

## **Collaborative Design in Education**

### *Evaluation of three Approaches*

Jos van Leeuwen, Frans van Gassel, Ad den Otter

*Eindhoven University of Technology, The Netherlands*

<http://www.ddss.arch.tue.nl/7m832>

**Abstract.** Collaboration in design can take place in a physical, social space, in a distributed or virtual environment, or in a combination of both. Design teams use a range of ICT means to support both synchronous and asynchronous communication. While these tools are designed to facilitate collaboration, the collaboration process still requires planning and organisation in a social context, which are activities 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. At the department of Architecture, Building, and Planning at Eindhoven University of Technology, we have developed a course on Collaborative Design in the Master of Science curriculum. This course addresses both the organisational, social, and technical issues of collaboration in design. The paper introduces the objectives and educational methods used in this course. It describes the experiences of both teachers and students that were gained now that the course was taught in three subsequent years.

**Keywords.** Collaborative Design, Multi-disciplinary Design, Computer Support for Collaborative Working, Education, Design Management.

### **Introduction**

As part of the curriculum of the Master of Science in Architecture, Building, and Planning at Eindhoven University of Technology, a course on Collaborative Design has now been taught for the third time since 2002. This course addresses both the organisational, social, and technical issues of collaboration in design.

The objective of this course is to let students experience what collaborative design is. The course has been taught in three consecutive years, in each of which we have applied a different approach. While in all three approaches, creativity, organisation, and the use of relevant communication means and channels play a central role, in the first two years the focus has been mainly on developing collective creativity while in the third year the focus was on organising the collaboration process. Another important difference between the three approaches lies in the way the teams were formed. Both aspects, the focus on creativity versus organisation and the team forming, appear to have a strong influence on the attitude of the students, on the effect of incrementally gaining experience, and on the results of the learning process.

This paper outlines the objectives of our course and the general educational method we applied – experiential learning. We briefly discuss the three different approaches we have followed in the past three years and the experiences we gained with them. Three key issues appear to be important in learning collaborative design: creativity in teams, collective communication, process organisation. Before drawing conclusions, we discuss the assessment of the students and the evaluation of the course.

### **Defining Collaborative Design**

Following Kvan (2000), we can define 'to collaborate' as 'to work together with a shared goal'. This is different from 'to cooperate', which we could define as 'to work side-by-side with mutual goals.' The key issue in collaborative design is that designers

van Leeuwen, J.P., van Gassel, F. and den Otter, A. 2005. "Collaborative Design in Education - Evaluation of three Approaches." In Duarte, Ducla-Soares, and Sampaio(eds.): *Digital Design: the quest for new paradigms - proceedings of ECAADE 2005*. Lisbon: Instituto Superior Técnico. 173-180.

with individual backgrounds, objectives, and motivations make an effort to achieve a shared goal, which is to get a better result from their conjoint design activities by making optimal use of each others knowledge and experience. Because design processes essentially are human action systems (van Aken, 2005), only through collaboration can a group of designers become truly creative as a team.

### *The necessity to teach Collaborative Design*

Generally, design education focuses on teaching students how to solve design problems systematically and creatively. Yet, many of the aspects of *collaborative* design that they will encounter in design practice are not always consciously learned nor taught (van Gassel *et al.*, 2004). Working in a context with many different disciplines, different individuals, different companies and different interests requires a lot of attention for the *organisation* of collaboration. It is our believe and experience that this is something that, in an educational setting, can be learned only in a situation that is set up particularly for this purpose. In 'ordinary' design assignments for groups, the students will easily let their activities be driven by individual objectives, of which scoring the study points is not the least important. This motivation steers their focus towards achieving a design solution which they believe will be best evaluated, rather than towards getting the best result *as a team* and the most experience from the collaboration process.

### **The course Collaborative Design**

The course Collaborative Design is taught in the first year of the MSc programme, which used to be the fourth year in the five year Engineers degree programme. The course is an elective course for all students of the Architecture, Building, and Planning programme, and mandatory for two of the nine specialisations within this programme. Its study load is 84 hours and the students receive a credit of 3 study points (ECTS).

The objectives of the course are to gain insight in the problem domain of collaborative design, to get to know the possibilities of methods and techniques to approach this problem domain, and to gain experience with collaborative design in a situation that comes close to the reality of practice. Methods and techniques here concern both organisational instruments and ICT related tools.

### *Competences*

After having completed this course, students are able to organise and manage a (virtual) design team. They can take decisions concerning the composition of the design team, the assignment of tasks, and the planning of activities. They also have insight and experience in deciding when such a design team should meet face-to-face and when it can function on distance, and what ICT means can and should be used in the process. Furthermore, they have experienced the complexity of multi-disciplinary design projects related to the complexity of collaborating in different contexts, both intra-organisational and inter-organisational.

Specific competences that are acquired through this course are the following.

- Playing a social and organisational role in a team-working project: identifying the roles that people play in teams and becoming aware of one's own role.
- Playing a professional role in a multi-disciplinary design process: focus on the professional activities and responsibilities of the team members.

- Working together in a design team. The critical issues here are the creativity in the team and the members' contributions to the creative process, crossing the boundaries of individual disciplines.
- Being 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.
- Reflecting on the work of the team and on the individual's contribution. The key to reflection is one's awareness of the overall process in the team as well as the activities, roles and actions that one has taken up individually.

### **Experiential learning**

The educational approach that was chosen in this course can be indicated as 'experiential learning.' This means that the student is expected to be 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 (recently renamed the Washington Internship Institute, <http://www.ielnet.org> as of May 2005), 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)

In our course, students are submerged in an experiential learning situation that confronts them with the need to collaborate, to organise, to select tools and methods, and to become pro-active. In the past three years, we have experimented with different schemes to achieve and support this experiential learning situation. Dreyfus (cited by Dorst and Reymen, 2004), distinguishes levels of expertise (novice, advanced beginner, competent, proficient, expert, master, and visionary). In our course, 'novices' or 'advanced beginners' are placed in a situation that normally is experienced only at the 'competent' level. The didactical hypothesis is that the problems and possible failures they are confronted with cause a strong learning effect that, after thorough evaluation and reflection, can be very positive.

### *Tutoring vs. coaching*

The course is built around a sequence of assignments that are given to the teams of students, comprising the design of a facility. A fundamental decision for this course was to require students to be self-organising in the execution of the assignments. Rather than guiding the students through the necessary steps to perform these tasks by closely examining them and showing them how to do it, the lecturers take up the role of coaches instead. This means that students have to develop their working methods by themselves and can ask the lecturers for advice and suggestions. The lecturers evaluate the process and the progress on a weekly basis, by holding plenary discussion sessions with all students involved.

This approach has the advantage of stimulating students to take initiative and become pro-active, and to become aware of their role. A disadvantage is, however, that for lecturers the students' development does not become apparent automatically (as would be the case when observing the students at work) and that a thorough evaluation on a regular basis is necessary to bring out the difficulties in the teams.

### *ICT tools – demand vs. supply*

At Eindhoven University of Technology, all students own a notebook with much of the software that is relevant and required for their study. The university campus provides Internet access through a wireless network.

In line with the choice for coaching rather than tutoring students, they are free (or indeed required) to choose their preferred ICT tools to do the job. Instructions and support are available on demand, but the initiative to select the tools and to plan and organise their application lies with the students. There is one exception to this: the students also have access to a document management system, which is the medium used by the lecturers to receive the students' work. In practice, this implies that the teams use the same system to share and work with documents. In the first two years, the document management system we used was Cyco AutoManager® Meridian. In the past year, we used Microsoft® SharePoint Services. For future years, we are considering to use Nuxeo Collaborative Portal Server, a system built on top of Zope®.

For the design tasks, students mainly chose to use SketchUp® and AutoCAD®, Autodesk® VIZ, the whiteboard functionality in Microsoft® NetMeeting or Messenger, and the application sharing facility offered by Messenger.

### **General format of the course**

In each of the years, the students were given five assignments:

- 1 Literature review
- 2 - 4 Design related assignments
- 5 Individual reflection report

At the start of the course, each student presents a summary and findings from two professional or scientific publications they read on the topic of collaborative design. This appears to be a very useful way to submerge the students in the problem domain of the course and stimulates them to be committed and get actively involved.

Then, design teams are formed and students start learning to collaborate in face-to-face design sessions and by communicating through digital media, either synchronously or asynchronously. This last form of working together urges them to organise their common and individual activities and tasks before they can actually start designing. Students are required to choose what form of collaboration is appropriate for the various circumstances.

The course is finalised by the writing of an individual report in which the students reflects upon their activities and experiences gained through the course and the assignments. The assessment of the students' work is based on this individual report.

### **Three approaches for collaboration assignments**

The differences between the three approaches concerned the formation of the teams, the contents of the design related assignments, and form of knowledge transfer during the lectures. The design related assignments always aimed at the design of a facility by a multidisciplinary team. The organisation of the design process was different over the years, and in relation with this also the teams were composed in different ways.

#### *Year 1 and 2*

In the first two years, the assignments and the format for knowledge transfer were the same. Only the team formation was different in the second year.

## Assignments

### Assignment 2 – Designing in a team

Write the functional specifications for the design in face-to-face sessions. In this assignment, students start acting their professional role in a multidisciplinary team and are able to concentrate on their well-functioning in the team.

### Assignment 3 – Designing in a distributed team

Design and select solutions for the functions of the facility in virtual meetings. Students continue to work in the same multidisciplinary teams, but cannot meet face-to-face. Focus is on how to design together on distance.

### Assignment 4 – Designing in a distributed organisation

All teams collaborate in finding an integrated solution. The objective of this assignment is to let students experience how collaboration is more complicated when the organisation becomes bigger. Within a team, collaboration is relatively simple. Collaborating with multiple teams is more complex. Rather than working from individual roles, the teams were now given new professional roles per team. So, as a team, the architects now need to negotiate with the engineers, and so on.

## Team formation

The teams were initially formed by selection by the lecturers. The students have a varying background, but always one in architecture or construction, so the professional roles were assigned to them in an arbitrary way. In each team five disciplines were represented.

In year 1 for assignment 4, the teams were maintained but given a new role, this time per team. This effected in a change of roles for most students, which required them to change their mindset for this last assignment.

In year 2, we decided not to change the individual professional roles for assignment 4. Instead, we decided to change the teams. On the one hand, this allowed the students to continue their professional role. On the other hand, it required them to adjust to the new teams.

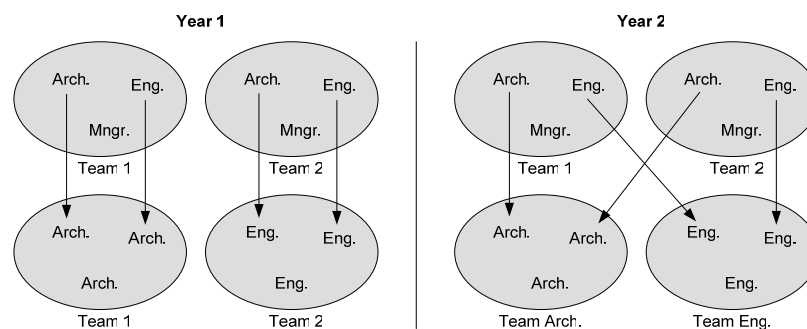


Figure 1 On the left, team formation in the first year: same teams, change of professional roles. On the right, team formation in the second year: new teams but keeping the individual roles.

## Knowledge transfer

Weekly lectures on topics relevant to the course, followed by a discussion of the progress in the assignments. The lectures included topics such as team-building, creativity techniques, tools for distant collaboration, design process management, contract forms, etc.

### Year 3

#### Team formation

In the past year, the process of team formation was changed once again. This time, the group of 40 students was divided into two consortia of five companies each. These two consortia 'competed' through the assignments to acquire the project commissioned by the lecturers who acted as principals. The design project commissioned was the development of a compact university campus with three departments, central facilities, and student housing.

The teams were not formed by the lecturers. Instead, only the directors of the companies were selected in advance; the other students then applied for jobs in the newly 'established' companies. This helped students to get committed and motivated for the job. Most students were graduate students, but part of them were post-graduate; from this latter group the directors were selected.

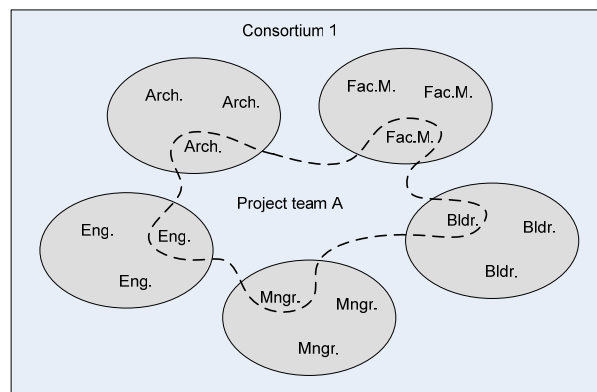


Figure 2 Team formation in a consortium: Initially, each team works as a company with the director as its representative in the consortium – Later, project teams are formed across the consortium.

#### Assignments

The assignments were also reformulated. The general objective with this year's assignments was to have the students build up the consortium and organise the design process with the aim to achieve the common goal of winning the design competition.

##### Assignment 2 – Project Management

In the first stage, each of the consortia was asked to discuss and formulate a project management plan. The focus in this plan was on information and organisation of their activities in relation with the time that was available.

##### Assignment 3 – Project Vision

This assignment required the consortia to define their vision for the project. In this vision, they were asked to express their interpretation of the principals design requirements and to translate these to organisational, functional, architectural, technical, social, and managerial concepts.

Assignments 2 and 3 were to be taken by the individual companies first and then to be integrated in to a single document at the consortium level. This integration was done by the management of the consortium, consisting of the directors of the companies.

##### Assignment 4 – Project Design

In the final assignment, the consortia were expected to further develop the architectural concept into a design proposal that was ready for presentation to the

principals. This assignment required the consortium to subdivide the complex design problem into smaller tasks that could be worked out by a number of project teams that were formed by representatives from each of the companies in the consortium.

For the final presentation, the results from these project teams needed to be integrated into a consistent plan.

### **Knowledge transfer**

In contrast with the previous years, there were no lectures offering a predefined body of knowledge to the students. Instead, this year we planned much more time for evaluation and discussion of the process and organisation in the consortia. Some 'mini-lectures' were given on demand or when during the evaluations the need arose for extra background, theory, or examples.

### **Assessment**

The students work for this course is assessed through a reflection report that students write *individually*. In this report, they summarise and analyse the collaboration process, but in particular also they reflect on their individual experiences gained through the course: to identify the learning process, the competences gained, what went wrong and what should have been done differently. An important aspect of the reflection was to discuss the importance of organising the design process and how communication tools can effectively be applied to support the collaboration when time is too limited for regular face-to-face meetings.

### **Course evaluation**

Evaluation of the course is done in two ways: informally by the lecturers themselves and in a structured way through an enquiry among the participating students.

The yearly evaluation by the lecturers has resulted in the adjustments to the course that led to the approach with the consortia as followed in the past year. A number of conclusions can be drawn from the current formula for this course:

- The literature review assignment is an important kick-off for the course, that submerges students in the domain quickly and deeply.
- Requiring the students to hand in their work through the document management system from the beginning helps them to get acquainted with this tool that is normally new for them.
- The self organising principle of team formation through the application process brings students together in an active manner very quickly and gets them motivated for the course from the first week.
- Starting the sequence of assignments with one on organising the design and collaboration process into a project plan is good in the sense that it makes students aware that such planning of a complex design process helps to improve the collaboration.
- On the other hand, this postpones the moment that students are actually involved in collaborative sessions, which is a very important activity to experience the different team roles as identified by Belbin (1993), e.g., Coordinator, Shaper, Team Worker, etc., and their role in creative thinking in a team, applying various creativity techniques.
- Changing the level of collaboration from the initial group level with only 4 or 5 members to a higher level between multiple of these groups is an important

addition to the complexity of the collaboration. Generally, within the groups working agreements and appointments for real or virtual meetings are relatively easily made. But the need to plan and organise collaboration in a more structured manner arises really when the complexity of the organisation is increased. Enforcing a more complex form of collaboration appears to be a crucial step in the learning process.

- The individual report is an essential means to assess the course, particularly since the assignments are mostly group assignments. A structural reflection (Reymen, 2001) is, to our opinion, the best way to assess the students' learning results. However, this is often a difficult and inconvenient task for students. While they are used to more general evaluations of group work, reflecting on their individual role, in relation to expectations and results, is much more challenging.

The course was evaluated by the students in every year. The overall appreciation of the course on a scale of 0-5 in the subsequent years was: 4.0 (year 1); 3.6 (year 2); 3.6 (year 3). Although the questions in the enquiry were not the same in all years, we can conclude that in the first year the students had a slightly higher appreciation of the relevance of the course and also thought they had learned more, as compared to the 2<sup>nd</sup> and 3<sup>rd</sup> year. This may be contributed to more attention for collective creativity in the first year, whereas in the third year there was more attention for the organisation and planning of the collaboration process. Students like the creative tasks better than the planning tasks. On the other hand, as lecturers we *observed* a higher learning effect in the third year, when more problems occurred, especially organisational problems, as the complexity of the process increased.

The reduction of lectures in the third year (only mini-lectures given as needed) made it less inspiring for students, according to the enquiry results, but did not decrease the stimulus for students to participate actively.

## Conclusions

Experiential learning is very effective in the education of collaborative design. This course has applied an effective combination of self-study, lectures, a strong focus on group assignments, and thorough individual reflection.

We conclude that it is very useful to build up the exercises such that first the *social* aspects are learnt and experienced, and then the organisational and ICT aspects are introduced in incrementally complex exercises. This way, students become aware of the fact that besides a professional role they also have a social role in the functioning of a design team in complex projects. Both types of roles need to be addressed sufficiently in courses of this kind.

It has proven to be important that the students experience the necessity of management and organisation of the design collaboration process. This becomes evident particularly when distance between team members starts playing an important role, when the need for using ICT tools in the process becomes more crucial, and when the complexity of the organisational context increases. When the exercises have a sufficient level of realism that can be related to the future practices of students, they offer a way for them to learn from difficulties they will encounter in the collaboration process and, in some cases, from conflict situations.



van Leeuwen, J.P., van Gassel, F. and den Otter, A. 2005. "Collaborative Design in Education - Evaluation of three Approaches." In Duarte, Ducla-Soares, and Sampaio(eds.): *Digital Design: the quest for new paradigms - proceedings of ECAADE 2005*. Lisbon: Instituto Superior Técnico. 173-180.

## References

- van Aken, J.: 2005, Valid knowledge for the professional design of large and complex design processes, *Design Studies*, vol. 26, p. 379-404.
- Belbin RM.: 1993, *Team Roles at Work*, Pfeiffer & Company.
- Dorst, K. and Reymen, I.: 2004, levels of expertise in design education, in Lloyd, P., Roozenburg, N., McMahon, C., Brodhurst, L. (eds.) *The Changing Face of Design Education: Proceedings of the 2nd International Engineering and Product Design Education Conference*, September 2-3, 2004, Delft University of Technology, The Netherlands.
- van Gassel, F., van Leeuwen, J., and den Otter, A.: 2004, Experiences with a course on collaborative design on distance, in *Proceedings of the 21th International Symposium on Automation and Robotics in Construction*, Jeju, Korea, September 21-25, 2004.
- Kvan T.: 2000, Collaborative design: what is it? *Automation in Construction*, 9(4) 400-415.
- van Leeuwen, J.P., van Gassel, F.J.M., and den Otter, A.F.H.J.: 2004, Teaching Collaborative Design in *Proceedings of the International Workshop on Construction Information Technology in Education 2004*, Istanbul, Turkey, September 7th 2004.
- den Otter, A.F.H.J. and Prins, M.: 2002, Architectural design management within the digital design team *Engineering, Construction and Architectural Management*, Vol 9(3), Blackwell Science Ltd.
- Reymen, I.: 2001, *Improving design processes through structured reflection, a domain-independent approach*, PhD thesis, Eindhoven University of Technology, NL.