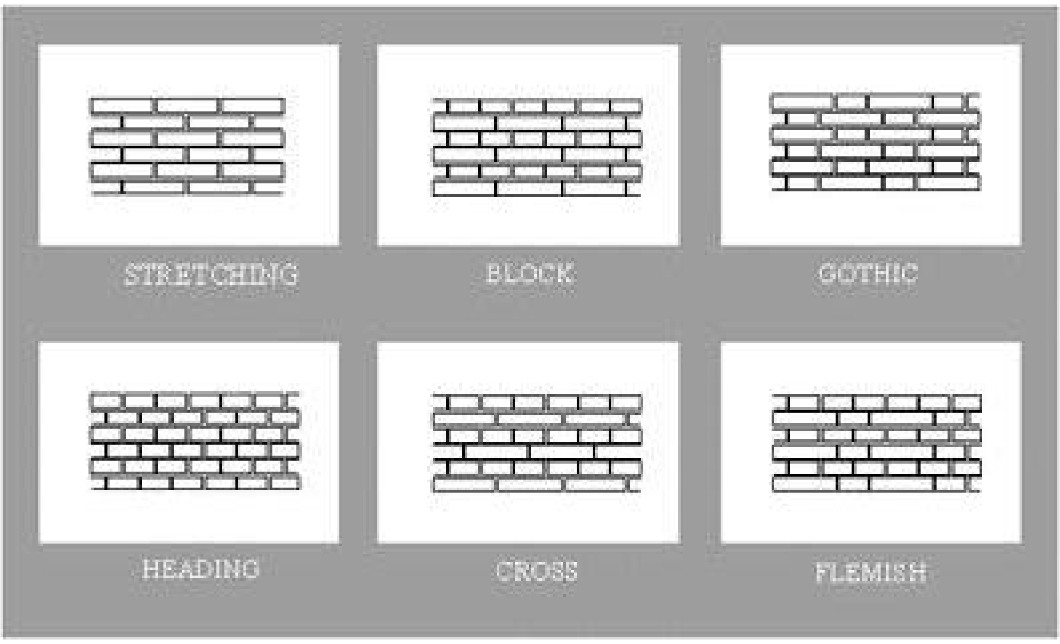


Figure 5. The bonds.

The construction of the entire wall is carried on through the assembly of elements corresponding to standard situations.

The elements are: left end, right end, left corner, right corner, window, door, blind wall. Ends and corners are standardised as they maintain their configuration whatever can be the entire wall length, while, of course, windows, doors and blind walls are parametric.

All the element lengths are defined as functions of number and length of bricks. Only three quarters bricks and half bricks are allowed when necessary. Consequently, the design module consistent with the dimensions of all the bricks employed is the quarter of the brick. As the standard brick dimensions are 5.5x12x25 cm, if the module has to consider also the joint breadth its default dimension will be 6.5 cm (25 +1 (joint))/4.

The procedure of drawing a complete brick external wall of a building is as follows:

1) a drawing of the wall is made, not bothering about consistency of openings and blind walls dimensions to the brick module;
2) bond, wall thickness, brick dimensions are chosen;
3) the number of floors is input;
4) for each floor ABD operates a checking about the consistency of wall and opening dimensions with modular lengths based on the brick and joint dimensions;
5) if the result of the checking is negative ABD suggests for each proposed length two dimensions, immediately longer and shorter, consistent with the bond;
6) after the acceptance of all the suggested dimensions ABD draws sequentially the entire perimeter of the brick wall.

Actually the procedure is run interactively as, if the checking of the final dimensions of opposite walls is different, the designer has to care for the consistency of the whole adding or subtracting a brick module.

An example follows.

The example

This example deals with a two floor building to be built with walls three layers thick with Flemish bond, only the external walls are drawn.

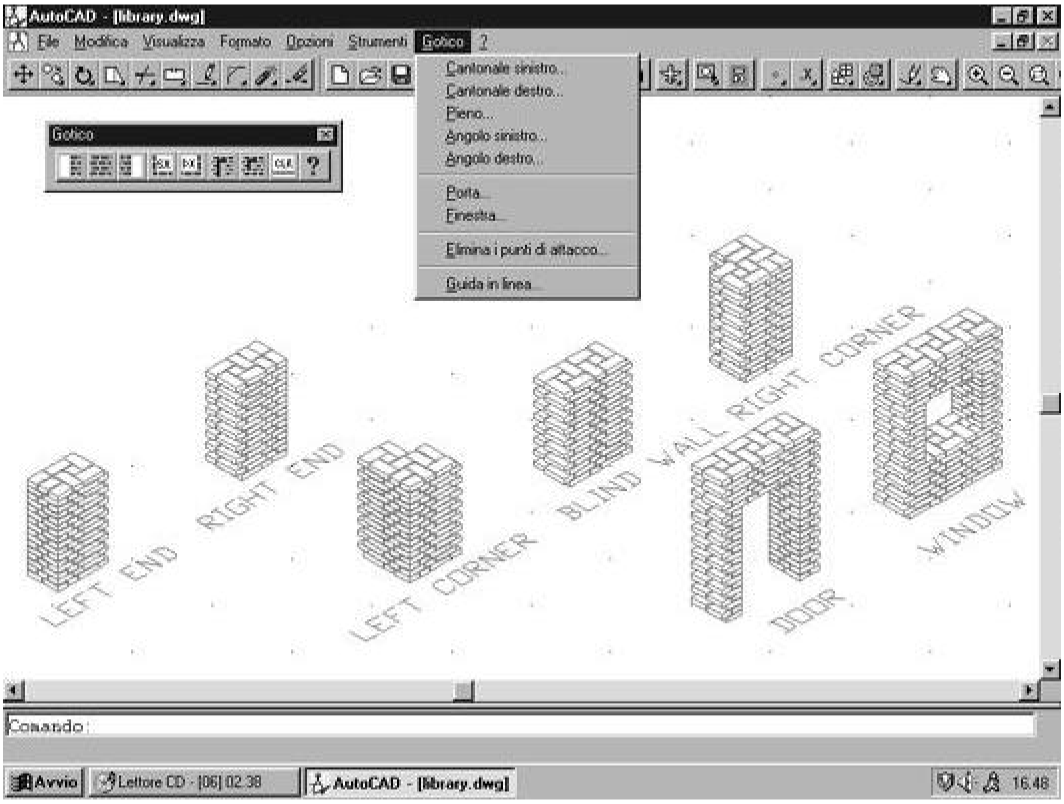


Figure 6. The elements of the library.

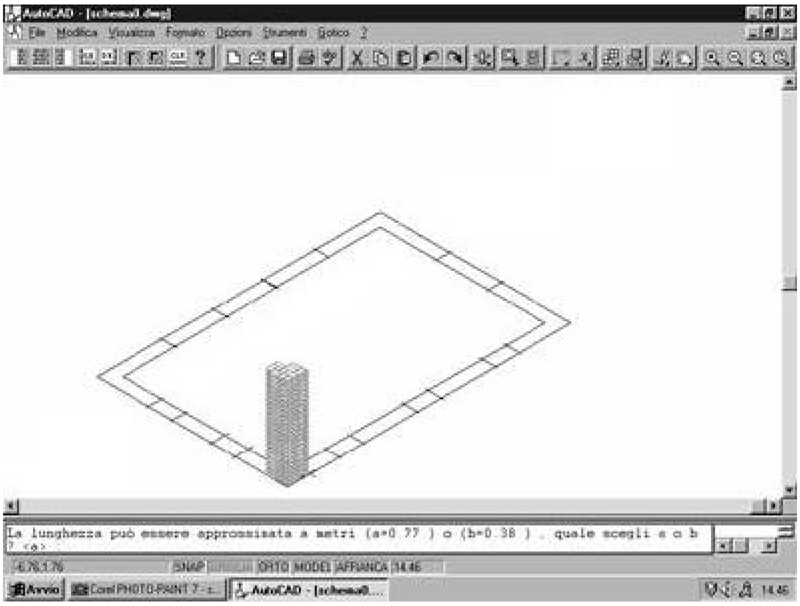


Figure 7. Construction of an external wall: dimension consistency check.

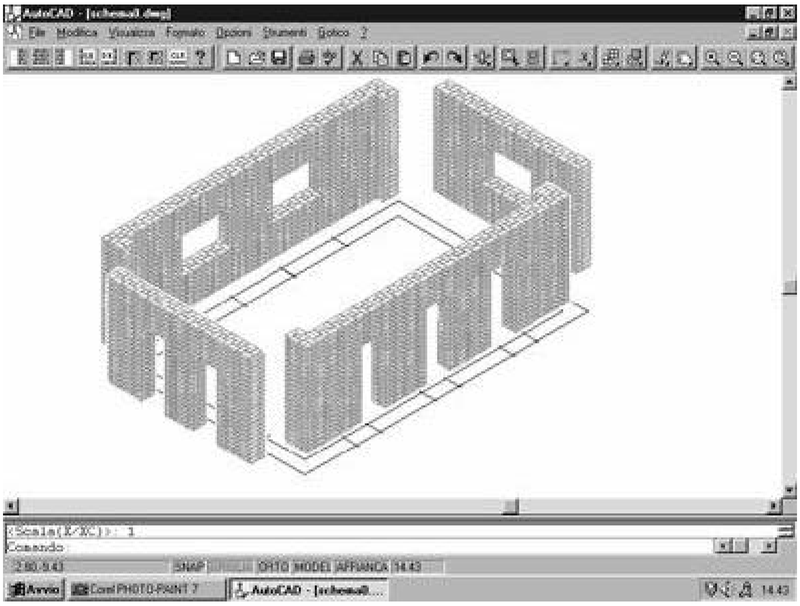


Figure 8. The complete external wall: exploded view. In this phase the general consistency control of opposite walls is made.

Conclusions

Actually this simple tool can be useful , besides, of course, as a practical design tool, as a didactic means of showing, in the phase of designing the detail drawings of a project, the modularity of the brickwork and the consequent opportunity of choosing modular design dimensions if one wants not to spoil, with late arrangements, a regular bond.

Up to now the bonds taken into consideration are only those above mentioned. ABD should be more useful if it could handle any other possible bond. In fact we are developing such a capability. In a more advanced version ABD shall be able to aid to construct different kinds of bonds, suggesting and checking the consistency of the superposed layers and defining for them the same constituting elements of the wall.

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Architectural Bitmanship : Towards new experiments in architectural education

Roel Daru

Department of Architecture

Eindhoven University of Technology

PB 513, 5600 MB Eindhoven, The Netherlands

Crafts and craftmanship are about internalised skilled activities, practiced by individuals. According to the particular tools, materials and know-how used in history, it is possible to make distinctions and shows common roots between physical craftmanship, penmanship, draughtsmanship and (in our information age) digital craftsmanship. Every era develops its own crafts and demands its own system of education and pedagogical experiments to achieve the necessary skills. After retelling a very compressed history of all sorts of skills with their accompanying educational experiments in architecture, this paper suggest new experiments needed and required for the nascent era of digital craftsmanship

Introduction

From ancient times to our time, architects got their education in very different ways. Much of their education was bound by the actual tools then available to design. Those tools defined the skills, knowledge and education needed and possible. A very short overview will be given here of the main periods of emergence and predominance of certain tools and skills, shaping and moulding the architect in his or her designers role at the time. For each periode we will deal briefly with:

• the description of the skills and tools used and resulting abilities needed,

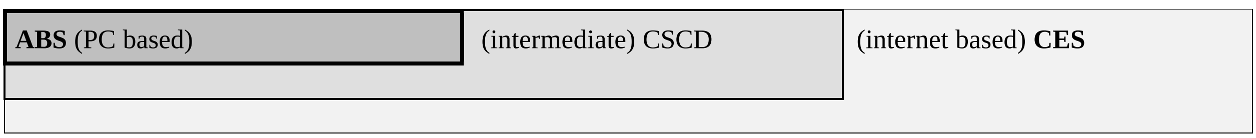
• the background and meaning of each approach and how much residue there is of each in the architectural education system in general and as an example in Eindhoven in particular,

• the mental load and span brought along with all the applied craftsmanships (= x-manship) and the evolutionary consequences it had for the design activities performed and results obtained.

Based on those findings and the current state of the art of the Information Technology (IT), I will present here two (interconnectable) IT supported proposals for new pedagogical experiments about new ways of:

• Computer Supported Cooperative Designing (CSCD) with an Architectural Breeding System (ABS) and

• marketing crafts by a Craft Exchange System (CES), an internet site with supply and demand advertisements about design related architectural services and facilities.



Manual and digital craftsmanship and the experienced designer

In order to avoid conceptual confusion some comments are needed about the meaning of ‘craftsmanship’, ‘computerised craftsmanship’ and ‘the experienced designer’. With regard to the understanding of classical craftsmanship, has been the subject of many books from Diderot’s and d’Alembert’s ‘Encyclopédie’ (1762-77) to the work of by Edward Lucie-Smith (1981) on ‘The Story of Craft: the craftsman’s role in society’. Malcolm McCullough (1996) wrote his intriguing ‘Abstracting Craft: the practiced digital hand’ to introduce the concept of craftsmanship into the digital world. The abilities and competences of the professional experienced designer have been studied from a variety of viewpoints as well. One of our own lines of approach is summarized in the PhD thesis of Anton van Bakel (1995) about ‘Styles of Architectural Designing: empirical research on working styles and personality dispositions’.

Craftsmanship	Experienced Designer	Digital Craftsmanship
Diderot & d’Alembert / Lucie-Smith	van Bakel	McCullough

Craftsmanship in general

To begin with, what is a craft (and by extension craftsmanship) anyhow? In general it is an internalised skilled activity, practiced by individuals. It depends on particular tools, materials, media and personal know-how. As such a craft is the application of tacit, not explicit personal knowledge to the giving of form either as a physical artifact (handicrafts) or its projection on a surface (draughtsmanship) or screen (bitmanship). A craft combines manual, visual and mental abilities to produce well executed, usually practical products. It involves activities of feeling, seeing and thinking. It is an integrated activity of ‘reflection in action’ (Schön, 1983): ‘to craft is to care’. Essential in craftsmanship is tracking or keeping a tool on target. It is about the ability to recognize and recover errors in time and without overreaction. And last but not least it is also about using tools resourcefully, imaginative and to be able to compensate their short comings. In this general sense the description of craftsmanship is applicable to:

physical	**craftmanship**	of an artisan wrestling with his tools and materials
visual/symbolic	**penmanship**	of an critic wrestling with his words and pen on paper
visual	**draughtsmanship**	of a designer wrestling with his sketches and pencil on paper
visual/symbolic	**bitmanship**	of a digital designer or programmer wrestling with his application or programming software and computer on screen
visual/symbolic	**(bit)netmanship**	of an internet user or provider wrestling with his information transmission and retrieval system and internet connected computer on screen

Physical craftsmanship, conceptual span and the quality of designs

Manually based craftsmanship involves the shaping of resistant physical materials. As such it is often a matter of hard work. As Jones (1970) once observed, due to the arduous work with real material, the ‘perceptual span’ of the craftsman is limited. It is very difficult, time consuming and costly for the manual craftsman to predict the consequences of drastic changes in some parts of the design for the form and function of the whole. This is the reason why in handicrafts inventions and innovations occurs so slowly and gradually (but after a lot of iterations also so perfectly adapted) in an evolutionary process of trial and error. Information about the elements applied, its distribution within the whole and the accompanying working style is stored in the crafted product itself. Nevertheless manual craftsmanship allows the development of very complex, well fit forms, when there is enough time for learning by doing. With hands-on experience the craftsman discovers and knows very thoroughly the limits of often difficult changeable materials. Hands are both effectors and probes: they feel, practice and give sense to design ideas and decisions. Together with the eys and mind, they search, reveals, recognise, appraise and release. Some students at at Eindhoven (and undoubtedly elsewhere) do not sketch: they prefer to give form to their ideas directly with scale models. In practising material techniques they can experience the unity of designing and making. This is at its best when the students get the opportunity to design something at real-scale like an original piece of furniture. Surrogate materials in small-scaled models for large-scaled building projects do not allow this unity of conceptualisation and realisation as perfectly.

characteristics	**perceptual span**	**quality**	**invention rate**	**adaptation**	**experience**
of a **craftsman**	limited	high	slow	well fitted	hands-on

The experienced designer

The experienced designer corresponds equally well with the professional designer as with the designing craftsman or draughtsman. A commom factor to the experienced desgner and the craftsman, is that both need a fairly long time to ripen. Our course at Eindhoven has a span of 5 years. Students emerge with a diploma but little experience. The question is: can CAD simulation be a crash-course in design experience? I think not. Real-world experience needs the sedimentation of trial-and-error in long-term memory of the learning designer. The experimenced designer is someone who is able to react adequately at a strategic and tactic level. Experienced designers have been tested by Anton van Bakel (1995) in his PhD thesis at our faculty. The experienced designer is someone able to work and decide efficiently and effectively: who is able to discover in a very fast way the most promising spots in the (combinatorial) solution space available. (S)he is also someone who is able to restate the brief if necessary or profitable for the client or other persons or groups involved. One of the qualities of the experienced designer is his or her ability to improvise properly. In almost every school of architeture the draughtsmanship (and in a lesser extent craftsmanship) of the experienced designer is practiced widely in the design studios, involving individual counseling, group discussions and evaluations. Penmanship is exercised too, but in a very modest way. In Eindhoven for instance theses are asked to finalize some architectural theory courses. Compared with the craftsman’s characteristics the experienced designer features are as follows:

characteristics of	**perceptual span**	**quality**	**invention rate**	**adaptation**	**experience**
experienced designer	expanded	moderate	moderate	moderate fitted	infered

Tutors in traditional architecture studios rely on what they know of designing experience. But when CAD specialists in a faculty are not at the same time part of the designers’ culture, the merging of digital and traditional design experience is patchy in the case of Eindhoven this lack of fit has lead to a split-up. This split is not a solution. It is not the first time in history that such a technology-split has taken place. A first split took place during the Renaissance between craftsmen and designers-by-drawing.

FIRST EDUCATIONAL EXPERIMENTS: shaping architects as experienced draughtsmen

Until the Renaissance of the fifteenth century, the architect was trained within the realm of the Crafts Guilds. But with the founding of the Academia Platonica a first notable challenge against the conservative grip of the Guilds was started. With this system of academic learning, a more universally skilled and experienced artist-designer could be educated like Leonardo da Vinci and many others. Sketches and drawings as design media came into being to record and play with design ideas before crafting the real thing. Penmanship has always had a high status, with Alberti as one of the greatest examples from the Renaissance. Inspired by (the penmanship of) Vitruvius, he wrote (among others) the ten books of architecture. But other artists-designers of the Renaissance and beyond were also trying to raise and promote their status by claiming to be also a treatise writer, philosopher and practical scientist. But in general, their penmanship was not essential to exert their practical and professional expertise.

A second major attack against the Guilds took place in seventeenth century France, where the Académie Royale d’Architecture was established in 1671. The objective was twofold: to counteract the Guilds independency of Royal rule and to foster exact knowledge and suitable theory (obviously about architecture, mathematics and perspective, but also about fortifications and stone cutting for instance). Because of that, the Academy only offered lectures, with the students learning to design and draw in the ateliers of their architect employers. Regular competitions became the rule for the selection of students. The Académie survived the French revolution (with the Royal stamp removed) and was re- established afterwards as the Ecole Royale des Beaux-Arts in 1819. As such the school became the model of architectural education throughout the world, with a split in the educational system in theory and practice of design. The first was taught horizontally per course year and the latter one was organised vertically per atelier with students of all years within one atelier of approximately hundred students large. On top of the atelier there was a patron as the teacher, with two senior students with responsibilty to assist him and manage the place in his absence. Within such a vertical system, the freshman especially, (but also students of other years) could learn intensively in a fast and varied way in a one to one or (at the farthest) in a few to one situation of communication by assisting more advanced, elder students. In our time however, the ateliers or design studios are less efficient and effective organised because students of the same course year with aproximately the same level of knowledge and expertise are not able to transmit much additional knowledge. In that case learning is more teacher centered in a one to many situation of instruction, demonstration and exchange of all sorts of information.

architectural education in:	**practice** (secrets of the trade)	**ateliers** (design teaching)	**lectures** (theorie transfer)
crafts guilds	yes, apprentices syst.	no	no
Academia Platonica	no	yes, possibly, vertical	possibly vertical
Académie Royale d'Arch	yes, learning the trade	no, later competitions	yes, possibly vertical
École R. des Beaux-Arts	no, not compelled	yes, vertically structured	yes, per course year

In the Beaux-Arts riping takes place, but the resulting design experience is separated from the direct wrestling with the matter.

Visual draughtsmanship: disconnecting designing from making

While manual craftsmanship involves the physical reshaping of materials (either with difficult changeable originals or easier alterable surrogates), visual draughtsmanship is about the much easier projection of those shapes on paper or a computer screen. Gradually, with the emergence of the Renaissance and beyond, a split between designing and making took place. Conceptualisation became the privileged occupation of designers with pen and paper while the production of material forms was left to the craftsman and later to the progressively deskilled worker of (ultimately) the assembly line. Even the job with pen and paper was split up in the real design work with sketching as the main activity and the implementing activity of detailing, rendering and finishing of the sketch design in scale drawings as the major occupation of the draughtsman (or now the CA(AD)D operator with his virtual 2D or 3D model). At Eindhoven we had once a special craftsmanship course for scale and real scale model building. In the same vein a number of special draughtsmanship courses were given in for example final design drawing, rendering, storyboard planning, photography & filming, model drawing and design sketching. But also for instance in computer supported 'diagramming' to restructure and optimise hidden relationships interactively and visually in combinatorial and attributional matrices in order to conceptualise data-congruent classifications and typologies in architectural history and design (to establish for instance typologies of buildings or groups of related architects, or for example to optimise building layout plans).

craft/shape related characteristics	**craftsmanship**	**sketchmanship**	**draughtsmanship**
physical reshaping	on the job	no	no
projection of inexact shapes	no	on design sketches	no
projection of exact shapes	on site/workshop	no	on finishing drawings

Why visual draughtsmanship: enlarging the 'perceptual span'

As Jones (1970) pointed out this split up between designing and execution made a radical division of labor possible. By specifying the geometric dimensions of a shape in advance, separate pieces of work could be allocated to different workers for separate drawing and manufacturing and (in the end) assembling those parts subsequently to produce the desired whole. This made an unprecedented increase possible in size and rate of production. But this also took away much of the mental fun and challenge from the workers, to the sole benefit of the design professions with their sketching tools. The designer has the benefit of a larger ‘perceptual span’, when sketching, because the object of his attention is only the projection of spatial forms, and not the physical transformation of matter. Throwing shapes on paper is already working in virtual reality. At Eindhoven I deliberately introduced a sketch design course without computers, in order to maximise the perceptual span achievable with draughtsmanship. Our experience with sketching on computers was that the manipulations with mouse, screen, keyboard, tablet, etc. were a strain on the free flow of ideas of students. With the ‘perceptual span’ enlarged with sketches and drawings, inventions and innovations takes place at a much faster rate than possible with manual craftsmanship. But because fewer feedback loops are involved and direct physical experiences behind the feedback is missed, no near perfect adaptation is likely to occur as is the case in a more natural way of development.

characteristics	**perceptual span**	**invention rate**	**quality**	**adaptation**	**experience**
designing	expanded	moderate	moderate	average fitted	in infering
drawing	not needed	not asked for	high, if supervised	by scaling	in detailing
execution	not needed	not asked for	high, if supervised	of deviations	in implement

Visual draughtsmanship: mental limitations

Assessing the form and function of a whole from drastic changes in its parts is made easier to perform with fast produced sketches or slower developed drawings later on. Using sketches, the experienced designer might appraise the consequences of changes in the shapes of some parts for the form as a whole. But this is done at a cost: the sketch or drawing can not be used to simulate the behaviour of the designed object nor calculate its technical operation; neither can it be used to appraise performance in use of the design or estimate its manufacturing consequences. With sketches the designer is also restricted to the depth-first strategy: working with only one alternative at a time instead of evaluating every time a range of basic alternatives simultaneously (breadth first strategy). And foremost during the most critical phase of design sketching it is very difficult (if not impossible) to exploit the imaginative minds of a team of designers, expert advisers, clients, users and other persons involved. As we will argue in a moment these drawbacks might be addressed by morphogenetic designing with an Architectural Breeding System (ABS) as a possible digital successor of of hand design sketching as a design tool and skill (Daru & Snijder, 1997).

SECOND EDUCATIONAL EXPERIMENT: shaping architects as industrialised craftsmen

To counteract these drawbacks manual craftsmanship was again propagated in the twenties of our century within the scope of a new pedagogical experiment. Amidst the aftermath of the first world war and the industrial revolution with its disappearances of craftsmanships at the assembly line, Walter Gropius wanted to (re)unite craft with industry through the education of specialised craftsmen. That is, designing craftsmen, knowing how to craft and design simple and efficient products in accordance to the capacities of the mass producing industry of those days. At the opening ceremoy of the Bauhaus, he stated that ‘art cannot be taught, but craftsmanship can, and that architects, painters and sculptors are craftsmen in the fullest sense of the word’. To that end he started his pedagogical experiment with a curriculum based on a series of workshops for shaping wood, metal, textiles, glass, clay and stone. The Bauhaus and the Beaux-Arts educational system contrast at least at the following points:

BAUHAUS	**ÉCOLE (ROYALE) DES BEAUX-ARTS**
horizontal workshops (learning from the teacher)	vertical workshops (learning mostly from elder students)
craftsmanship training emphasised	draughtsmanship training emphasised
industry efficient, mass production design tasks	monumental building design tasks

artistic designing by abstract formal precedents	prototypical designing with classical building style
history banned	history based

At our own department this variety of Bauhaus-like workshops is compressed and simplified within a student workshop for scale model building. This well equiped workshop is used when needed, not on a regular basis within the curriculum So, it is in the student workshop as a result of work done in the design studio, that the students are learning their craftsmanship and not in specialised courses. But this implies also that craftsmanship learning happens only in a haphazard way by trial and error: learning by doing and when needed. An explicit training however in craftsmanship and by extension in draughtsmanship is almost completely abandoned in the past in favour of academically more respectable courses in applied sciences, computer mediated draughtsmanship and the like. Within our post-industrialised society with the abandonment of the assembly line, the re-introduction of the single piece and just in time production techniques and the emergence of bitmanship, the time is now ripe for new pedagogical experiments, based on the realities and possibilities of our own time and technology. At the end of this paper two interconnectable proposals are made to implement such new pedagogical experiments for Computer Supported Cooperative Designing (CSCD) with an Architectural Breeding System (ABS) and an internet based Crafts Exchange System (CES) on an ECAADE wide scale.

From craftsmanship over draughtsmanship to digital craftsmanship

In craftsmanship there is a progression detectable from the primacy of the preconscious hands in classical crafts over the growth of the importance of also the preconscious eyes in the visual crafts or draughtsmanship towards the mind in charge of both unconsciousness and consciousness. As Allen Kay (1990) postulated (quoting Piaget and Bruner) learning is best accomplished if first acquired kinesthetically (like in handicrafts by doing) and then iconically (as in draughtsmanship by sketching images). Only after these two intuitive stages comes the final stage of obtaining more consciously symbolic skills and knowledge (like in penmanship working with words or in bitmanship by ‘hacking C++’ as Mitchell has expressed it. Based on these considerations at Xerox PARC Allen Kay once defined the first Graphic User Interface as follows:

GUI definition	**tools**	**learning type**	**ability**
DOING	mouse	enactive	know where you are, manipulate
with IMAGES	icons, windows	iconic	recognize, compare, configure, concrete
makes SYMBOLS	Smalltalk	symbolic	tie together long chains of reasoning, abstract

In bitmanship as craft, the eye takes a crucial position.

The strategic position of our eyes

Because enactive, iconic and symbolic learning were once obtained in evolutionary different times (and processed in different places in our brain), they don’t perform in a synchronised way. They might even act in opposition to each other in order to get control of the situation. As is now generally known in psychology, creativity has least to do with our symbolic faculties, already more with our handicraft capabilities and is most connected with our visual-spatial abilities. The eyes explore and recognise, they define and specify, they compare and dispose, they organise and classify. At Eindhoven, these considerations are digested in the mentioned sketch design course. The probabilities to evoke (in our imagination) or to see (within the multitude of our visual impressions) analogically or metaphorically inspiring alternative patterns is indeed very high, compared with the impressions we get from our kinesthetic or symbolic faculties. The 2D image is a powerful medium which can evoke more dimensions and is instantaneously perceived. The symbolic abilities of language (penmanship), music and mathematics lack its instantaneous overview of patterns. They are mainly auditory based and therefore time dependent. Written words and formulas for music or mathematics are in principle linear expressions of pronounceable statements and can only escape in a very restricted way this linearity if writing on paper or screen.

visual perception of pictographs and graphics	auditory perception of language, music and mathematics
1 variation in mark perpendicular on paper (**Z**)	**1** variation in sound (or shape), plus
plus **2** dimensions of the plane (**XY**)	**1** variation in time **t**
provides in **1** moment time **3 dimensions XYZ**	provides in **1** moment time **1 dimension** + **t**

Design sketchmanship and computer support

At the present official curricula of design schools, amazingly little attention is paid explicitly to design sketching as the most prominent tool of designing by draughting. It is considered as an integral part of studio teaching. Still less is generally known about the possibilities to base such a sketch design tool and skill on sound psychological findings and principles of design creativity and crafts-/draughtsmanship abilities. Psychological principles and findings to guide us in determining what can and can not be done with what technique of design sketching and in which field of design it might be applied. Findings and principles also being capable enough to provide us with ideas about how we might stimulate both original and useful design ideas in either our pre- or sub- or full-consciousness (respectively our Short and Long Term Memory). Ideas to be developed with a way of design reasoning and finally in either a re-creative manner (seeking solutions well fitted within the stated brief and constraints), in a sub-creative fashion (exploring and broadening the boundaries of the given solution space) and in a trans-creative way of designing (exploring well beyond the boundaries of the stated solution space). This results in six design approaches of which four were once conceptualised by Broadbent, 1971 (see the table at the end of the paragraph). In the pragmatic approach, form follows function; in the analogic approach, form follows meaning; in catagorical reduction, form follows reduction; in synthesis, function follows form again; in the canonic approach, more is different; in the iconic approach, variety is all. At Eindhoven in the architectural (hand design) sketching course, the developed exercises are based on the aforementioned findings and principles.

With the acquired experiences I became aware of the extremely difficult opportunities to support in an effective and efficient way the hand design sketching skills with digital means and devices. Tablets and touch sensitive pens, personal digital assistants and organisers with drawing software facilities are still clumsy alternatives of the very cheap, easy held, used and stored hand pencil and sketchbook. Awkward alternatives moreover without new exciting possibilities to compensate for those disadvantages. Considering these circumstances I maintained the hand based design sketching course and shifted the search drastically from computerised supporting tools for the human hand, towards tools for the pre-conscious eyes. A device capable to produce those sketches automatically on screen, leaving the user rathter in the role of the visually selecting breeder instead of the hand based producer of shapes defining sketches.

mental characteristics of several approaches to design	**Memory**	**conscious-ness**	**way of reasoning**	**creativity level**
pragmatic),* **first principles**	ShortTermM	full-	deduction	re-creative
analogy, **prototypical**	LongTM	sub-	induction	sub-creative
categorical reduction	STM	full-	deduction	re-creative
synthesis, **recombination**	STM	pre-	induction	sub-creative
canonic, emergence, **restructuration**	STM	pre-	adduction	trans-creative
iconic, precedental, metaphorical, **mutation**	LTM	sub-	abduction	re-creative

*) in *italics* are concepts used by Broadbent, 1971

The experienced designer and structured improvisation

Today improvisation is needed due to the manifold of changes and possibilities one is confronted with and which are too much to anticipate in advance. Improvisation presupposes some sense of structure to vary, experiment and play with. Sketched irregularities based on some sense of a guiding structure underneath (like shapes and configurations obeying an invisible orthogonal grid system) offers just such possibilities of exploration. They provides alternative subshapes as suggested by an invisible grid from which to built new pleasurable expressions and meaningful compositions and interpretations. In craftsmanship and draughtsmanship the eyes have the ability to recognise all sorts of emerging possibilities within imaginable structures. As we will see in a moment with morphogenetic computing, it is possible to apply the same ability within a supplementing man-machine system. Computers perform badly where human eyes excel and inversely. Eyes are very good in pattern-building and discovering, in pattern recognition and appraisal within conceivable structures and that is precisely left to the user in morphogenetic computing. Computers on the contrary are strong in tireless calculations and visualisations and as such are given exactly those tasks to perform.

eyes	**computers**	*characteristics of eyes and computers*
good	bad	**pattern building**, discovering, recognition and appraisal
bad	good	**data processing** by tireless calculation & visualisation

Bitmanship

While manual craftsmanship is about the reshaping of physical materials and visual draughtsmanship is about the reshaping of graphical forms on paper, digital craftsmanship or (to put it briefly) ‘bitmanship’ is about the reshaping of virtual forms with symbolic software on a computer screen. But bitmanship is (like manual and graphical craftsmanship) also about the personal mastery of a medium. However instead of solid material and handtools to carve, sculpt and chisel (or paper and pens to apply meaningful marks), the medium is the computer with its accompanying software and input and output devises like keyboard, mouse and screen.

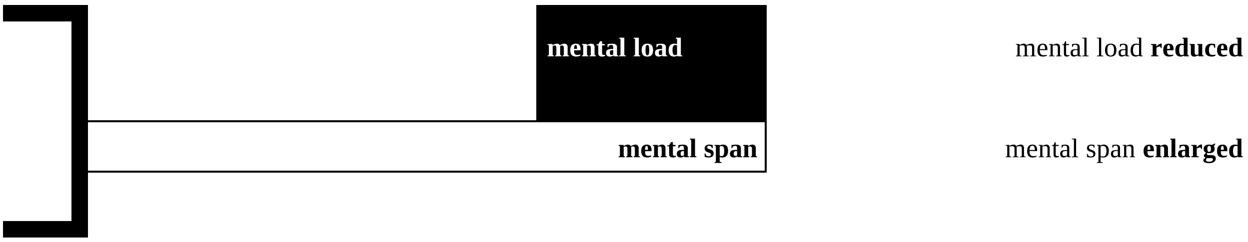
characteristics of x-manships	**craftmanship**	**draughtmanship**	**bitmanship**
form processing	physical in material	graphical on paper	graphical on screen
speed of realisation	slow	faster	fastest, if not impaired
test: appraisal of consequences	trial & error	by supposition	evaluation function
supplying an overview	in the mind	in sketch/drawing	product model

Like in any craft, bitcraft is about direct manipulation and the application of personal knowledge in the giving of form. But here personal knowledge is about the digital process of making, about tracking on screen, about recognizing and recovering input errors in time and without overreaction. However still the same challenge as in any designing craft is valid about using tools and knowledge resourcefully, imaginative and compensatory. It involves still the personal control of the process and the identification and conscious involvement with the work to be done. Even the engagement with material (as it is first changed from physical to virtual), is up to be reversed with CA(AD)D/CAM techniques.

characteristics of	**mental span**	**quality**	**invention rate**	**adaptation**	**experience**
a **bitman**	basically high but might be impaired by perceptual load	high, if not impaired	high, if not impaired	more perfectly fitted, if not impaired	calculation based evaluations

Digital mental load, counteracting extended mental span

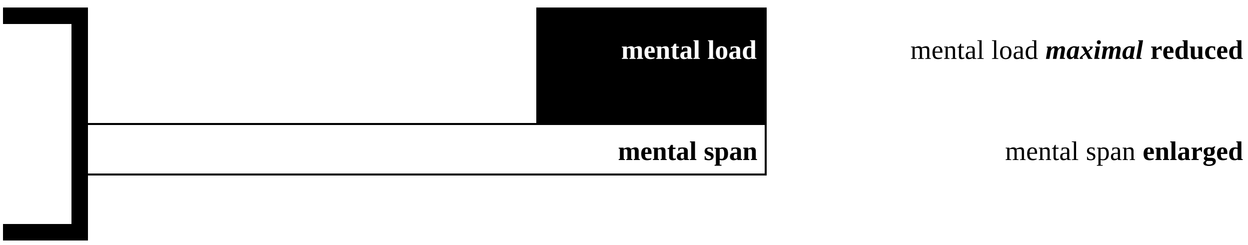
With information based techniques the mind of the craftsman might be reinforced considerably, if applied properly. This is like physical tools and machines taking over the role of the hands to handle muscle power and consequently freeing those hands (and matching eyes) to improve, strengthen and extend their accompanying observing and correcting capabilities. But this will only be the case, if the ‘perceptual and cognitive load’ of the software and interface is kept well below our enduring level of stress sensitivity, irritation, frustration, discomfort, arousal and distraction. These psychological loads are about time delays, visual strain, repetition, muscle stress and other discomforting considerations. According to Ben Shneiderman (1987) there is a variety of softening factors available to relieve perceptual and cognitive load, like consistency, availability of shortcuts, continual feedback, closure, error handling, reversibility, sense of causation and limited use of short-term memory (Miller’s 7 ± 2 rule). For instance (as we all know now) instead of remembering and reproducing textual (DOS/UNIX) commands with the keyboard, it is much easier to recognise and activate (Mac/Windows) icons already presented on screen. By shifting those instructions to observations, by translating cognitions to perceptual sensations or logical operations to reflexes, those loads are transformed from foreground attention drawing to background (contextual) awareness, making room to extend and broaden the much desired psychological span. An increase in mental span should be counterbalanced by a decrease of mental load.



According to Schön (1983) designing is ‘reflection in action’. Too much command actions to handle the computer affects the reflection part of designing. The question here is how much attention is given to these considerations by IT teachers and developers. How much root or heuristic learning is imposed, how much is sensible or insensible transmitted either implicitly or explicitly and what is left to exercise one’s own working, learning and designing style? In the past the pressure from our university, faculty and IT group to conform to MS-DOS instead of the then available graphical user interface of Macintosh for example shows how little thought was given to these considerations.

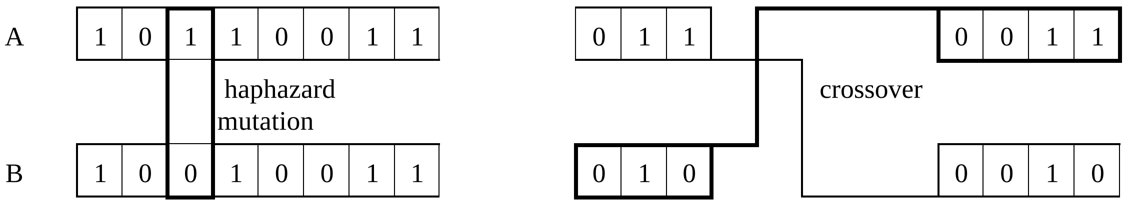
The morphogenetic approach: how to get rid from digital mental loads radically?

With manual design sketching intensive practice is required to shift this activity from a foreground exercise to a background skill (just as with typing). The same is true with the handling of CA(AD)D or paint programs to sketch, draw or model. Even if their software and user interface are conceived and implemented in a very clever way, they still weigh down on the so desirable psychological span. This is unlike the morphogenetic software we are developing at our architecture department, where the psychological load of sketching is radically reduced (Daru & Snijder, 1997 and Snijder & Daru, 1997). This allows the user to concentrate on high level ideas generation and decision making. Choices are accomplished by making selections between alternatives as they are automatically presented on screen. By choosing alternatives, the user navigates (in a very fast and easy way) through an enormous combinatorial solution space of recombined shapes. This amplifies the psychological span far beyond the possibilities of either draughtsmanship on paper or with a CA(AD)D system on screen. The perceptual load is reduced decisively because the difficult, time consuming and distracting sketching or drawing activity is completely taken over by the software. The user is left with alternatives of already evaluated solutions for visual inspection and ultimate selection and breeding on screen. The visual selection is needed to introduce all considerations not already built-in in the evaluation function.



The morphogenetic approach: advantage or disadvantage?

In morphogenetic software, the symbolic definition of a system in general and its geometry in particular is encoded and stored in recombinatorial strings. This ensures consistent expressions of the shapes involved. But simultaneously their structural identity and integrity defines and confines the (genotypical) family of shapes possible. For the end-user this might appear as a drawback: not every conceivable shape is possible. However, from a stylistic or typological point of view this ensures also formal consistency.



With the morphogenetic approach, designing is split in two separate activities: the (genotypical) composing of the (string) structure by the programmer and the (phenotypical) exploration of the possibilities and extent of that structure by the end-user. The ability to navigate between families of options (breadth-first strategy) represents an fundamental improvement over the much slower reshaping iterations (depth-first strategy) of the classical design approach. In spite of the astounding fluidity of shape generation, selection and regeneration with the morphogenetic software, this procedure is still very structured and as such can also be more or less easily passed on to the CA(AD)D formats of other programs for more detailed transcriptions.

At Eindhoven (in design morphology exercises) our architecture students get the opportunity to explore the emerging principles of morphogenetic designing with the general available software program Cybertation. This particular program is about the principles of shape generation only, because it operates with visual selection options and without also an evaluation function to constrain the visualisation task up to allowable alternatives on screen. As soon as we get ready, we will introduce our own developed constrainable morphogenetic design software for layout planning. We have the intention to complement this type of software with the modelling, animation and rendering software 'xfrog' from Lintermann and Deussen (1997) for complex biotectonic shape development.

IT as a medium for craftsmanship

The question whether Information Technologies (IT) as a medium have created and reinforced the bitmanship or 'computerised craftsmanship' side of architectural design education might be answered in a very mixed way. With regard to the deployment of IT there are at least three cases:

old-old:	***difficult to computerise***
	For instance design sketching, mock-up building and simulation in the physical lab.
	From this perspective the impact of IT in architectural education is rather smal. If compared to what is delivered in design support, the intellectual efforts and investment in software and equipment is largely wasted. Especially IT failed to provide an appropriate tool for the sketch design phase. As far as I know, no substitute CA(AD)D system exist able to compete with the performance of hand sketching as a very simple, fast, but effective way to acquire and fix floating design ideas. Even compared with paper and sketch pen, touch sensitive pens and tablets do not perform easier. With the AI based software of Mark Gross (1996) however at least the functionality if not the speed of tablet based sketching is substantially extended.
old-new:	***easier to computerise***
	For instance CA(AD)D drawing and 3D modelling, computerised rendering, virtual simulation, tablet based sketching.
	In this field of computerised craftsmanship the impact is adequately if not tremendous like in drafting, 3D modelling and rendering for presentation purposes. But a mixed result is achieved with 3D modelling and manufacturing: we still do not encounter real CA(AD)D/CAM installations in most buildingmodel workshops

	or architectural design studios. And even for CA(AD)D as a drawing medium a quantum leap in performance is only apparent in special cases.
new:	***computerisation a necessity***
	For instance Virtual and Enhanced Reality, internet surfing, Computer Supported Cooperative Work (CSCW) or Design (CSCD), respectively shape breeding with an Architectural Breeding System (ABS) or developing very complicated shapes with folds, twists and so on with a suitable CA(AD)D system or with the morphogenetic program x-frog.
	For this types of representation and transmission IT techniques have acquired their incontestable position. VR supported simulations for training and operational experience is even able to increase our acquisition of experience.

The growth in maturity of a new medium is conditioned by a shift from imitation of a well-known old application in an parent medium (old-new) to the exploitation of the new medium's own, original characteristics (new). Now the time is ripe to make the shift from CA(A)DD to Computer Supported Cooperated Design, Architectural Breeding System and Craft Exchange Sysem among others.

IT as a risk and challenge for the experienced designer approach

If sensibly and reasonably applied IT might contribute to our design knowledge (including theoretical insight and practical experiences). IT might stimulate our thinking about the design knowledge needed to execute the design proces properly and to get the results required. It might give us some knowledge about formal rules of designing, the nature and purposes of drafting, modelling and VR representation. But until now IT get more in the way of the sketcher as an experienced designer. The speed with which the stream of ideas emerge in the consciousness of the designer does not keep up with the pace present IT can offer. Certainly not if we compare these IT based means with the very cheap, portable (and for the practised hand of the designer effortless, easy) and simple to handle devices of sketch pen and paper. What IT might bring about is the deskilling of old craftsmanship and draughtsmanship before a full-blown digital substitution is developed and generally applied. Moreover this phenomenon of handicraft deskilling and (at the same time) digital reskilling might trigger negative transfer reactions, making it difficult to go back and forth, for instance from hand design sketching to digital design sketching and back. What IT might cultivate or encourage consciously or even promote unintentionally are digital nerds or freaks, making de-nerding or de-freaking training necessary if as a result too little time is left for designing in the design studio.

promise	enlarges our knowledge about designing and representation and formal rules used in design
risk	brakes speed of idea development; deskills, trigger negative transfer, instigates nerds or freaks

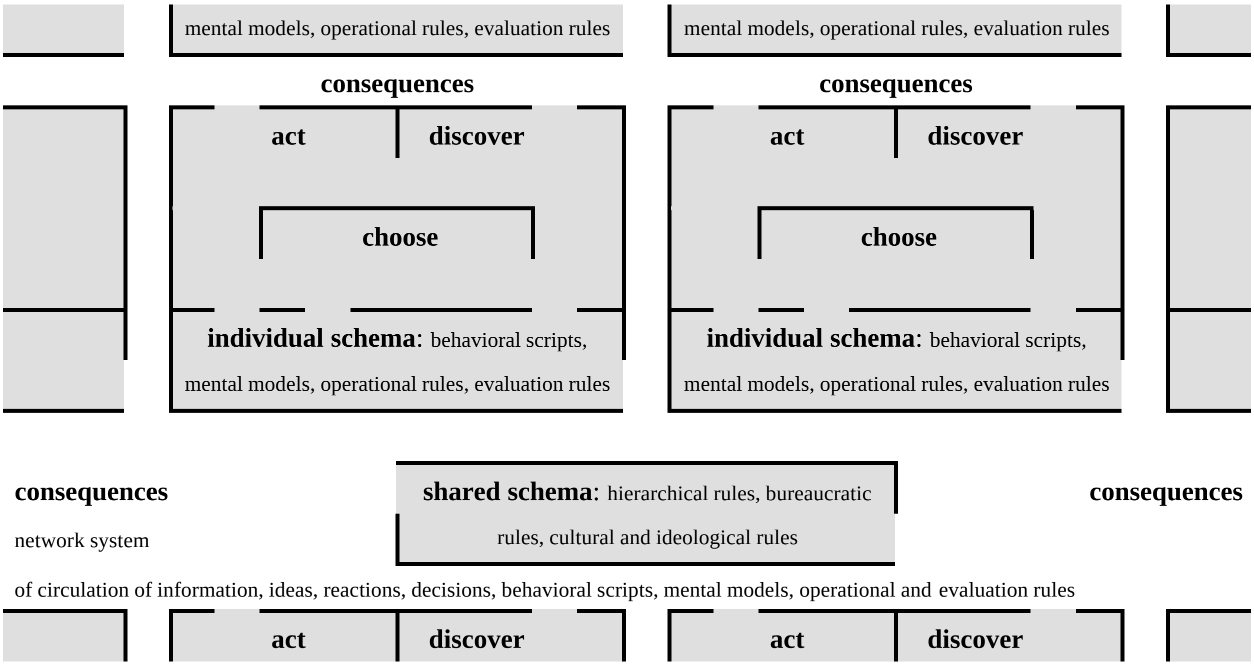
IT: from structured working styles to structured programs for improvisation

Most IT/CA(AD)D applications enforces a structured working style with imposed procedures and often a careless and implicit application of design methods. This results in discouraging effects on people with different designing and learning styles. Styles with their own qualities and often better suited for at least the conceptual phase of design. A phase where conventional design thinking (with for instance predefined libraries of shapes or components) should be avoided. The application of CA(AD)D programs according to some pre-determined method of designing at the beginning of a project obstructs pre-conscious explorations as it is stimulated with manual design sketching. Moreover with the application of preconfigured CA(AD)D, the tendency is perceivable in students to go too fast through the conceptual phase of designing. This is often been done inorder to get more time for modelling, combined with the assumption that fast modification of criticied elements is possible afterwards. But reservations against a structured working style should not be confused with a resistance against structured programs. On the contrary, when a craftsman shows his mastery by playful improvisation, it is based on a sense of structure. But such a structure does not force him or her to follow a pre-determined sequential path of activities. In digital photography for instance, the pattern of pixels of a picture provides the substance upon which the digital craftsman can act. With all the possibilities of filtration and tone scale adjustments provided by the digital photo manipulating program a very clear structure is created to work with, but without some imposed order of operation. IT groups should select (or at least allow) the use of structured programs in alle design studios instead of imposing workstyle restricting applications.

characterisations	**structured working styles**	**structured programs**
allow improvisation	no	yes
allow pre-conscious exploration	restricted	yes
allow all design styles exercised	restricted to structured design style	unlimited
fosters non-conventional thinking	no	yes

IT: from outdated design methods to nonlinear open system processing

Design methods however often suggests the linearity of the assembly line, in which activities builds on each other, with or without correcting feedback loops. Although these processes might be worked out in very complicated flow diagrams of (alternative options for) activities, they are still lineair in principle. In the follow-up of the conceptual design phase, a planning with those flow diagrams might be reasonable. But even the workflow planning in the detailed designing, development and implementation phases should be played down as far as knowledge work is involved. In knowledge work routines are very often upset by new information erupting unpredictable from outside influences or ideas from pre- or subconscious levels of thinking, resulting in the end in very different paths of further development. Where insecurity is maximal, chaotic procedures of information acquisition based on unpredictable chances and events are preferable above systematic methods ignoring contingent information. As such, much knowledge work proceeds nonlininear in perhaps some erratic succession of activities like acting, discovering and choosing (Stacey, 1996), but not necessary in those order. Choosing is based on individual and shared schemes according to formal or actual rules of conduct, while discovering might be based on the perceived consequences of acting in the surrounding world. The figure below shows an organisational (complex adaptive) network system with open permeable boundaries for the simultaneous throughput of two-way information. According to Stacey, the schemas might work in reaction or anticipation. Schemas change individually through learning or evolve collectively through interaction and dialogue. Every acting-discovering-choosing individual has his own experience, inspiration and anxiety, his own conformity and individualism, his own qualities of leadership and followship, his own participating and observing abilities and sensibilities. All this results in often unpredictable, but also self-organizing and creative behaviour of individuals, (in)formal groups or society as a whole. The traditional design methods originated in the era of industrialisation with manual workers as the source of reference. As such it is not well adapted for our post industrialised society with its needs for flexibility as it might be achieved by decentralised organisations, where responsibilities is assigned to the lowest level possible: the empowered, self-managing individuals in a knowledge team (Fisher & Fischer, 1998).



Experienced designers are prototypical for those self-managing individuals as they are working within a broader composed knowledge team of experts and other persons involved (like client, users and governmental representatives) in the creation of an architectural solution. In design studios this type of (experienced) designing is only simulated to a limited extent.

THIRD EDUCATIONAL EXPERIMENTS: shaping architects as experienced bit(net)men

In order to support those (self-managing) experienced designers in their (non linear open system) exchanges with others involved in design-related activities, another form of organisation is needed in the studio with a CA(AD)D environment. That is, a coalescence or cooperation should be aimed for between the bitmanship of IT specialists and the social networked draughtsmanship of actual experienced designers. This is most likely to occur if the representatives of those craftsmanships work together in both, design studios and research and development projects. But unfortunately this is seldom the case and is often even attested by a different status in the faculty. However to realize pedagogically effective and architecturally meaningful experiments, we still need to accomplish just this type of design oriented cooperation.

New pedagogical experiments might also be connected to the legacy of both the Bauhaus and the Beaux-Arts traditions: the Bauhaus tradition with its explicit designer and industry oriented craftsmanships training and the Beaux-Arts tradition with its mutual exchange system of services and training between junior and senior students (vertical organised ateliers).

characteristics	**educational experiments**		
generation	1e	2e	3e
institution	BEAUX-ARTS	BAUHAUS	ECAADE
goal	installing the architect as a experienced draughtsman	reuniting craftsmanship in industrial design	installing the architect as a experienced bitman to match the needs and possibilities of our post industrialised time

epoch	1e ind. revolution	2e ind. revolution	post industrialised		
role of history	important	recent only	depending on the school		
mental span	moderate	small / moderate	expanded, if mental load is reduced		
reshaping	on paper	physical/on paper	virtual on screen		
invention rate	moderate	slow / moderate	fast, if mental span is expanded		
evaluation	estimated	tested / estimated	calculation function		
assignments	mostly public buildings	abstracted	buildings		
main device	pen and paper	craft tools	PC & software	& internet/modem	
workspace	atelier	workshop	workshop	virtual workshop	
worksite	local	local	local	global	
training	draughtsmanship	craftsmanship	bitmanship	(bit)netmanship	
organisation	vertical	horizontal	horizontal	vertical	
teaching	student based	teacher based	teacher based	student based	
proposals	inapplicable	inapplicable	**ABS**	CSCD	**CES**

The Bauhaus approach might be augmented with digital workshops to complement the capabilities of the manufacturing and services industries of our post industrialised time. To that end we should include digital labs with CA(AD)D/CAM, multimedia, VR and simulation facilities adjoining the classical workshops to design, breed, represent, simulate, evaluate and regenerate architectural environments. In order to achieve pedagogical synergy (in the design connected usage of those labs and workshops), to anticipate needs and identify the hard and software obtainable to satisfy those needs, a local collaboration is required between the existing but often scattered groups in a faculty having those facilities at their disposal. With an internet site mediated by ECAADE (with their experience in Erasmus exchange programs), those local groups and collaborations might expand more globally. This creates also the conditions to introduce (on the same global European scale) the Beaux-Arts practice of mutual exchanges of services and training between younger and older students. Educationally, this system is both efficient and effective; efficient, because it relieves the teachers of the bulk of the training and information transmission time; and effective, because students exchange their knowledge, skills and techniques within their own ‘reflection in action’ time (Schön, 1983), on the spot, at the moments they need and are willing to supply them. Older students have still a recent experience of learning pitfalls, how to identify when experienced by others and how to transmit the solutions found to their peers. This vertical setup on a global, virtual scale might compensate partially the horizontal organisation per course year of almost all schools of architecture today. All this provides us with the needed infrastructure to introduce the (already mentioned) proposals for an ArchitecturalBreedingSystem-based ComputerSupportedCooperativeDesign development and the establisment of a CraftExchangeSystem(-ECAADE) internet site.

ABS based CSCD as a digital tool for a 3e generation educational experiment

As mentioned before, one of the most important steps to merge craftsmanship and draughtsmanship into digital craftsmanship was accomplished with the development of the first Graphic User Interface at Xerox PARC in the seventies. The GUI was directed towards the needs of (among others) the experienced designer. In the same vein, the development and application of morphogenetic computing (with ABS, Architectural Breeding Systems) merges the craft based abilities of man and computer in a complementing way (with computers performing calculations and visualisations and the experienced designer performing selection tasks based on pattern-recognition, pattern-building, pattern-discovering and pattern-appraisal).

Some differences in CSCD	**CA(A)D related**	**ABS related**
ShortTermMemory load	high (lots of in between actions)	low (only selection actions)
ease of handling	difficult (shape construction)	easy (selection of next generation)
interaction level	high (to generate a shape)	low (to select a shape)
chunking	needed (to shape and evaluate)	eliminated
processing attention span	high (to shape and evaluate)	low (automated in software)
LongTermMemory support	surplus of help functions	database of shape/meaning fields
rate of generation	one at a time	a whole range per generation
applicable design strategy	depth first only	both depth and breadth first
evaluation	per designed model	per breeded generation of models
routine training	needed	eliminated
iconic representation	input needed for evey alternative	automated
shape generation	by hand line after line	by the software
analogic representation	sometimes present	by matrices
evaluation function	symbolic defined	analogic defined (with matrices)
symbolic representation	present	translated in analogic representat.

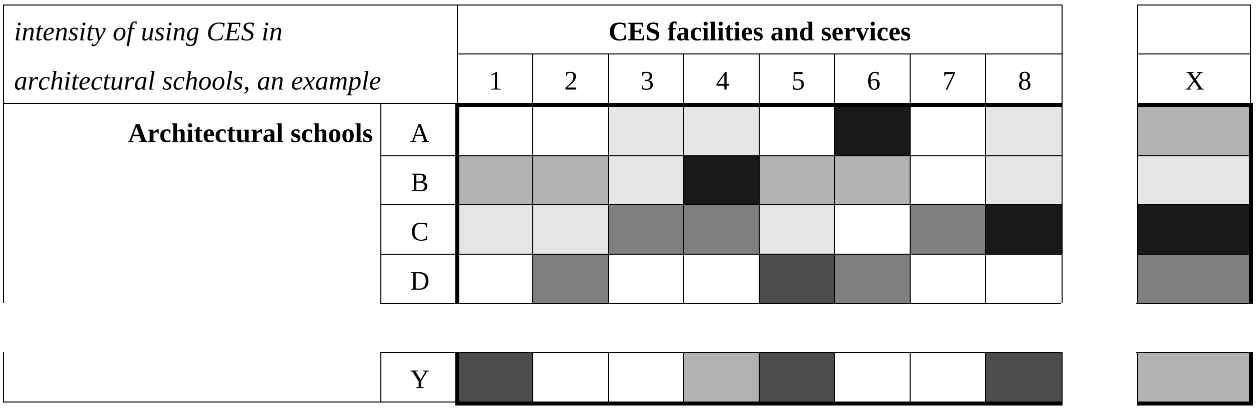
Because (and in contrast with design sketching) everybody in principle is capable to perform these exploratory and appraisal tasks (of selecting and navigating through an immensly large combinatorial solution space) without special training, this opens up the possibility of a real effective CSCD: Computer Supported Cooperative Designing. Unlike CSCW(ork), where a workbag full of (PhD) tested tools are already developed, Computer Supported Cooperative Designing is rather underdeveloped. This might be attributed to the deployment of CA(A)D tools. As already discussed, no really effective CA(A)D substitution of the hand design sketching tool is known yet, and possible surrogates like tablets are not widely used in practice. The development of ABS's (Architectural Breeding Systems) might change these weak spot of Computer Supported Cooperative Designing. With a Architectural Breeding Systems type of Computer Supported Cooperative Design, the power and knowledge of many individual brains might be used to generate a conceptual design. Together with the facilities of the internet, the power of one distributed mind might be tapped from many individual brains all over the globe working together, both in sequence and simultaneously. This might be linked up with general or specific virtual studio design(sketching) projects within an ECAADE wide network. But now inspired and motivated by the new possibilities as revealed in a reconditioned digital version of the design sketsch medium.

CES as an internet based tool for a third generation educational experiment

While Architectural Breeding Systems developments might push the establishment of Computer Supported Cooperative Design, with a Craft Exchange System a more general objective is intended. Not only a learning by doing or by communicating about desirable selections between alternative shapes is meant to be, but also a student centered learning approach about all skills and x-manships involved in analysing, designing, presenting and evaluating (architectural) asignments. With a Craft Exchange System, the student centered learning might be about giving, getting and using advice and services not yet available or mastered enough to apply it by someone self within the time left to finnish an asignment. But with a Craft Exchange System even a more general didactical goal might be aimed for: to get people away from their exclusively centralised mindset (Resnick, 1997) as a legacy of the Newtonian world view (assuming direct linear causal relationships everywhere), in favour of the new views of the world with some feeling for complexity and chaos related phenomenas, with emerging properties and self organisation, instead of assuming in advance and everywhere wilful agents as an explanation.

Possible, but arbitrary examples of CES services
- documentation about locally obtainable design precedents,
- scale models produced with a locally available special (for instance lithographic based) machine,
- hard end/or software expertise, locally available and applicable for special applications
- a special effect rendering of a CA(A)D model,
- a special calculation needed and locally available somewhere,
- a special software module, to be written in an (un)usual programming language,
- ideas to solve some stated problems,
- making an arrangement to stay somewhere and to visit some people or institutions,
- and so on.

A Craft Exchange System is meant to establish a site as a marketplace for services and facilities between architectural students, their teachers and administration / management bodies on an ECAADE wide level. Because (design) students have more time and special skills to bid, then money available to spent for the same purposes, an exchange of services and facilities without EMU-money involved should tried out as well. Moreover, with those skills or x-manships of students, rare, expensive or otherwise not widely available facilities (on some or other architectural school or university) are then accessible free of charge by more people from elsewhere. A Craft Exchange System is in principle an instrument for differentiation, to exploit valuable and available specialties. But for its establishment, it needs some integration and coordination by moderators or correspondents recruited from ECAADE members, able to develop and maintain a suitable Craft Exchange System site. A Craft Exchange System might in due course evolve and incorporate a variety of people, services and facilities up to disciplines and professions far away from architectural design. But this should not restrain us from starting such a bottom up and in the end, self operating system. A system well suited for the formation of vertical organised virtual units with students of all years participating in one and the same, virtual design studio. This will complement the (mostly top-down organized) local educational system with its design studios populated by students of the same year.



Conclusions

Although in our time we have seen the emergence of bitmanship or even (bit)netmanship in general and in Computer Aided Drawing and Modelbuilding in particular, we have not witnessed the same bit(net)ship emergence in architectural conceptual design. CA(AD)D is still too slow to keep up with the stream of ideas as hand design sketching is very capable of. And CA(AD)D still has no other new features to beat hand design sketching in another way relevant for conceptual design in architecture. CA(AD)D brings about too much mental load in steering the program, without broadening the mental span through a faster production and/or evaluation of alternatives.

In this respect the Beaux-Arts and the Bauhaus offered more real innovations in their time. The Beaux-Arts made designing more effective and design teaching more efficient. Designing was made more effective by favouring draughtsmanship over craftsmanship and therefore broadened the mental span. Design teaching was made more efficient by involving the students in the teaching process (student centered). By bringing together students of all years of the study in one and the same atelier, younger students could learn from the older ones, making it sufficient for one teacher to coach aproximately hundred students. The Bauhaus experiment was more mixed in its results. On the one hand it tried to adapt the teaching context and content to the new requirements of the mass producing industry by design asignments related to industrial production and more to the point by reintroducing craftsmanships lost in industry, as the most important training of design skills. On the other hand the grouping of students horizontally per course year was less efficient in teaching and less effective because the mental span was narrowed by the reintroduced craftsmanships training and the abstract, low complex artistic asignments in the basic course year.

In order to evade the accumulation of mental load and simultaneously to broaden the mental span, two proposals are made as a follow up of the still actual parts of the Beaux-Arts and Bauhaus ideas:

• an Architectural Breeding System (ABS) as a more promising tool for conceptual design in architecture, both individually or cooperatively and locally or globally used as an Computer Supported Cooperative Design (CSCD) device, and

• a Crafts Exchange System (CES) as an internet site to make globally possible vertically organised virtual design studios as a counterbalance of the horizontally (per course year) organised local design studios of the architectural schools or departments.

ECAADE with its European wide membership and (among others Erasmus) experiences might be the right agency to promote and support such proposals. Architectural Breeding Systems experiments to be used as a Computer Supported Cooperative Designing tool and a Craft Exchange System with the capacity to grow into a much wider self organising system of services and facilities.

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