

Teaching Collaborative Design

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ABSTRACT: In conceptual design of architectural artefacts, designers from different disciplines work together. Multi-disciplinary collaboration is required when buildings and their construction have a complex nature. If this collaboration is not effective and efficient, it will lead to the construction of buildings that clients did not want, that cost too much and that take too long to construct. Collaboration in design can take place in a physical space, but also in a distributed, or virtual environment. Virtual design teams use a range of ICT tools to support both synchronous and asynchronous communication. While these tools are designed to facilitate collaboration, the collaboration process still requires planning and organisation, which is an activity that students and professionals need to learn. In current practice there is a need for designers and design managers who have the competences to collaborate in design and to organise distributed collaboration processes.

1 INTRODUCTION

The Architecture, Engineering, and Construction (AEC) industry needs designers who are competent to design as a design team on distance. To acquire this competence, a course on Collaborative Design is developed at Eindhoven University of Technology in The Netherlands for students in the Master of Science curriculum on Architecture, Building, and Planning. The participating students have backgrounds that vary from design management, architecture, building physics, construction management, structural engineering, to urban planning and building information technology.

In this paper, the lecturers of this course evaluate the effectiveness of the course and reflect on how improvements are necessary and possible. The paper starts with a discussion on the critical aspects of collaborative design, the learning objectives of the course, and the approach followed. It then discusses our experiences and draws conclusions on improvements.

2 COLLABORATIVE DESIGN

One of the first issues in teaching collaborative design is to convey an understanding of what the term *collaboration* means. Kvan distinguishes between the terms *collaboration* and *cooperation*. In [1], he notes that *cooperation* relates to working together for mutual benefit, while *collaboration* relates to

working together to achieve shared goals. The main distinction between the two forms of working together, according to Kvan, is the creative aspect of collaboration.

Kvan also distinguishes closely coupled design processes, in which participants continuously work closely to realise a design (see Figure 1), from loosely coupled design processes, where participants each contribute from their particular domain expertise at moments when they have the knowledge required (see Figure 2). The latter model is observed more in practice.

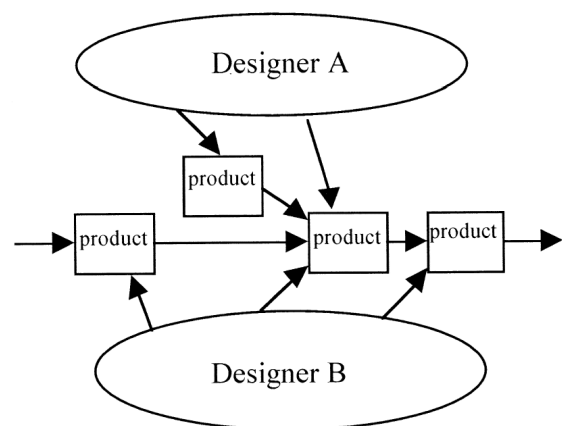


Figure 1. Loosely coupled design process.
(adopted from Kvan [1])

Dekker describes collaborative design as a process of creating and sharing knowledge by working together on an actual result [2].

In the course presented in this paper, we stress that participants of collaborative design sessions in a multi-disciplinary team will make their own design thinking transparent and are able to listen with interest and respect to each other. They are willing to learn from each other and realise that only in this way a good and integrated design result can be achieved. The organisation of the design process is crucial here, especially when designers need to work on distance. They will make use of organisational instruments, such as meetings and scheduled tasks, as well as ICT tools for both synchronous and asynchronous communication and data exchange.

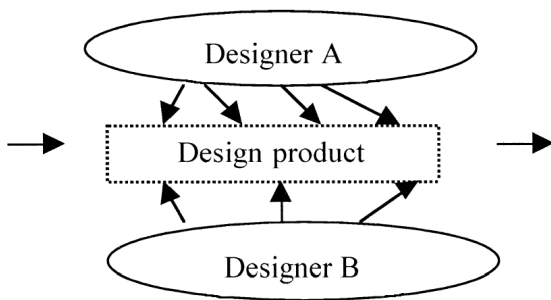


Figure 2. Closely coupled design process.
(adopted from Kvan [1])

3 COLLABORATIVE DESIGN IN EDUCATION

In educational master programmes on architecture and engineering, initially students often work alone on assignments, the results of which they discuss with their supervisor. When teamwork comes into play, students have to organise their activities and make a project plan. They have to find answers to questions such as: what are the general objective and problem; what is the approach followed; what is the planning; who does what; which results are expected when? At the authors' department, the skills to organise such a project are practiced in a multi-disciplinary design project in the third year of the Bachelor's programme.

However, as noted before, Collaborative design is more than working together in the sense of cooperating with individual tasks in such a project. Both organisational and technological issues are involved when a team needs to collaborate, particularly when collaboration takes place on distance. Questions that arise are: how do you organise a design meeting; what is the team members' organisational role as opposed to their professional role; which techniques can be used to enhance creativity in the group; how will we communicate on distance with respect to

verbal and graphical communication; what about asynchronous communication? The course 'Collaborative Design' that is developed by the authors in the Master of Science programme aims to teach these skills and to provide students with insight in the particular complexities of (distant) collaboration in multi-disciplinary design projects.

3.1 MSc Course on Collaborative Design

The objectives of this course at Eindhoven University of Technology are to gain insight in the problem domain of collaborative design and to get to know the possibilities of methods and techniques to approach this problem domain. Methods and techniques concern both organisational instruments and ICT related tools. Specific competences that are acquired through this course are the following.

- To play an organisational role in a team-working project. This involves being able to identify social and organisational roles people play in teams and becoming aware of one's own role as assumed and as required.
- To play a professional role in a multi-disciplinary design process. Here the focus is on the activities and responsibilities of the students from the viewpoint of their respective expertise and specialisation.
- To work together in a design team. The critical issues here are the creativity in the team and the students' contribution to the creative process. An important aspect is for students to realise that creativity in a team of designers and engineers must pass the boundaries of individual disciplines; taking one another's viewpoints is essential.
- To be able to use, assess, and select relevant ICT tools for support of face-to-face as well as distant, synchronous as well as asynchronous communication during design processes.
- To reflect on the work of the team and on the student's individual contribution. The key to reflection is the student's awareness of the overall process as well as the individual activities and the roles and actions that the student has taken up.

The educational approach that was chosen in this course can be indicated as 'experiential learning.' This means that the student acts as an active learner

and that the teacher's coaching role is focused on the student's activities.

According to the American Institute for Experiential Learning [3], this educational concept is composed of three components:

- Knowledge (concepts, facts, information, and prior experience)
- Activity (knowledge applied to current, ongoing events)
- Reflection (thoughtful analysis and assessment of one's own activity and its contribution to personal growth)

The activities in the course were organised into five assignments, of which two were individual assignments and three were group assigned design tasks:

1. *Literature review.* Each student prepares a summary and short presentation of a review of two scientific papers on the topic of collaborative design.
2. *Designing in a team.* In this task the student is member of a multi-disciplinary team. Within each of the six teams, students represent various construction-related professions, such as architect, structural engineer, contractor, principal, HVAC consultant, etc. (see Figure 3). The team designs the function of a building object in one or two face-to-face meetings. The result is a design brief.

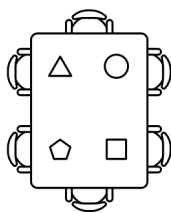
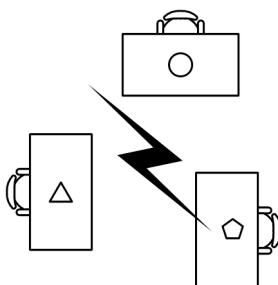


Figure 3. Task 2: Design in a multi-disciplinary team through face-to-face meetings.

3. *Designing in a distributed team.* The same multi-disciplinary team now works on distance and organises virtual meetings to design a spatial layout for the building object described in the brief from task 2. The virtual meetings take place through synchronous



communication using a selection of ICT tools (see Figure 4).

Figure 4. Task 3: Design in a multi-disciplinary team through online meetings and distributed work.

4. *Designing in a distributed organisation.* For this task, a re-organisation of the teams takes place. The various multi-disciplinary teams are re-organised into mono-disciplinary teams that represent each of the construction-related disciplines. While the students keep their original professional role, they are now teamed up with others that have the same role. Together these teams form an organisation of multiple professional disciplines (see Figure 5). The organisation's task is to agree on the final design of the building object, based on the designs previously made in task 3. The choice for a face-to-face or virtual meeting is open. The organisation as a whole has to deliver one final plan for the building.

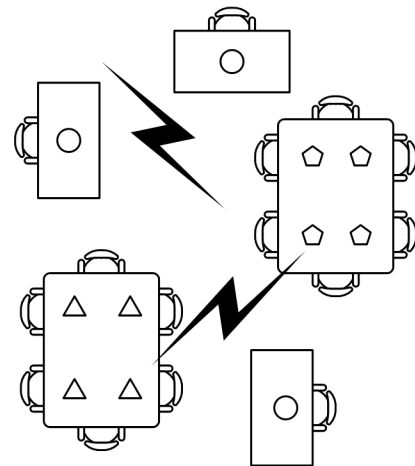


Figure 5. Task 4: Design in a distributed organisation of multiple mono-disciplinary teams.

5. *Individual final report.* Every student writes a report on his/her experiences with the course, describing what he/she has learned and providing an evaluation of the ICT-tools that were used.

The three team assignments were important in the course, but mainly as a way for students to gain experiences. For this purpose, the team sessions were not tutored. The way that the teams addressed the organisational problems was completely left open. Lecturers would not actively involve themselves in

the teams' functioning, but could be consulted at any time.

The individual final report formed the sole basis for the final assessments of the student's work in the course. This made it possible for students to experiment in the teams, while at the same time removed the mutual dependencies of students to successfully conclude the course. The team was allowed to fail: individual students were assessed by their perception of the process and the personal actions manifested during the process.

The student workload of this course is 84 hours, corresponding to three study points in the ECTS. The course is described on the website that includes all necessary information about objectives, tasks, literature, time planning, relevant web links, requirements for deliverables, presentations, lecture notes, reflection criteria, etc. [4]. Students' contributions and the results of activities in the three design tasks were submitted through the document management system.

3.2 *Thematic lectures*

Apart from the assignments and the plenary discussions of the progress of the teamwork, the course included interactive lectures on the following four themes.

3.2.1 *Organisational and social aspects of designing in teams*

In these lectures, the objective was to make students aware of the many social aspects to collaboration, such as the need for mutual acceptance, openness, commitment to shared goals, shared responsibilities, etc. Becoming aware of the roles people can play in a team was an important issue. Students were asked to identify their own role according to the test devel-

oped by Belbin [5,6]. In this test, team roles are distinguished in three categories:

- action-oriented roles - Shaper, Implementer, and Completer Finisher;
- people-oriented roles - Co-ordinator, Teamworker and Resource Investigator;
- cerebral roles - Plant, Monitor Evaluator and Specialist.

Students found it useful to become aware of their own natural role in a team. It allows them to recognise their own behaviour, to take advantage of their natural strengths, and to be conscious of their natural weaknesses.

Another kind of role is the professional role that students play in the team. As the students have different backgrounds, the teams were multi-disciplinary teams. The multi-disciplinary design tasks allowed the students to play their professional role and experience how the nature of this role has an influence on their behaviour and in the relation with the other team members.

3.2.2 *The use of ICT tools for collaborative design*

Besides email and instant messaging tools that students are already accustomed to, the ICT tools that were mainly used in this course are Netmeeting (Microsoft), Architectural Studio (AutoDesk), and the document management system Automanager Meridan (Cyco Software).

All participating students own a notebook computer with software that is relevant and required for their study. The university campus, including many student residences, provides internet access, partially through a wireless network.

While the observed process can be represented by the schema in Figure 6, which is a modified version from [1], an additional activity was inserted in the schema to represent the synchronous communication that takes place while team members work individually on distance.

national governmental organisation on the experiences recently gained during the introduction of new ICT related procedures in the organisation's daily practice on construction project management.

Figure 7. Students collaborating on distance.

4 RELATED COURSES

A course that is similar to the one described here is taught at the University of Florida and the University of Illinois at Urbana-Champaign. This course is called Collaborative Design Processes (CPD). O'Brien et al. describe the intention and organisation of the course and their experiences with it [7].

The objectives of this course are:

1. To understand the group dynamics and to develop negotiation and decision making skills through direct experience of group design work and through critical reflections, evaluation and analyses of multidisciplinary, net-based collaborative design processes.
2. To complete a facility design including a plan, schedule, budget, and structure using different work processes enabled by the use of information technology.
3. To learn how to evaluate and integrate technologies of multi-disciplinary remote collaboration in AEC design projects.
4. To design improved work process methods and to make recommendations for the development of improved software tools for collaborative, multi-disciplinary design.

The main differences with the course described in this paper are:

- The course by O'Brien involves a higher level of detail of the required end-results from the design assignment.
- Their course is based on Bricsnet's Project Center rather than Automanager Meridian and AutoCAD instead of Architectural Studio.
- Their course is focused more on technical aspect of the distant collaboration and not so much on the social aspect.
- In the course by O'Brien, the personal reflection is an informal document, whereas in the author's course the student's individual reflection is the main means for assessment.

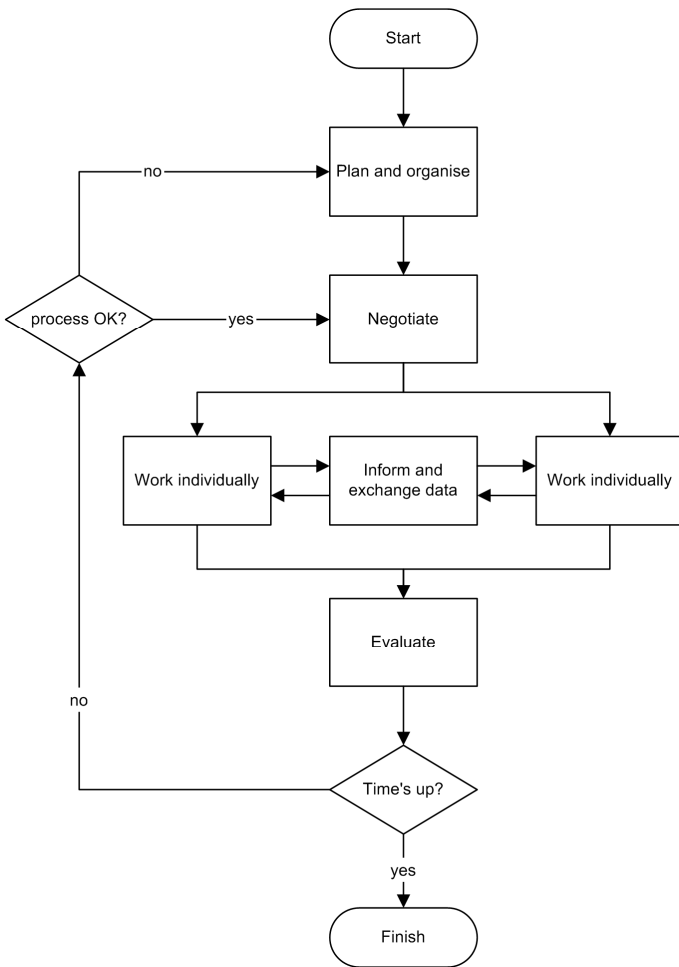


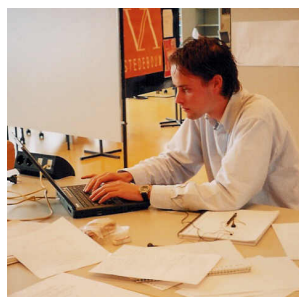
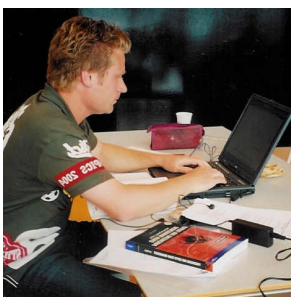
Figure 6. Collaborative design process.
(modified from Kvan [1])

3.2.3 Organising and managing the design process

Apart from the group-level aspects of collaborative design, the course also addressed the issues of how to manage design processes and what kind of information environment organisations can deploy in design and construction projects. The potential of project websites was discussed with particular interest in the business implementation issues. The way that an organisation is adjusted to new tools and the drive to stimulate co-workers to accept them are of crucial importance for successful application of tools that are allowed to play such a central role in a company's core-business.

3.2.4 Collaborative design in practice

This was a guest-lecture by an IT manager from a



Sun and Lin developed a number of educational approaches with the use of Internet. They called them the ASIA principles: Active learning, learning via Simulation, Interactive and inter-creative learning, and Accumulative learning. They conclude that the pedagogical principles are plausible and the environment is effective in stimulating interests and innovation in students as well as their willingness to collaborate [8].

5 COURSE EVALUATION

The course was taught in 2003 and in 2004. To be able to assess and improve the course it was necessary to evaluate both content and format. The type of questions that an evaluation of the course should provide an answer to were:

- Is the educational approach effective and do students actually acquire the targeted competences?
- To what degree have students been able to develop themselves with respect to the domain of collaborative design?
- Have they acquired sufficient skills using the tools for distant collaboration?
- Are students capable of using the tools on their own initiative?
- Have the students been able to integrate the organisational and technological skills in their work?

Answers to these questions have been obtained in two ways. First, the individual reports of the students contained information regarding their personal reflection on the course and the learning experiences. Second, a formal evaluation was carried out in 2003 and 2004 by the department's educational support section.

In the students' reports, we could find information regarding the collaboration process during the three design assignments, an analysis of these processes in terms of activities, roles, and tasks, and their experiences in participating in the design team and in using organisational instruments and ICT tools.

The formal evaluation was carried out by a departmental evaluation officer in the form of a written enquiry among all participating students. The results of this enquiry give insight in the perceived relevance of the course objectives, the quality of the course and the assignments, the time spent by students, the learning yields, etc.

5.1 Evaluation results

The main conclusions from the evaluation based on the individual reports by the students are:

- Most students were aware of having experienced a new kind of design process.
- Working in a team of people previously unknown to each other has a significant and positive influence on the learning experience.
- Students were actively aware of the roles they played in the team; this concerned both the role as a team member (e.g. according to Belbin) and the professional role in a multi-disciplinary team.
- It appeared difficult to be aware of, or even to play, both types of role at the same time.
- Playing the professional role is difficult because of the unrealistic setting in an educational project.
- Organisation of the collaboration is crucial for the success of the process.
- Reflection is the most difficult part of the experiential learning format that was applied in this course.
- Sufficient skills with ICT tools are necessary: lack of skills will frustrate the collaboration process.
- Physical distance is necessary to enforce distant collaboration (if they can easily walk and meet, they will).

From the formal evaluation, these conclusions were drawn:

- Students find that they learn a lot from the experiences gained through this course.
- The reflection is a good way of finalising the course. It helps to intensify the learning effect.
- Students appreciate the combination of social and technical aspects of the course: 50% of the students appreciate the balance between technical and social/organisational issues in the course. 25% find the course too social, 25% find it too technical. Also, around half of the students find the combination of these issues the most interesting aspect of the course.
- Students appreciate the completeness of the course material on the website.
- Students rated this course by 3.5 (was 4.2 in 2003) on a scale 1-5.

- The appreciation for the ICT tools varied:
26%: too simple
32%: too complex
42%: effective
- The teamwork on the assignments was largely untutored. 60% of the students agree with this approach and have no need for intense guidance during the design tasks.
- Students found that the format of the course stimulates their active participation.

[3] American Institute for Experiential Learning.
www.ielnet.org.

[4] Course material of the course 'Collaborative Design'. <http://www.ds.arch.tue.nl/7m832>

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6 CONCLUSIONS

A general conclusion after teaching this course for two consecutive years is that a satisfactory level of collaboration is not easy to achieve with students that are traditionally trained in cooperation and coordination. Much effort is needed to convey the notion of collaboration. Experiential learning is a very good way for students to learn the need for, e.g., organising collaboration processes. Providing students with theory and examples, and also discussing such issues in groups, does not lead to the same effectiveness in learning through experience.

Future development for improvement of this course will focus on redesigning the tasks and probably adding smaller exercises. These exercises will focus on a more limited number of aspects of collaborative design. For example, separating the focus on organisational roles from that on professional roles is preferable in early exercises. They can be combined in later exercises or assignments. This is likely to increase the awareness of the differences and the influences on students' behaviours.

While experiential learning was successful, the effect can probably be increased by informing students about the approach and the expected effect.

7 REFERENCES

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[2] Dekker H, van Ginkel K, Nieveen N, Keursten P, Rondeel M, Wagenaar S. 2000. *Werken aan Kennis, Methoden voor het creëren, delen en toepassen van kennis* (Working on Knowledge, Methods for creating, sharing, and applying knowledge). Report in Dutch for the Hogeschool van Amsterdam. Kessels & Smit.