ABSTRACT

Education in the Department of the Built Environment (Eindhoven University of Technology) aims to prepare students for multidisciplinary design teams. The Bachelor program offers a broad range incorporating essentials of urbanism, architecture, structure, building physics, real estate, construction, services et cetera. This broad BSc program lays a foundation for students and is followed by a Master program that focuses on specialization. There are six specializations: Architecture, Urban Design & Planning, Structural Design, Building Physics & Services, Real Estate Management & Development and Construction Management & Engineering. Multidisciplinary in the BSc is more than offering a variety of knowledge in courses and lectures. The Department also puts a lot of effort to train students to gain experiences in integral design teams. This takes shape in studios but is best expressed in the Multi-project (a semester assignment in the last year of the Bachelor). This assignment is organized by 9 coaches (from all specializations in the Master). The assessment is always a practice-based issue, and students have to cooperate as a design team during one semester. Developing the Multi-project has been a long route that took place over many years with several adjustments according to experiences and information gathered by student inquiries.

This paper gives a very global overview of the present setup to contextualize this assignment. After that, the main part of this paper focuses on the kickoff (first 2-3 weeks). Here students start in parallel studios, meant to put them on track for integral design. Each studio combines two disciplines and compels students to precede design by analyzing all kind of issues in the light of the specific assignment. Because of the complexity of this assignment we frequently ask students to fill in an enquiry. Because of this we are now able to draw conclusions from major changes during the last 10-14 assignments (2007 – 2013).

Keywords: multidisciplinary education; case study; integral design; organization of studio; coaching.

1. INTRODUCTION

Today’s building demands become more and more complex which necessitates academia to prepare students for a practice in which they are ready to cooperate in design teams in close interaction with all disciplines. To gain the most from this interaction requires an education of team workers who can put themselves in the position of other domains. A study of already a decade ago pointed at that time a great demand in building practice of broad educated engineers who have thorough knowledge of a specific discipline, but who are able to cooperate in a team (Clough, 2004). Ten years later this finding acquires additional significance.

Preparing a student to work in a design team requires more than providing knowledge of adjacent subjects and different disciplines. Book knowledge is yet essential, however enabling a student to gain actively experience in collaboration in an integral design team is considered a key to cooperation, as the proverb says: the proof of the pudding is in the eating (Swagten, 2010).

To school engineers in the built environment to become broad educated engineers with a thorough knowledge in a specific discipline, the Department of the Built Environment of Eindhoven University of Technology (TU/e) offers a BSc program with a broad range of courses incorporating essentials of urbanism, architecture, structure, building physics, real estate, construction, services et cetera (as indicated in Figure 1).
Each square in the scheme of Figure 1 stands for a course of 5 EC (European Credits) and equals a course load of 140 hour. A course lasts for one quartile (with 8 weeks of lectures / assignments plus 2 examination weeks). So a student attends 3 coinciding courses per quartile (commonly 2 lecture-based courses and 1 studio-based course). To enable more complex studio assignments most studio-based courses combine two contiguous blocks to enable semester assignments.

Squares in the scheme of Figure 1 with a solid frame represent common courses, while a square with a dotted frame represents that a student has an option. As can be seen 56% of the BSc-courses are compulsory courses of all kind of building disciplines, most to be found in the 1st year. 33% of the courses are studio-based.

In the 2nd year, students choose from three different studio assignments: Technical (emphasizing on structure and building physics in a spatial design), Design (emphasizing on urbanism and architecture in a spatial design), and Management (emphasizing on management and real estate in a spatial design). Here a student gets in lane for a later discipline, yet always in the context of the total building scheme. In the 3rd year, students work together in the Multi-project, which is explicated in the next paragraph. After that, the last studio assignment in the final semester offers 6 choices, to prepare students for one of the six specializations in the Master Architecture, Building & Planning (ABP): Architecture, Urban Design & Planning, Structural Design, Building Physics & Services, Real Estate Management & Development and Construction Management & Engineering.

In this set-up TU/e offers a broad BSc program to lay a foundation for students, followed by a specialization in the Master.

2. MULTIDISCIPLINARY ASSIGNMENT IN THE CURRICULUM OF BSC-ABP

The position of the multidisciplinary assignment (Multi-project) in the curriculum of the BSc ABP is shown in Figure 1. Learning goals, way of organization, supervising and coaching, and assessment procedures are described in (Moonen 2013a and 2013b).

The aim of this studio assignment is to train students with knowledge and experiences in integral design on practice-based design projects using Design-Based Learning (DBL). Design-Based Learning is developed to learn students to integrate and apply knowledge (Wijnen, 2000). Design-Based Learning elaborates on educational principles of Problem-Based Learning (PBL) (Graaff, 2003). Problem-Based Learning is based on the principle that essential knowledge will be acquired in courses, lectures, and small exercises and that this knowledge is used in studio assignments by using
realistic problems. Problem-Based Learning supposes that students develop skills and integrate knowledge by solving ill-defined problems (Kolodner 2003). Academia commonly use Problem-Based Learning in engineering education, however there are significant variations between different engineering domains, particularly in the characteristics of projects, the role of teachers and coaches, and in design elements (Gómez Puente 2013). Most of the architectural education is based on studio assignments (Goldschmidt, 2010). In a design studio, desk critics are given by a tutor and this is the major pedagogical method: Criticism is the act of making judgments and evaluations from tutors to students (Graham, 2003:18) to communicate design knowledge, and to bridge the gap from theory to practice (Salama, 1995:70).

The multidisciplinary assignment is always a practical assignment to train students in solving problems with the complexity of today’s practice. Another major point of particular interest is to learn students to cooperate in a team in which every student takes responsibility for a specific domain.

2.1 Structure of the multidisciplinary assignment

Figure 2 shows a schematic timetable (developed for sem. 2, 2008-2009, and still into use). This timetable follows the educational agenda of TU/e with 4 quartiles: 7 weeks with lectures, assignments, and studios followed by 1 week without lessons (enabling students to prepare for exams) and rounded off by 2 weeks with examinations. The Multi-project is a semester project, so there is always a break in the middle. This break disturbs the progress in design teams in some perspectives. However others also regard it beneficial to have a forced moment of contemplation at 2/3rd of the process. Yet having to split a complex process emphasizes an even stricter planning in addition to the complexity of teamwork and the complexity of students facing different interacting task and responsibilities.

Figure 2 shows the sequence of Multi: team design – individual elaboration on different disciplines – team presentation. This sequence has always been the backbone of the Multi-project right from the start in 2002. The intermission by discipline weeks enables a student to work on a specific part of the team design in detail, elaborated from the perspective of the students’ disciplinary responsibility. This helps tutors to mark individual results as well as team collaboration.

Workshop weeks at the outset of the scheme in Figure 2 are introduced in 2009. Before that, from 2002-2009, the studio started in the very first week with students in design teams. In those years there were quite a lot of complaints at the end of the semester. Most of the complaints came from students in technical disciplines (structure, building physics, building technology, and construction) and could somehow be traced back to the start of the project. Here students of technical and managerial disciplines put pressure on urban and architectural designers, since the other students had the idea that their work could only start after the outline of a plan was set. This often resulted in urban and architectural designers who were not allowed to start with a proper analysis by other team members. A corresponding effect was also noticed that technical students weren’t all that involved in the early design decisions (due to the time pressure) or didn’t yet have the adequate understanding to take in consequences of early decisions. In many design teams the technical consequences just reveal at the end of a semester, leaving little time to elaborate on solutions. Other complaints affected students of technical disciplines who assisted the urban and architectural students to speed up the design. This resulted in students who were largely involved in urban and architectural designing, leaving not enough time to pass requirements in their own domain. To withstand these negative effects, we introduced workshop weeks from 2009 on to enable all students to start with a good analysis in their domain, and to enable tutors to prepare students to stay involved directly from the start. How these workshop weeks are organized is described in the paragraph 3.

Figure 2: Scheme of timetable of the Multi-project with different phases and assessment deadlines (since 2009)
2.2 Student inquiries to keep a finger on the pulse of this multidisciplinary assignment

Because of the many complaints in the period before 2009 and the complexity of the studio, we have performed student inquiries in all semesters from 2009 (semester 2) until now. Unfortunately we don’t have many inquiries in the years before 2009. In all these years we were able to keep the questionnaire quite commensurable, which enables analyses of the effects of the measures taken over the years. Apart from the formal inquiries there are many informal interactions of students and tutors to keep grip on the effects and to keep improving the concept of this studio. One of the informal interactions is a feedback session of all tutors with the different design teams, where students are encouraged to suggest propositions to improve the studio.

The number of students that replied to the inquiry is shown in Table 1. Of course more students were involved in the different semesters because not all students have given a response to the inquiry.

Table 1: Number of students that answered the inquiry (not all participating students have given a response)

<table>
<thead>
<tr>
<th>Academic year</th>
<th>semester</th>
<th>total inquiries</th>
<th>urbanism</th>
<th>real estate</th>
<th>architecture</th>
<th>structural design</th>
<th>building physics &amp; services</th>
<th>construction / building technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2008: 2</td>
<td>sem. 2</td>
<td>45</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2008-2009: 1</td>
<td>sem. 1</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008-2009: 2</td>
<td>sem. 2</td>
<td>54</td>
<td>8</td>
<td>9</td>
<td>13</td>
<td>6</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>2009-2010: 1</td>
<td>sem. 1</td>
<td>51</td>
<td>4</td>
<td>16</td>
<td>20</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2009-2010: 2</td>
<td>sem. 2</td>
<td>52</td>
<td>6</td>
<td>12</td>
<td>21</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2010-2011: 1</td>
<td>sem. 1</td>
<td>45</td>
<td>5</td>
<td>6</td>
<td>19</td>
<td>5</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>2010-2011: 2</td>
<td>sem. 2</td>
<td>41</td>
<td>4</td>
<td>4</td>
<td>17</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>2011-2012: 1</td>
<td>sem. 1</td>
<td>44</td>
<td>1</td>
<td>14</td>
<td>17</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2011-2012: 2</td>
<td>sem. 2</td>
<td>62</td>
<td>4</td>
<td>10</td>
<td>29</td>
<td>8</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2012-2013: 1</td>
<td>sem. 1</td>
<td>42</td>
<td>2</td>
<td>8</td>
<td>22</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2012-2013: 2</td>
<td>sem. 2</td>
<td>55</td>
<td>6</td>
<td>13</td>
<td>23</td>
<td>5</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>2013-2014: 1</td>
<td>sem. 1</td>
<td>28</td>
<td>2</td>
<td>3</td>
<td>11</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

One item in the inquiry refers to the time table shown in Figure 2 with a question “Do you think the project has a clear planning?”. Results are shown in Figure 3 with a remarkable change at the start of academic year 2011-2012. Here the project description was improved and a detailed script was made to streamline the project organization, as well as a scenario for dates and requirements that need to be arranged including necessary reservations. This script is used ever since, and reflects in the score of students.

Figure 3: Result of the question regarding the planning in the student inquiries of 11 semesters
2.3 A project with many assignments

A requirement to exercise supervision over a complex process is to offer a strict time table (shown in Figure 2), a clear program for all assignments (Figure 4), and of course explicit instructions. The different assessment components, mentioned in Figure 4 are described in (Moonen 2013b) and also in (Proveniers 2009). The method of individual marking that takes into account the participation in team process and also team results (with different pieces to be assessed and many assessors from different disciplines) is described in (Moonen 2013a).

Figure 4: Flowchart of the multidisciplinary project indicating the assessment components

The photo in Figure 4 provides an impression of the most important pieces of work of a design team that is presented at the end of the semester in an exhibition. Apart from this there are disciplinary reports from individual team members (about 30 pages not including appendices) and a final oral presentation (Figure 6).

Figure 5: Exhibition of the design from one of the design teams, including 3 models, reports, posters, et cetera
This large number of pieces of work that can be evaluated provide the assessors of this project a more detailed idea of the result of an individual student (particular for the technical and managerial disciplines). And because many assessors work together (in this course up to 9 assessors for 60-120 students), the marking is less subjective due to the number of marked subjects and the consideration among assessors.

Figure 7 gives the results of a question in the inquiry regarding the assessment segmentation. The question that was asked read as follows: “Do you think that the different assessment moments had a positive effect on the way the design team progressed?”. The score over the many semesters is quite constant and acceptable (especially when one considers that the answer is in the perspective of imbalanced workload of team members due to the different disciplines involved).
3. WORKSHOP WEEKS

Figure 4 shows the place of workshops and Table 2 shows 6 themes with different combinations of disciplines with corresponding topics in a specific semester. As the figure and table displays, the theme of a workshop is always an interdisciplinary combination of two areas of interest. To provide every team with the relevant information that is gathered in one of the workshops, we ask each design team to point two delegates to attend a workshop. A design team in the Multi-project is in general made up with six students (covering the disciplines, urbanism, real estate, architecture, structural design, building physics & services, and construction & building technology). However we also accept that students pick a discipline they prefer. Because there are more students who are interested in architecture (and less students who are interested in structure or building physics) a students’ design team often does not incorporate all of the six disciplines. Also the total number of students in a semester hardly ever equals a multiple of 6, so the set-up of design teams differs quite widely. As a result, a workaround had to be developed for the Multi-project. Therefore, independent of the preference of students in a design team we expect that all six fields are taken into account in the integral result of a team (even though one or more disciplines are missing). However we do not expect a thorough study by calculations or other means of underpinning of disciplines that aren’t covered in a team. However, we do ask every design team to participate with two students in each workshop. With about six students per design team, this comes to an organization based on 3 parallel workshops.

When workshops were organized for the first time in the Multi-project (2009) there were 3 sessions of 3 parallel workshops and workshop weeks took 4 weeks in total. This worked quite well in the beginning (Figure 8), but after a while students started to object that the issues in the workshops were quite laborious and that workshop weeks took too large a part of the semester (leaving too little time for design weeks and disciplinary weeks). As a result we reduced the number of workshops from 3 sessions of 3 parallel workshops into 2 sessions of 3 parallel workshops for the 2nd semester of 2010/2011. And in the 2nd semester of 2012/2013 we further reduced the workload caused by workshops by reducing it to 2 weeks.

Table 2: Example of workshops with topics (in 2013-2014, semester 1)

<table>
<thead>
<tr>
<th>workshop nr.</th>
<th>workshop participants and topics</th>
<th>participating delegates</th>
<th>main topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Real estate / Urbanism</td>
<td>Function, markets, genius loci</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Technique / Building physics</td>
<td>Room conditions, climatic concepts</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Architecture / Architecture</td>
<td>Architectural concepts</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Architecture / Urbanism</td>
<td>Historical and morphological analysis</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Real estate / Architecture</td>
<td>Typological analysis</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Construction / Structure</td>
<td>Site conditions, building systems</td>
<td></td>
</tr>
</tbody>
</table>

3.1 Workshop weeks: Forced delay to bring about time to start with analyses by all disciplines

The main reason to start a Multi-project with workshop weeks was to force students to start in analyzing the problem before jumping into solutions. And also to take away the pressure from students with a technical or managerial scope towards students who were responsible for urban and architectural interventions. However, another important aspect of introducing workshops at that time in 2009 was to provide students with comprehensive information in respect to the specific problem of the assignment and the explicit context of the assignment. Therefore a system with workshops was developed to render a vast amount of information and knowledge. This takes place in a set-up with 20-40 students per workshop (depending on the number of students in a semester). The supervisors of a workshop (always a combination of two teachers with different backgrounds) prepare 10-20 issues that relate to the specific problem of that semester; to the appointed situation for the design; or to gain more detailed knowledge on relevant items. Each issue is worked out by two students and presented to the whole group in the workshop. After that, the results of the elaborated issues are projected on maximal 2 A-4. The supervisors insist that all documents are uploaded in a SharePoint (to give all student access to all summaries of results). The uploaded pages of an issue always carry the names of the investing students on it, to enable other students to get additional information in a later stage, if required. In this set-up the 20-40 students acquire a lot of information in the short period of 2-4 weeks that makes an ideal starting point in the design teams.
An additional advantage of starting an integral design process by workshops instead of starting with discussions in a design team, is that supervisors can emphasize technical and managerial students to participate in the early stages of a design. This is important because most decisions that are considered in an early stage have far-reaching consequences (when technical and managerial experts in a traditional process are hardly interested). From the moment that a common engineer is confronted with consequences of a decision (in a later stage) it is very difficult or even impossible to change this for the better. While a proper interaction in the early design phase can prevent negative effects (and often leads to better overall solutions). An engineer who wasn’t involved in the early phase has no other choice than to make complex interventions, often with a negative effect on the technical discipline as well as on the overall design. Supervisors in workshops can point students on aspects taken in the early stage that strongly influences one’s discipline. And also to come up with alternatives for this (which is difficult for inexperienced designers to do by themselves).

Figure 8: Response of students regarding the workshops

Figure 8 expresses the appreciation of students in respect to the workshops. Here students answered the question “Do you consider a Multi-project with workshop weeks an adequate way to start?”. The result of the inquiry is interesting because in the beginning of 2009 students really appreciated this. From the additional remarks to this question it can be concluded that the high score is for a large part caused by the fact that these students knew the situation before 2009 (from other students who took part in the old set-up). They appreciated the change to the start with workshops. After about a year the reference of the previous situation faded. From the remarks in the inquiry in semester 1, 2010-2011 can be concluded that students knew that there was a lot of work to be done in the design phase and that they preferred to have more time in design weeks. The Multi-organization responded to this and reduced the number of workshops from 9 to 6 in semester 2, 2010-2011. The appreciation increased, however the effect didn’t last for long. We tried to improve issues in the workshops in later years, but the result in the inquiry was marginal. In semester 2, 2012-2013 we reduced the number of workshop weeks (originally 4 weeks) to 2 weeks. Thus the last two semesters give acceptable scores (although one can argue if students do understand the advantages, because they, unlike students in 2009, have no reference of another start since this is their first multidisciplinary exercise).

3.2 Workshop reports: More pieces of work to evaluate

Another reason to start with workshop weeks were complaints of students with a technical focus in the years before 2009, who were assessed for a large part on the disciplinary report. According to the assessment method the technical report had to be more than 5,5 on a 10-point scale (Moonen 2013a). The consequence of a disciplinary report that is substandard means that this student fails, even if the result of the design team as a total is considered very successful. The complaints of students related to designs that took a too long time span, leaving not enough time for making a disciplinary report on technical subjects. And because this was the only piece of work that caused the failing of a whole semester project, this was considered an unfair treatment. By changing the set-up by adding workshop weeks we could create an extra piece of work that was to be assessed at the beginning (where a students’ result wasn’t affected by working under pressure of time).
Figure 9: Response of students regarding the topics in the workshops. The results of the question “Are there enough interesting topics in the discipline weeks for the discipline that you represent?” are quite acceptable and the improvements in the later years are appreciated.

3.3 Workshop organization: Practice based

The idea to use workshops in the organization of the multi-project was partly derived from the way design teams function in real practice. Here members of a design team originate from different firms of consultants. Members of a design team meet each other quite often if they have to solve a complex assignment, however in the intermediate time the members will elaborate on a discipline at the office of the consultant. Working surrounded by (disciplinary) colleagues offers the possibility to ask a colleague for advice. We try to copy some of this by starting in a workshop, where all students with the same discipline meet and discuss with each other. This enables students to ask others for an opinion if they meet difficulties on a certain aspects. This interaction between students is a very effective way to gain knowledge for the student who brings up an issue as well as for the students who explains a matter to others. However a too strong focus on this in the early set-up of multi resulted in a kind of conflicting situation when students of a discipline tried to help one another to “protect the discipline against the others”. This is one of the reasons why we don’t have monodisciplinary workshops anymore but interdisciplinary workshops instead. Interdisciplinary workshops also provide an opportunity for a duo of supervisors to collaborate and to serve as a model.

Figure 10: Effect on students in regard to integral design
4. CONCLUSION

Educating students to gain practice in integral design is complex and requires a specific studio set-up. Even though students feel the pressure of this complex process we consider it essential to start by analyzing. In the first set-up (without workshops) it was hard to realize proper analyses to start in a design team. In particular the students with a technical and managerial responsibility in the design team put a lot of pressure on the urban and architectural designers in the team to produce a plan. The technical and managerial students had the idea that their work could only start after the outline of a plan was set. So other team members didn’t allow urban and architectural designers to start with a proper analysis. Technical and managerial students had the impression that they didn’t need analyses as long as the plan was not set. A consequence was that technical and managerial students weren’t all that involved in the early design decisions. Or they didn’t yet have the adequate understanding to take in consequences of early design decisions.

By introducing interdisciplinary workshop weeks we were able to make duo’s of supervisors that serve as a model for students in the design teams. We also are able to force all students to start with analyses of the specific problem, the appointed situation or to gain more detailed knowledge on relevant items. This is realized by 6 workshops (2 sessions of 3 parallel workshops in the first 2 weeks). In a workshop 10-20 issues are elaborated in teams of two students and the results are presented to one another and also a summary of the results of two A4 is uploaded in a SharePoint. This procedure renders a vast amount of specific information and knowledge in a very short period.

For the urban and architectural disciplines it is evident that an analysis is needed; they get the proper time and an effective method to make analyses. But also for all other disciplines it is an asset to start by analyzing specific possibilities. This also helps to involve the technical and managerial disciplines to be involved in the early design where the most far-reaching decisions are taken. In this set-up it helps students to gain experiences with an integral approach in designing. By choosing which topics and issues are addressed in the workshop, different supervisors have to tune the focus of the problem to be solved by students to one another. This also gives way for supervisors to put students on the educational track that they have in mind.

Although students are eager to start with the design, and in some way consider that the workshop issues keeps them from designing, it is in fact a procedure that puts all students to work and learns them a lot about the assignment in an extreme short time span.

5. REFERENCES


