Strategies for CAAD education - the Singapore way
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For over one year (1985/86) the author was as senior lecturer instrumental in developing and initiating a caad-curriculum at the Singapore School of Architecture. The paper describes the circumstances surrounding the aquisition of the Schools' large cad-system, the caad-curriculum proposals, and the first pilot courses. On the basis of this preliminary experience some observations for caad-teaching are made, which are related to more universal strategies for caad-education.

Singapore

Singapore is an independend island of 581 km² and approx. 2.5 million people. That is a density of over 4000 inhab./km², 12 times that of the Netherlands, 2100 times that of Australia. While it does give the visitor the impression of being very green and fertile, not at all the concrete jungle he may expect from the density numbers, there is hardly any agriculture. In fact, for practically all its commodities, including drinking water, it is dependent on imports. Thus the trade balance determines if people thrive or starve. The government uses every opportunity to bring that message home to the population. Politics are completely economy-dominated.

Because of this dependency on trade and its size Singapore is very vulnerable. At present its economy leans largely on only a few market sectors: harbour services, oil refining, banking services and electronics manufacturing. None of these are very stable. The government is more than elsewhere pressed to look ahead for stabilisers for its future economy. It believes to find these particularly in ensuring a good communications infrastructure, establishing a highly educated population, and being a forerunner in Information Technology.

IT receives a high priority. Studies have shown IT to become a US$1,000 billion revenue industry by 1990, influencing 30% of world GDP. It has a projected growth of over 10% p.a., and indicates to be a key technology in improving business efficiency and labour productivity, and in generating new businesses. Those that lag behind in exploiting IT will be unable to compete. Compared with its neighbours, Singapore is no longer a low labour-cost country. So its manufacturers are urged to exploit IT to reduce the labour content of their manufactured goods. For Singapore it is not so much a matter of whether you believe in IT, but simply to grab its
share before someone else does.

Singapore also realises that while the major impact of IT will be to raise efficiency and productivity, IT should itself be a growth industry. New IT products, such as optical disc drives and customised chips, are constantly being developed. These are high value-added products. Especially early in the product life cycle, when prices are high and volumes relatively low, manufacturers will look for production bases which offer quick start-ups, a workforce that can be trained up quickly, and a good infrastructure for the use of sophisticated technologies (Wong, 1986).

A good IT-strategy thus includes continuing to improve telecommunications facilities, develop IT-professionals, and through education establish an IT-culture, i.e. to overcome the resistance to change.

It is in this climate that in 1985 the School of Architecture of the National University of Singapore learned, that they might put forward a proposal for an educational computer-installation, and that it would not be considered unreasonable if that was priced over a few 5$ million.
The Singapore School of Architecture

The National University of Singapore is the largest of Singapore’s two universities, and the only one housing a Faculty of Architecture and Building. This Faculty consists of two separate departments: the Department of Building and Estate Management (incorporating the former Department of Building Science) and the School of Architecture. The Dept. of BEM is only loosely related to the School of Architecture and has its own computer equipment (a.o. a Prime mini and Apollo workstation). So far both departments are exploring entirely separate computer strategies. This paper further only relates to the School of Architecture.

The School of Architecture houses approx. 400 students and 40 staff, divided over five years of study. It is a two-tier system, with a first three years Bachelor of Architectural Studies (BaAS) degree, than a Year Out with a minimum of eight months practical design work, and then two years for a Bachelor of Architecture (BArch) degree. The School has further options for MArch- and PhD-degree study but no set courses. Few only take these options and never in direct continuation of the BArch.

The School supports a linear teaching system largely based on U.K. architectural university teaching. Students are strictly grouped by year, follow the set program for their year, and are assessed to pass or fail at the end of the academic year. During the year all students follow largely the same programme simultaneously. If they fail a subject they may repeat it next year, if they fail too many they have to repeat the entire year. This teaching structure contrasts with the credit system prevalent in U.S.A. and many European countries universities (eg. Delft Technological University). Credit system teaching tends to be more unitised, with various unit options possibly available more than once a year.

The Singapore School of Architecture is the only architectural education in Singapore. Therefore it has one overriding objective: to supply the state with the architects it needs. The flexibility that many architectural educations in other countries enjoy, to formally or informally support other educational end-results, is not entertained in Singapore.

The Singapore School of Architecture has another noteworthy feature: it harbours no or hardly any specialists. Almost all staff spends most of their time teaching studio design. Consequently there is f.i. no specialised computer teaching staff. At the same time many ordinary design teachers are encouraged to acquire teaching effluence with caad.
The Schools' Computer System

In the second half of 1965 the School was allowed to tender for a cad-system for teaching. A 22-workstation system was specified, with plotters, digitiser, scanner, video-camera and video-projection facilities. The budget was 5£ 2.6 million, at that time almost Dfl. 4 million. It was to be a full colour, fully 3-D system, and easy to learn. The tender procedure has been described elsewhere (Leslie, 1986). The final system choice for Intergraph was primarily based on the fact that at that time, it was the only system within the tender requirements which did not show incapable of providing sufficient local vendor support. Also the fact that a number of large public construction organisations among which the URA (Urban Redevelopment Authority) and the Public Works Department had Intergraph systems played some role.

The system aquired consists of 22 Interpro32 single screen workstations, each with 1Mb RAM and 20Mb hard disk. The workstations are linked through an Ethernet LAN to three MicroVAXII's, each with 674Mb hard disk and a tape unit. Also on the network 3 plotters: an HP 8-colour A0-size penplotter, a Versatec A1-size b/w electrostatic plotter (meant to obviate the need for screen-dump hardcopy units), and one idem colour plotter. Note these 3 plotters together consumed approx. 15% of the budget. One of the workstations had an attached video-projector for classroom-size projections. The digitizer, scanner and video-camera had to be deleted from the shopping-list for budgetairy reasons.

All available Intergraph architectural software was aquired, including the production drawing package (APDP), 3D-modelling package (AMOD), facilities management (SPFM) and clustering software (STPL). Although the Interpro32's can function as standalone UNIX-V and MSDOS workstations, no software was aquired using that option. AutoCAD was tried out, but performed disappointing on the Interpro32. ABACUS' GOAL software was succesfully run on the MicroVAXII's, but not used in the first year of operation due to deficiencies in the Tektronix emulation of the Interpro32.

Alongside the Intergraph system, from seperate budgets, the School also operates 12 IBM-XT-compatible PC's and 16 Atari 520 ST's with mouses, 6 A3-digitisers, 6 A3-penplotters and 3 printers. Although the micro's could be hooked to the MicroVAX's, such connection was not feasible considering the price of the Ethernet nodes.

While a decentralised setup was considered ideal, for practical purposes the system and all workstations are located centrally in the "Computer Suite". This room has,
with special computer furniture, been furnished as a model caad-workplace.

The system was installed in March 1986, after a two months' delay. Operational use was further delayed until May, due to problems with the plotters, which as it turned out could not be hooked up according to tender specifications, and the video projector which could not be made to focus properly. The first regular courses started in July 1986 (in Singapore the academic year starts in July). By January 1987 16 staff and approx. 140 students, or 30% of the Schools' population, had received introductory courses (of typically one full week duration).
Objectives Intentions and Aspirations

Teaching potential, objectives and implementation strategies were spelled out extensively, as well before the system was actually in operation (ao. Tan, 1986) as after the first term of experience with the system (Schijf, 1986). Main items directly relevant for the caad-curriculum planning were:

- The quantitative justification of the specified system was an estimated 1040 hours/week workstation-demand during term, with on a workstation availability of 12 hours/day and 75% utilisation factor. This was ac. based on the projection that year 4 and 5 students will do an average of 35% of all their drawing on the computer.

- The objective to exploit the variety of potential roles of computers in the School, such as:
  - A vehicle to obtain computer literacy (to know how to work with computers and to understand their widespread impact).
  - An additional working tool a.o. for appraisal and 2D/3D viewing (complementing drafting and model-making).
  - A communications medium.
  - A vehicle for simulation of office automation.
  - An instrument in educational technology (including computer aided learning).
  - A research tool as well as a research subject.
  - A facility for consultancy.
  - To build up the computer culture step by step, introducing caad in a low key, least disruptive manner.

- To build caad into conventional courses where possible.

- The notion that the computer can serve to prepare students for possible new roles architects may play in the building industry, including:
  - Changes in the way the design coalition is coordinated.
  - Increased emphasis on information handling and data banking.
  - Involvement in such areas as facilities management and life-cycle costing.
- Increased emphasis on design decision justification using appraisal and simulation systems.

- Changes in the relation between architect, consultant, builder and client.

- Further specialisations in building design, manufacture and management.

- To train students in the use of computers to make architectural design considerations more explicit, informed and rigorous and to give greater scope and balance to the more traditional aesthetics issues. To train students who can harness the computer both as a design tool as well as a medium of communication with other professionals in the building industry.

- To establish a comprehensive computer curriculum by 1990.
CAAD building blocks

Architectural design must be taught by doing. Studio design projects are central in teaching architecture, consequently CAAD-PROJECTS are central elements in the CADCURriculum-planning. At least one studio design project (option) with a caad-component is planned for each year. In practice this means that within the given studio schedule allowance must be made for the extra time it costs to use caad (up to 3 times slower than manual) and incentives should be given for caad-design submissions eg. by waiving certain conventional requirements if compensated by relevant and good quality caad-use.

Lectures and seminars are the secundairy elements of architectural teaching. As specialists tend to overrate their own specialism, in almost every school of architecture this element is too large in comparison to the time available for studio design and design exercises. However, lecture and seminar courses are potentially major computer users. There is no lecture or seminar subject which could not benefit from caad in one form or another, and this is certainly not restricted to technological subjects only (see appendix). As there is no universal recipe for computer-use in lectures and seminars, as a second CADCUR building block socalled CADLAB's were proposed for each year. The CADLAB is simply an afternoon or a few days in the week, when assistance is specially available for all computer needs of a specific year. The person(s) assisting should therefore be well-aquainted with what is going on in that year and may need to actively promote cad-application in specific lecture and seminar courses. The CADLAB can of course also support computer use in studio design, particularly for students wishing to use caad in other than the CAAD-PROJECTS.

Caad cannot escape the need to also claim at least one special lecture/seminar course each year. Although such need may eventually fade away when computer-use, including computer graphics, is comprehensively taught at pre-university level, but at present there are a number of issues and skills which are more effectively taught as lecture/seminars than as part of studio design. The third CADCUR building block thus is one or more CAAD-COURSES for each year. Typically each such course has a workshop character and is tailored to fit in normal lecture and seminar course slots with its subject and level related to the respective year (see appendix).
Caad-levels through the years

The appendix describes how each special caad-course can be inserted in each year. It also shows how in each year progressively specific aspects of caad are highlighted:

- YEAR 1 concentrates on graphics, visualisation and modelling. Graphics relates to manipulation of basic form, colour, text, and how to set up a drawing. Visualisation emphasises the information and communication aspects of design. Modelling refers to the notion that cad is not about making drawings but building a comprehensive digital model related to the design project.

- YEAR 2 emphasises modelling and integration. The modelling skills are furthered by experiencing what is implied when a model is made to progress from early design through to final design. This touches on aspects of integration with the realisation that all design considerations are related to the model, and that all drawings are subsets of it.

- YEAR 3 elaborates on modelling, simulation and appraisal. This implies the use of models to test the performance, visual as well as functional, structural, environmental and economical, of the design. A usefull side-effect of this endeavour is that caad thus presents itself as the integrator of the various specialisms in architectural design and design teaching.

- YEAR OUT focusses on two aspects of caad seperately: cad-production drawing and space planning / facilities management. The former as that may make the student extra attractive for a design practice during his year out. The latter because particularly facilities management remain a rather artificial subject if not taught in direct relation to the real world.

- YEAR 4 Takes up the issues of design analysis and synthesis. Additionally in a seperate optional course it provides an introduction to management aspects of computers in architecture. Both issues are also introduced as a potential area for further study, possibly during the fifth year. The design analysis and synthesis course is of more theoretical nature and is to include clustering and relational analysis as well as expert systems.

- YEAR 5 has no planned caad-content in the belief that year 5 students are capable to decide on their own direction. It is hoped, though, that many will use caad as a design or visualisation tool, and that some will take, and be given room for, specialist caad-studies.
In considering the above outline do note that all caadteaching is made subjective to the existing curriculum. CAAD-PROJECTS and CADLAB are intended, with relatively minor adjustments, to fit into existing teaching. The CAAD-COURSES are an extra element, but of small organisational impact, timewise requiring only a small allocation, and related to the ongoing teaching.

Also note that where the expression cad or caad is used, this is meant in the wide meaning and thus including anything from the use of spreadsheets and small alphanumeric databases, to full 3-D modelling.
Case studies

From July to November 1986, after some try-out courses in the preceding long vacation, a number of courses were piloted. They basically consisted of the same introductory CAAD-COURSE 1, emphasising graphics, visualisation and modelling, but given to different years with different emphases in different circumstances:

- Year 1 compulsory courses: 96 students divided over two groups, for a one week intensive course.
- Year 4 elective course: 15 students (and 2 staff) in a 10 session weekly course with an assignment at the end of the course.
- Year 4/5 extra-curriculum vacation course: 28 students (and 3 staff) in a 10-session course spread over two weeks.

Additionally some year 1 staff conducted studio design CAAD-PROJECTS with their students.

The CAAD-COURSE 1 is described in the appendix. For year 1 the course was conducted twice, to overcome the availability of only 22 workstations for 96 students. Students were teamed up in groups of 2 (sometimes 3). Each 5-6 pairs were assigned to one tutor. The caad-course started with 3 hours lectures on hardware and software in general, and an overview of architectural computer applications. The 9 workshop sessions each took half a day, introduced by an approx. 1 hour demonstration session in the video-room. Each workshop session had a particular program of exercises, related to the teaching of specific commands. Additionally the students spent a variable amount of time, typically 2-4 hours to practice on their own. A special command manual was written dividing the commands to be taught over the workshops for piecemeal learning. By the end of workshop session 8 the exercises had familiarised the students with approx. 60 separate commands, or 10% of Intergraphs' AMOS (incl. IGDS2D and IGDS3D) commands. The manual also explained the students an additional 140 commands, but with no obligation. With this manual most students were quite self-supporting after 2 or 3 workshops.

The caad-courses were evaluated through questionnaires and discussions among students and staff involved. It appeared that 50-60% of the students had prior computer experience, but on small computers and only a minority had prior experience with computer graphics. Generally the course was well-understood and successful, although the hard- and software, particularly inconsistencies in the userinterface, scored many negative remarks. An interesting comment was that one student experienced a sense of being lost in terms of level, scale and space, as compared with
directly drawing on paper. Significantly after the course most students were convinced that the cad-system helped in 3D-visualisation and presentation of various design aspects, but doubted its effectiveness in 2D-drafting.

An important issue during these courses was to ascertain that they would not degrade to mere training of cad-system commands. Therefore the design vehicle for the courses was subject to much experimentation and ranged from simple graphics exercises for year 1, to design information modelling for year 4. In this latter case students were asked to analyse their own or a well-known existing design in various terms of plan-organisation, form, or structure and material use. Level- (layer-) and colour conventions were suggested for each type of information.

Of the studio design projects in year 1 some focussed on basic 3D-manipulation, others on the use of design with components. Some year 4 students applied the cad-system in their studio design work. Occasionally the system was also applied by staff.

AMOD (INCL. IGDS) 600 COMMANDS

COURSE MANUAL 200 COMMANDS

EXERCISES 60 COMMANDS
Observations

The case studies described cover only the first year of teaching after the cad-system was installed. They highlight just a small part of the proposed CADCUR-planning. While these courses were considered successful and justified and are to be repeated, the further implementation of the proposals stagnated largely as a result of changes in management and personnel. Also, while there was generally a high level of interest in caad among staff, to negotiate space in the curriculum for the CAAD-COURSES and CAADPROJECTS proved very difficult and at times unsuccessful, thereby obstructing the phased planned implementation.

On the basis of the pilot CAAD-COURSES and CAAD-PROJECTS some further observations can be made:

- Often it has been commented that the capital outlay for this cad-system is outrageous in relation to the number of students. In comparison with practice this certainly seems the case, considering that during the first year of operation the average usage was less than 15% of an 8-hour day, and much less outside term time. However, the educational benefit cannot be quantified. In this case the expense is fully explainable in the light of the local emphasis on IT. It is certainly a lesser error to spend too much on IT education than too little. The timing of the acquisition, though, was badly balanced with the personnel planning, which greatly reduced the systems' effectiveness.

- For the cost of this system, in view of local market prices for micro-hard- and -software, each student and staff member of the School could have had a networked PC, with PC-based cad-software. The effect would have been completely different from concentrating the complete budget into a 22 workstation large cad-system. But, pervasive as it may seem to put micro-cad on everyone's desk, it is doubtful if that would have resulted in a deeper cad-penetration. Very likely the use would hardly have been beyond wordprocessing, some spreadsheets, and a little cad. 3D-modelling would have been virtually impossible. In fact the amount of cad would equally have been relative to the amount of staff input. Though the slogan which accompanied the acquisition of the Intergraph system: todays mini is the micro of the future may not be fully accurate, neither is todays micro representative for tomorrows micro (1985!). Meanwhile it should be noted that the decision to apply for a large system was a political one, the micro alternative never really existed.

- The courses given positively show that it is very well possible to teach students 3D-modelling in a short time. There seems to be no reason why a large system would be
more difficult to learn than a small one, once login, logout and filing operations have been made easy. Of course command structure, system response, system consistency, software robustness and all other userinterface aspects are of importance for teaching, but differences between systems are subtle and not related to the micro or mini issue. More elaborate systems appear more difficult because their overkill of commands, but once these have been scaled down to digestible portions, that problem evaporates.

- The disadvantage of a short caad-course is that it is quickly forgotten. Even simple instructions or command sequences are difficult to remember after a few weeks of doing other things. Caad-courses should directly be followed by opportunities to apply the new skill. Ideally there should be no large gaps between periods of use, at the risk of loosing fluency.

In caad-teaching there is a large potential for customising teaching user-interfaces, developing macro's and even computer aided learning software. However, the rapid development of cad presents a disincentive as any such developments made without vendor support may outdate within a few months, when the vendor comes with a new menu, his own macro's, or a new version of the system. Such user developments are only feasible if fully vendor-supported, or when a large number of schools, using the same system, join forces.
Strategies

Caad-education is maturing, certain patterns have been emerging, but there is hardly what can be called a universal strategy for caad-curriculum development. There are many reasons for this:

Firstly developing a strategy can have different objectives, f.i.
- To plan the development of a cad-curriculum in advance.
- To justify what has already been decided.
- To convince management.

Each of these different objectives call for different approaches and emphases.

Secondly, one never starts at a blanco situation. Cases as in Singapore, where a one-time big plunge into caad is made, are rare, and even there computer-teaching was already precedented. Most Schools of Architecture nowadays have some caad, and people involved with teaching caad. People are the dominant factor in any innovation; different people have and require different strategies.

Another important determinant is the type of school, as well in terms of general teaching method, as educational position and objectives. A credit system school can be approached completely different than a school with linear streaming, as is the case in Singapore. The credit system, while more difficult to streamline and monitor, is definitely more flexible and open to innovative new items of study. An undergraduate school has a different set of objectives than a graduate one, or than a mid-career education, or than a polytechnic or technical college. A school, teaching only mainstream architectural design has very different options than one catering for specialisms, or one with a caad-active neighbour building science department. A school where the objectives and teachings are controlled by the profession, as in Singapore and the U.K., needs a different approach than one enjoying full academic freedom, as f.i. in the Netherlands.

What strategies can be supported by the Singapore example? The Singapore School of Architecture has a linear streaming system with only few options open to the students (practically none in the first three years). It intends only to teach mainstream architecture design, no frills, no support by specialist cad-students, whether graduate or PhD. There is no building science department. It has all the problems of a tight curriculum where no-one believes there is any place in any year for any new item of study.
In this case there are only two strategic objectives:
- To teach to use a cad-system.
- To integrate caad in the curriculum.

This second objective denies caad as a separate subject in its own right. In the past caad has often been taught in isolation, but although it may be easier to develop and implement caad-teaching as a separate item, there is no justification for that. On the contrary: as studio design is central to architectural teaching, and also to exploit the integrating effect of caad, it is an essential part of any strategy to GET CAAD IN THE DESIGN STUDIO. As a start it hardly matters in which year this is first introduced, although there are good arguments for the earliest possible years. It does imply, though, that the caad-teachers are design teachers at the same time, or at least that the design teachers are well aware of the potential and limitations of the available computer facilities.

In applying caad it should make DESIGN sense, else it disqualifies itself. As a strategy any caad-application should be geared to IMPROVE THE THINKING IN DESIGN. There are many ways to achieve this and the key-words are 3Dmodelling, integration and information. Mere drawing and visualisation without a specific information structure do not add much to design thinking and degrade the level of education. In Singapore we experienced that many students, facinated by the power of the system, loose control over what they are doing and the computer graphics start living a life of their own. Teachers have to be very aware of this effect.

Also computers and particularly computer graphics have much potential as TEACHING TOOLS. It shows a degree of backwardness and lack of educational professionalism if educators do not embrace or even explore this potential in their own specialism.

An emerging problem is that, because of the lack of further education in caad, students who followed some introductory caad-courses are very often declared caad-experts. As a result is seems there is quite some young expertise available, but it is at a very low level. Caad-development and caad-management are to be treated professionally, requiring someone with an architectural background, but also considerable additional education. It can be very harmful to caad if it is supported at amateur level, which is now very often the case. A strategy should therefore be to DIFFERENTIATE CLEARLY BETWEEN MAINSTREAM ARCHITECTURAL STUDENTS AND COMPUTER EXPERT TEACHING.

Embedded in the previous issue is the question if students should learn a programming language. This is often defended
on grounds that teaching a language provides a better understanding of how the computer operates; but such understanding can be taught in an hour. Another argument is that the use of a computer language teaches analytical thinking; but it may also be argued that it teaches dumb thinking. If analytical thinking is to be enhanced there are other, more effective ways, among others on might take an excursion into systems analysis methods or knowledge engineering. Consequently there is NO NEED TO TEACH COMPUTER LANGUAGES TO MAINSTREAM ARCHITECTURAL STUDENTS.

Finally, it cannot be overemphasised, the quality of caad-teaching depends in the first place on the teachers, not on the equipment. There are numerous examples of excellent caad-teaching with very little equipment. On the other hand, to anticipate the impact caad will have on architectural design there should not only be good, but also sufficient personnel to support caad-use on all the platforms where it is relevant. And any school should be entitled to good equipment, relevant to the future of architectural computing, and not to the past or even the present.
Acknowledgements

The cad-aquisition, -curriculum development and -teaching was a team effort. Since this started, some time early in 1985, the team as well as the management of the School changed considerably. To name all would be too long, but three names are outstanding. Milton Tan, who was a lecturer at the School until mid-1966, was the main motor and brains behind the aquisition of the system and the initial implementation strategies. Without him there would have been no or hardly any caad in the School of Architecture. Richard Hyde and Ong Boon Lay, both also lecturers at the School, shaped and conducted the year 1 caad-course and cad studio design projects and brought life to the CADCUR-proposals in a very intelligent and creative way.

Although it was originally planned to conceive this paper together with the latter two, the distance between Singapore and Sydney proved too long for that. While I am confident that both will agree with most if not all of the above, they cannot be held responsible for anything in the contents of this paper.

Bibliography


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APPENDIX

N.U.S. - SCHOOL OF ARCHITECTURE - CADCUR-plan 1986-90

YEAR 1

YEAR 2

YEAR 3

YEAR OUT

YEAR 4

YEAR 5

SPECIAL DEGREE

PRACTICE

86/87  87/88  88/89  89/90
A CAAD-COURSES

Besides use of CARD in Studio Design, which is essential for successfull GRAD - penetration in the School, special CAAD -courses will teach computer - related items that cannot feasibly or by nature form part of an existing curriculum item. Each tear will thereto have its own CARD Course(s), either compulsory or optional, relating to that years' overall objectives and CAAD-teaching in preceeding and following years.

Each course is designed to take roughly 4 - 6 student hours weekly (contact and assignments) over one term. For each course each 20 students or less will take one teaching staff.

1 CARD-Course 1

Description:

A year 1 compulsory course with emphasis on Graphics, visualisation and modelling. Introduces the student to the School's facilities while trying to steer away from a mare training in the use of specific commands. The course is accompanied by theory lectures on computer hardware, software and architectural use in general. Related to and integrated in year 1 Graphics Course. Graded as part of that course.

Objectives:

- Introducing the School's facilities as a readily available tool for further use in any study activity particularly studio design. Having followed the course the students should feel confident to further use the system without much assistance.
- A tool to increase demonstration for and experience facets of the Graphics Course, as well making certain manipulations easier (e.g. lettering, perspectives, colour, repetition, scaling), as to further awareness (e.g. 3D - manipulation).
- To arouse an interest in computers in architecture and an awareness of their potential and limitations.

Requirements:

Intergraph's AMOD (and PROCASSO) software, as well as wordprocessing, spreadsheet and simple graphics software for Atari. Full use of Interpro 32 workstations, CPU and periferals, and Atari micro's.

2 CARD-Course 2

Description:

A year 2 course with emphasis on modelling and integration of design aspects and applications. Builds on the year 1 course, going deeper into AMOD (cells, perhaps DMRS), perhaps APDP, focussing on design process aspects of using a CAAD - system: how to progress a project model from sketch to final design and detailing.
Objectives:
- To teach efficient use of the CAD-system in the (studio) design process.
- To demonstrate and teach the increased modelling and visualisation possibilities the system offers, as well for formal aspects, as for aspects of planning and technology. This should lead to a better understanding of how such diverse aspects are closely related in a design.

Requirements:
Intergraph's AMOD and perhaps RSURF and APDP. Use of the CAD system and all periferals.

3 CAAD-Course 3

Description:
Regular course for year 3 with emphasis on modelling, simulation and appraisal. Strongly related to lecture courses end including a building costing element. Builds on the year 2 course, which may need to be an entry requirement.

Objectives:
- To teach simulation end appraisal as an important design issue, made feasible by computer use.
- To demonstrate and experience the multivariate nature of design.

Requirements:
Intergraph's AMOD and/or APDP as a central geometric modeller, linked to appraisal software such as GOAL and/or SCRIBE and/or to separate applications as in technology and costing. It is assumed that the USEWARE research project will bring forward operational availability of some of such operational software on the School's CAD-system and

4 CAAD-Course 0a

Description:
Option for year out students who wish to gain experience and possibly use the CAD-system in a production environment. Assumes a relation to the design office in which the student is doing his practical work, possibly even on a commercial basis (through CADLAB 0). The course emphasises production drawing in 2D and perspectives. Builds on the year 1 and possibly year 2 course, which may be an entry requirement.

Objectives:
- To teach the student in what methods to use in a production environment and to provide initial training in related software.
- To make it more attractive for practice to take-on a student from the School for practical work.
- Together with ADLAB 0, to facilitate use of the system for practice, as well for the experience thereby gained by the School, as to achieve fuller use of the School's system capacity (particularly during vacations, possibly also evenings and weekends), as to enable practicing architects to come into contact with a technology not otherwise available to individual practices.

Requirements:

Intergraph's APDP, linked to IGDS 3D (and AMOD?) and all the CAD-systems peripherals. To hire an external tutor experienced with use of the system in practice for at least part of the course.

5 CAAD-Course 0b

Description:

Option for year out students using Space Planning and Facilities Management computer applications. SPFM promises to significantly expand the work-terrain of the architect's office during the life time of the project. The promise is increasingly coming true, especially in the USA. The issue is very practice related, and therefore most suitably taught in relation with the period of practical work. Serves at the same time to promote the idea of SPFM to Singaporean practice.

Objectives:

- To provide awareness of and experience in Space Planning and Facilities Management possibilities in the architectural profession.
- To promote SPFM to Singaporean practice.

Requirements:

Integraph's SPFM (linked to IGDS 3D and AMOD?) and all the CAD-systems peripherals. To hire an external tutor experienced with use of such software in practice for at least part of the course.

6 CAAD-Course 4a

Description:

Year 4 elective emphasising design analysis and synthesis options of computers. Could relate to electives or topics on architectural programming and design preparation and has strong design methods aspects to be covered in theory lectures. To extend into the area of artificial intelligence and expert systems.
Objectives:
- To provide awareness of and experience in design analysis and synthesis applications of computers.
- A vehicle for furthering excursions into design methodology and design theory, particularly as related to Expert Systems.
- To introduce an area of architectural computer expertise, which may later be taken up by students in thesis or degree research.

Requirements:
Intergraph's STPL complemented by other packages such as ABACUS' SPACES 2 and MAGIC and various English, American and Australian Expert Systems. Requires, at least for part of the course, a tutor who is knowledgeable in the field, 'beyond the mere use of STPL.

7 CAAD-Course 4b

Description:
Year 4 elective emphasising evaluation and management of CAAD-systems. To include hands-on experience with a broad range of systems, e.g. from AutoCAD to IGDS, from 2D -Drafting to appraisal. The course is meant for those who have over the preceding years build up considerable CAPO knowledge and experience, to round this off and tackle operational and feasibility issues of CAAD.
For participation students will be required to have followed at least CAAD-Courses 1, 3, Os or Ob.

Objectives:
- To complement students' knowledge and experience in CAAD with a critical understanding of computer use in practice, related to present day practice and the state-of-the-art in computer technology and use.
- To broaden the perception of CAAD beyond the systems the curriculum will have been focussing on in the previous years. CAAD To prepare -students with an excellence in CAAD for application of their skills in practice.
- To introduce an area of architectural computer expertise, which may be furthered in thesis or degree research.

Requirements:
Access to various CAD-systems, possibly extended to systems at other departments of the NUS. Excursions, seminars with -computer managers in local practice. Requires a tutor who is knowledgeable with a broad spectrum of use of computers in design practices.
B. IN EXISTING LECTURE COURSES AND SEMINARS

All lecture and seminar subjects in a School of Architecture are related to (to be) designed building or urban projects. As such CAD visualisation, from urban or landscape mapping to 3D-details, is useful to enhance such course. Additionally some courses imply computational or database search aspects, possibly in relation to a design model, for which the computer provides convenient tools. Finally, computer use has always led to a reflection on the design process and design methodology, culminating in, so far mainly theoretical work in Expert Systems.

More specifically, examples of computer use in existing lecture and seminar courses are itemised below:

- History and Theory Courses
  Visualisation of typologies, 3D-details, analysis of case studies, databases influences of computer technology on the design process, computer-human design analogy. For Theory of Urban Design also mapping. Possibly related to CAADCourse 2.

- Building Construction Courses
  Visualisation of construction elements in case studies, 3D-details, component design and application. Related to CAAD-course 2 and 3.

- Building Structures Courses
  Typology of structures, visualisation of structural elements in case studies, 3D visualisation of structural nodes, simulation of deformation, possibly integrated with stress end deformation calculation, component design and application. Related to CAAD-Course 2 and 3.

- Environment Control and Building Services Courses
  Case study computation and visualisation of shadow casting, illumination levels, noise levels and thermal performance, case study visualisation of installation elements (piping, ducting, cabling) either schematically or "real world", component design and application, escape routing. Related to CAAD-Course 2 and 3.

- Building Technology Courses
  As above, complemented to economy aspects of Building Technology, working drawing production, specification writing, including use of product information software. Can build on CAAD-Course Ga.

- Building Practice Course
  Impact of appraisal software, office and architectural project management software including for planning and scheduling (bar charts, CPM). Can build on CAAD-Course 3, related to CAAD-Course 4a.

- Topics and Electives
  Various if not all existing topics lead themselves to computer use.