

# ICT as a means of education.

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*ICT and architecture are often viewed as separate subjects, that can also be taught separately. If the goal of teaching is to produce learned designers, then it is necessary to combine both issues into a single course. The paper presents the innovation of a traditional CAD course that suffered from decreasing results. We present the problems identified in the existing course and the measures taken to reorganise the contents and didactical approach of the course. The paper focuses on the innovation of the course by the introduction of information and communication technologies (ICT) both in the contents of the course and as a means of education. Abandoning printed images as the result of students' work, the new course required students to create a web page to present their efforts on architectural design, modelling, and visualisation. This had a beneficial effect on the students' attitude and enthusiasm for the course. It also allowed better planning of the course in terms of computer-facilities. The innovated course shows how, when taught in combination, ICT and architecture can strengthen each other.*

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## **Introduction**

Teaching CAAD is invariably a combination of computational issues and architectural issues (Achten 1996). However, a balanced approach is often difficult to achieve and courses typically have a focus on either one of these aspects. It is general practice to teach basic computational issues and basic architectural issues in separate courses, rather than combining both issues, for example, in a CAD design studio (De Vries, 1997). This paper presents a course that mixes computational issues and architectural issues which has been running for some time, but has encountered problems with a diminished number of students achieving the end of the course. We present an innovative approach in the computational issues to address this problem, which can also shed some light on the balance between both types of issues.

## **Description of the course contents**

The course is called 'Presenting Architecture with CAD' and is lectured to all second year students of the faculty of Architecture. This includes students that will choose, later in their study, to graduate as an architect or urban planner, but for instance engineers in building physics, construction, structural engineering, and real estate management as well. The course aims to teach students the insight and skills needed for modelling and presenting a simple architectural design using CAD software.

The computational issues in this course are centred directly on the usage of the software. For the modelling of the design, AutoCAD<sup>1</sup> R13 is used. The design is not first sketched on paper, but directly modelled using the CAD software, in 3D. This involves controlling the techniques of solid modelling, including boolean operations, and manipulation of the model in 3D space. The presentation of the design is done using 3D Studio<sup>1</sup> R4, importing the AutoCAD model and applying materials to its surfaces. The focus in this part of the course is on the application of coloured light-sources and the usage of camera position and properties to create different perspectives and ambiances for the architectural scene.

The architectural issues in the course (Dubbelman, 1996) concentrate on aspects of form and composition (Ching, 1979). In the design of the composition, a choice of the following principles of ordination are to be kept in mind by the students:

- ❖ Symmetry, dis-symmetry, or asymmetry;

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<sup>1</sup> AutoCAD and 3DStudio are trademarks of Autodesk.

- ❖ Size and proportion, based on a grid;
- ❖ Expression of gravity, visual inertia;
- ❖ Dominance or co-ordination;
- ❖ Human and overall scale;
- ❖ Rhythm and harmony in solids and voids, using a grid;
- ❖ Dynamic direction in the composition.

These principles are to be used as guidelines during the design process itself. Also, the presentation of the design should focus on expressing the selected principles, using the computer tools as the means to support this expression.

### **Summary of the problems encountered in previous years**

In the academic year of 1996-1997, the course suffered from unacceptably high number of students failing the course. The results of the work done by the students was in itself not unsatisfactory, but only a very low number of students finished and handed in their work by the end of the term. This was the main reason for the evaluation of the course contents and the approach of teaching followed, at the end of that year. Also, re-organisation of the teaching staff made this a good moment to redesign the course.

From enquiries with the students and the lecturer involved until that year, it could be concluded that the following problems formed the main causes for students not to complete the course:

- a. The design task appeared to be rather abstract. One of the requirements to achieve the principles of ordination in the design, for example, was to use the Golden Section for measurement and positioning of the composition, which students felt difficult to apply. Also, students felt overwhelmed with the requirements of creating a design on the basis of these abstract principles, especially in conjunction with the application of new tools and techniques to model and present their design.
- b. The whole of the second year of students showed a large variance in computer skills. Some were already quite experienced, but a considerable group was incompetent in using computers, and especially newer software, at all. Some students were not much acquainted with the Windows<sup>2</sup> operating system. Many had forgotten most of the introductory course on using CAD they followed in the first year, which in fact is more than one year before the start of this course.
- c. The course is granted only a minimum number of points in the total amount that are to be gained throughout the second year of the curriculum. The course was to be completed by handing in the work on the design, modelling, and presentation at the end of the term. This leads to the situation that students are not very disciplined to complete the course in the appropriate term, especially when the pressure increases from other courses that have a higher weight in the total of the second year.
- d. The amount of students in the second year is normally around 170. This number is too high to provide students with individual facilities in tutored laboratories. The available facilities therefore need to be used by students in groups of two, while the hours of contact with the tutors is limited to two per week. Especially creating the output of the modelling and visualisation of the design on A3 plotters formed a major and time-consuming problem.
- e. The way architecture is taught in general in our curriculum, with paper as the main medium to be used during the process of design, stimulates students to think in 2 dimensions. Making scale models in wood or foam of course does help to develop 3D insight, but the main way of thinking about architecture remains in terms of plans and elevations. The transition from thinking in 2D to designing immediately in 3D appears to be hard and may even block creativity rather than stimulate it.

Some of the above mentioned problems appeared to be too profound, either to be solved within the space of time given before the new course should start, or to be solved within the scope of this course at all. For instance, the problem of students being computer-illiterate could not be solved before the start of the new course. However, the planning and approach of the new course should very well take all of the above problems into account in order to gain acceptable results. This led to a set of measures to be taken in the implementation of the course, which are described in the next two sections. Besides these more obvious measures, innovative use of ICT in the course was implemented which is described in the subsequent section.

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<sup>2</sup> Windows is a trademark of Microsoft.

### **Summary of proposed measures**

Solving some of the problems described above was approached by restructuring the contents of the course and its exercises, and a redesign of the lectures in the way information was presented. These measures are summarised below and explained in more detail in the next section.

#### ***problem***

Design task too abstract

Variance in students' computer skills

Undisciplined attitude of students

Insufficient computer facilities

Thinking in 2D rather than 3D

#### ***proposed measure***

Reduction of the complexity of the design task, allowing more time for the relation between the design task and the usage of the computer tools.

Explicit attention in the exercises to basic computer skills. Planning of the exercises and provision of tutorials in a way that stimulates self-study.

Stepwise exercises with deadlines throughout the term. A stepwise approach in the exercises also helps students to better grasp the total body of new knowledge offered in the course.

Avoid the necessity for printing and plotting the output of the exercises. This reduces the amount of time required for the exercises and thereby increases the efficiency of the available facilities. Also, if printing and plotting is not required, students can use their home-PC if available.

Stepwise exercises that allow the students to slowly make the transition from 2D thinking to 3D thinking. Introduce the approach of 3D modelling gradually so that it becomes an automatism in a new approach of 3D design.

### **Implementation of the proposed measures**

Since the aim of the course is to teach insight and skills of how to use computer software in architectural design, it was decided that the complexity of the design task itself should be reduced. The application of the Golden Section as proportion system in the design was abandoned, releasing the constraints put on the design task and giving the students more freedom in their design.

This reduction in the complexity of the design task allowed us to give more attention to the relation between the design task and the usage of the computer tools. This relation forms the basis for the lectures that are given in a collaboration of the CAD-teacher with the architecture-teacher. The architect explains the theory on architectural design principles and for example some theory on light and colour, demonstrating and illustrating them using traditional media such as overhead projector and slides of for instance example buildings. This theory is presented in short sessions of about 10 minutes, each of which is followed by a session on the usage of computer tools, demonstrating how the design aspects just presented can be translated into activities in the computer environment. In this way, computational and architectural issues are presented as intertwined, not separate, making it easier to grasp their interrelationship. A typical sequence of such sessions is shown in the scheme of figure 1.

The problem of students having so many different levels of computer skills led to the conclusion that the exercises should be divided into steps. This helped students in many ways: firstly it offered them the opportunity to first exercise the basic skills of using computers in general, while gradually moving towards the more advanced techniques required for the actual exercise of the course. This means that exercising the basic computer skills was made a part of the total of exercises, thus ensuring that lacking

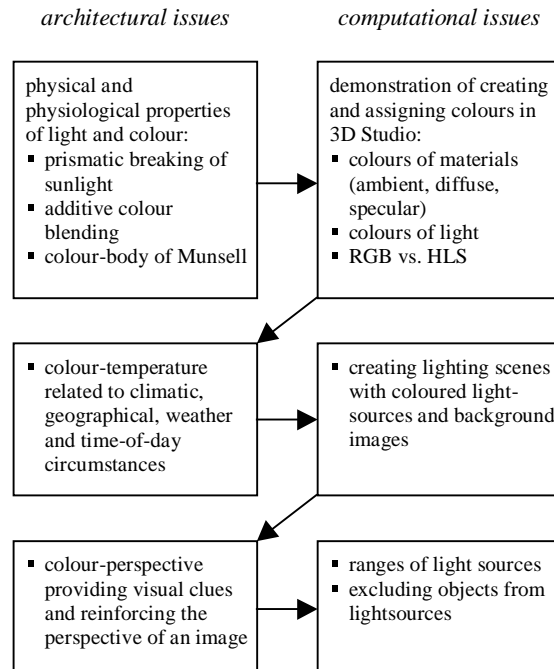


Figure 1 Example of a sequence of sessions in lecturing theory on presenting architecture and in instructions on the practical application of computers for this purpose.

these skills would not keep any of the students from continuing with the course. The stepwise approach in the exercises allowed the more advanced students to move quickly through the easier parts and focus on the main exercises. Secondly, dividing the practical part of the course into different exercises helped student to get used to thinking in 3D. The first exercise focused on making this transition from 2D to 3D modelling, thus resulting in a situation that all students after this first exercise achieved the approach of 3D thinking. Finally, since the exercises had deadlines by which the results were expected to be delivered, this helped students to moderately move through the exercise in a disciplined manner, feeling less tempted to leave all the work for the end of term or postponing completion of the course altogether.

The main bottleneck in the exercise of the course as practised before, was the printing and plotting of the resulting work in the final presentation by the students. This resulted in a situation that virtually all students were dependent of the facilities provided at the university's computing centre. Also, the printing and plotting consumed a lot of time from the total exercise, which increased the problem of dependency of printing facilities. This problem was approached by finding an alternative way of presenting the final work of the exercises, using Internet and email. Together with other indications that these new ways of communication could help develop the course in a positive manner, this led to an innovation of the course, which is described in the next section.

### **Innovation of the course through the application of ICT**

Several of the problems and related measures described in the sections above, led us to believe that an innovation of the course, introducing modern information and communication technologies (ICT), could enhance the value of the course, the results of the students, and therefore the results of the course itself. The motives for introducing ICT in the course are briefly described.

The variance in the level of computer knowledge of students requires that the study-materials for the exercises be provided to them in a way that stimulates individual working. During the complete term, for two hours per week computers are reserved for the students to work in a classroom with tutors giving support where necessary. For those students who are not very experienced in working with computers,

this may not be enough, while for many others the tutored classes are not a necessity, other than because of the need for computer facilities not otherwise available, such as printing and plotting. This means that the tutors' time could be more efficiently used if the requirements of the computer facilities could be met in an alternative manner.

Since printing and plotting formed an important bottleneck in the process of completing the works, it was decided to remove this aspect from the course. An important issue to support this decision was that other means of communication, such as email and the world wide web, are now widely available and becoming increasingly important also in the daily practice of architects and other designers. Internet and email today form a major means of communication in many fields of research and industrial practice. We realised that it was time to also introduce these media in our courses, not in the least because the University of Eindhoven has decided to provide all first year students with a notebook computer. This important step in the direction of digital support of education requires that students are made acquainted with the new tools and especially with new media of communication. Since several years, at Eindhoven University all students have access to Internet and email through the computer facilities at the university. However, with the advent of the notebooks, the factual usage of ICT is likely to grow considerably.

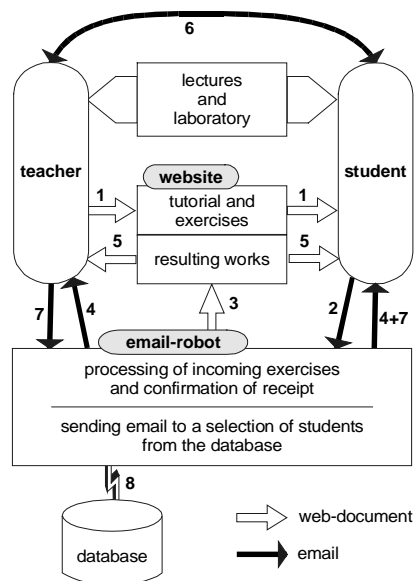


Figure 2 Communication-lines between teachers and students after the introduction of ICT in the course.

For our course, the introduction of Internet and email means that an important part of the communication between lecturers and students now takes place by means of these digital media. The consequences of this for the communication lines between teachers and students are shown in figure 2.

Referring to the numbers in figure 2, the communication between teachers and students follows this path:

The study-material to be used during self-study and exercises is made available through Internet (1). Most of the tutorials are accessible only on Internet. The student works on the exercises and sends the outcome of this work via email to a specially devised email address for this course (2). The email is received by a so-called email-robot, that automatically receives the messages (looking every 60 seconds for incoming mail) and processes what it receives. The robot processes the exercise of a student into a web page which is then added to the web-site of the course (3). The students' works are displayed without their names (unless specifically added by the student) to ensure anonymity. The robot also replies to the student, confirming that the work has been received and returning the URL of the student's work on the Internet. Also the teacher is notified that the student has successfully submitted the work (4). If any problems arise during the communication so far between student and email-robot, the robot will try and react appropriately, notifying both student and teacher what problem has occurred and how this can be solved. All activities of communication are logged into a database (8).

After the work has been put on Internet, both teachers and students can now browse through the work of the exercises (5) and discuss them in lectures and the computer laboratory, or communicate by sending each other email directly (6). For sending email to students, another tool is available for the

teachers. Because all information regarding the students, their work on the exercises and the communication activities is available in a database, the teacher can select students on various criteria and send messages to a particular group of students (7), for instance regarding the progress of the work or repeatedly occurring mistakes or problems in the exercises. In this manner, after the second exercise groups of students were sent some hints and issues of attention on how to improve their model so that the end-result would reach a higher quality. After the third exercise, however, it was chosen to communicate to the students via email directly (6), because more personal remarks were appropriate.

The assessment of the course was done by the teachers while simultaneously browsing through the students' works. The grades were entered into the database, sent to the students by email, and anonymously displayed on Internet as well. Unlike the assessment of other subjects where examination takes the form of, for instance, multiple choice questions, the assessment of creativity in CAD courses cannot and should not be automated.

### **Effects of the course innovation**

With the introduction of ICT, the course has benefited in many ways. These findings are supported by the results of an enquiry held among students at the end of the term.

The bottleneck of printing and plotting the work in the computer laboratory was eliminated from the process, resulting in a more efficient usage of both time and computer facilities. It also allowed students to work at other locations than those where the plotting devices could be accessed, for instance at home. Working at home was also stimulated by the availability of all the course-materials on Internet, and the possibility to communicate with teachers via email. This option was used by many of the students. For the teachers, using email to contact students was an important means of communication, especially with those students who never attended lectures or classes in the computer-laboratory. In this manner, the attention of the students could be drawn to apparent problems in their work; they could be stimulated to finish their work in time, and tutored in groups or individually. Without the usage of email, students working at home are the ones more likely to drop out or fail the course, while in this approach a majority of successful students hardly visited the computer-laboratory at the hours reserved for this course.

The stepwise approach of the exercises worked out well in that the students progressed through the exercises at the speed that best suited their level of knowledge and skills. The purpose of the exercises was more easily understood, allowing students to gradually develop the desired skills without being overwhelmed by an abundance of new techniques and methods in design. Again, this stepwise approach was strongly supported by the availability of course-materials on Internet and email-communication between students and teachers.

Displaying the results of the students' work on the exercises on Internet had a very nice influence on their commitment to the course. Seeing their own work on display for the whole world not only stimulated to be part of it, but also to try hard to perform well. Their work could easily be viewed in the context of the work of their peers, which had a healthy competitive effect. Displaying the work on Internet was a direct result of the students' effort. The email-robot is active 24 hours per day, so the feedback to the students is immediate. This also supported the efficiency of putting deadlines on the stepped exercises: failing the deadline now becomes very visible on the net. Another effect of the web-site with resulting works was that during the term an automatically growing exhibition was built up.

The usage of email and Internet was rather new to many of the students and appeared very interesting to them, contributing much to their enthusiasm towards to course. However, for many students using email and Internet also became a necessary part of the learning process. This was anticipated in the definition of the exercises, because the purpose of the first exercise was to practice just how to email text and images and find the results on the Internet. Therefore, although emailing the work replaced the elaborate task of printing it, this did not result in a reduced workload for the students. Yet, acquiring these skills of using email and Internet was experienced by the students as being instructive, very useful, and relevant for their study and future practice.

In conclusion, the result of the course in terms of the number of students who successfully completed the course as a percentage of the number of inscriptions to the course, approached 80% in the academic year 1997-1998, in strong contrast with the previous years when this percentage dropped to a mere 25%.

### **Discussion**

The introduction of ICT as an integral part of our CAD courses has proven to be very useful in the sense that (1) it makes following the course more independent in space and time, while (2) stimulating an intensive, yet non-laborious communication between teachers and students; (3) it introduces a new,

relevant, trendy, and interesting aspect to the traditional area of computer aided design; (4) it works as a didactical aid not only as a means of communication, but in particular as a means of displaying students' work and stimulating an active participation in the course.

Yet, the introduction of ICT, in our view, does and will not replace the need for lectures, demonstrations, and tutorials in a computer-laboratory. The effect of the direct, and personal, form of contact in lectures and tutorials is essential for an introduction to the more deep transfer of knowledge that is achieved using media like paper or digital media. This has become very evident in the many computer-demonstrations during the lectures on how to use the computer-tools in the course's exercises. A live demonstration with interaction between teacher and students boosts the level of insight of students before they start working on the exercises. Also answering questions and ad hoc problems while reaching a large group of students can best be done during lectures or tutorials in the computer-laboratory, rather than by email or Internet. These findings are confirmed by the fact that the students kept visiting the lectures in high numbers, despite the availability on Internet of *all* information including the answers to ad hoc questions. Apart from this, it's much nicer to lecture in classrooms than to lecture on Internet. Therefore the usage of ICT should be seen as a valuable addition to the more traditional, didactical means, which surely is applicable to many other areas of education.

In this paper we described an innovative approach to teaching a class that combines architectural and computational issues. The course shows how the combination of ICT and architecture can forcefully enhance understanding of these aspects. We propose that a successful learned designer is only possible when he has mastery over the medium he is using. In the case of this course, the medium is ICT, and more specifically, CAD software, rendering software, and communication technology. The strength of the course lies in the combination, making students aware how to achieve, understand, and express architecture with the use of computer tools. The challenge of future courses lies in further developing this relationship.

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For the course tutorials, visit: <http://www.ds.arch.tue.nl/education/courses/7u253>

For the course results, visit: <http://www.ds.arch.tue.nl/education/courses/7u253/results>