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# ORGANIZATION OF BSc AND MSc PROJECTS IN PROJECT FAMILIES

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## ABSTRACT

This work reports organization of student thesis projects in project families, with the benefit to both teaching and learning. The project organization went *from* student projects broadly distributed on topics related to different research issues and individual supervision *to* project families with closely related topics, group supervision in lab and weekly group meetings combined with individual supervision. The overall topic of all student projects was "Use of alternative ashes in concrete" and they were experimentally based. A key challenge in this organization of projects is on one hand to offer individual projects with students as project leaders and open problems and on the other hand fit each project into a well-defined frame. This challenge has been overcome and with positive side effects. The findings are based on experiences from families with up to 5 individual projects.

In the first part of the semester, the project family followed the same overall predesigned pattern. The students followed standard procedures and compared their special concrete with standards. The experimental procedures were taught to all students at the same time, releasing significant time for specialized academic supervision and enabling peer-instructions. This first part of the projects ended with a student poster presentation with participation of students from the project family, supervisors and other staff. The second part of the projects was designed by the students on basis of the poster discussions and followed individual approaches.

This way of organizing project families follows the basic ideas of CDIO. In the first part of the project technical knowledge and reasoning were major headlines. A knowledge platform was created from where untraditional ideas and enthusiasm grew. In the second part, the students' personal and professional skills and attributes were developed. They learned time and resource management, used engineering reasoning, took initiatives and were willing to take risks. This can also be met through solely individual projects, but in addition the organization of project families strongly supported development of interpersonal skills; teamwork and communication. The students continuously compared and discussed results and became comfortable in using professional engineering language, a point which was very clear at the final oral defenses.

From the very beginning the students were presented with clear research goals of the Zero Waste Byg team. They were welcomed into the research environment and knew their results were of great interest. They have expressed that this was a highly engaging factor. The project families have been a tremendous source for experimental results and scientific conference papers have been published based solely on results from project families.

## KEYWORDS

Student thesis projects, group supervision, students peer supervision, standard 7 and 8.

## INTRODUCTION

This work reports the experiences from organization the student thesis projects (BEng, BSc and MSc) into project families, with the benefit to both teaching and learning. The project organization went *from* student projects broadly distributed on topics related to different research issues and individual supervision *to* project families with closely related topics, group supervision in lab and weekly group meetings combined with individual supervision.

The projects were connected to the newly formed ZeroWaste Byg research group. The overall topic of all student projects in the actual case was “Use of alternative ashes in concrete”. Each project was experimentally based and focused on concrete properties obtained with the projects specific ash type. As the concrete properties are highly dependent on the ash characteristics in a complex and yet not well understood connection, each student project brought new knowledge and constituted a puzzle piece to the overall research plan of ZeroWaste Byg.

A key challenge in this organization of experimental projects is on one hand to offer individual projects with students as project leaders and open problem formulations and on the other hand to fit each project into a well-defined frame requiring the same type of experimental work and requiring answers to specific questions. This challenge has been overcome and additional positive side effects observed. This paper reports how the challenges were met and the positive side effects gained. The findings are based on experiences from four closed and one ongoing project family each with up to 5 individual projects (1-2 students in each), over a 2 years period.

## FROM ISOLATED PROJECTS TO PROJECT FAMILY

The authors decided to focus all projects on one, general topic “Alternative ashes in concrete” and to develop a new student project approach; project families. Our initial requirements to this project approach were:

For the overall project organization

- Enthusiastic and academic study environment
- Each project is individual
- Interaction and discussion between project groups
- Specific research questions are in focus for all projects in a family

For the learning process the students:

- Work with open problems
- Are active as project leaders
- Take responsibility of own learning
- Pass through the process of standard testing, evaluation of results and design a concrete with interesting properties on basis of this
- Put their findings into perspective in relation to technical and sustainability issues

The departments 250 annual projects students shall receive proper supervision and be able to choose relevant project topics. This is not necessarily easy achieved with the current allocation of teaching resources. It was decided that the development of the project family concept (fulfilling the overall requirements from us listed above) should also be evaluated on the use of resources related to the supervision.

Before initiating the first project family, one group worked with the use of alternative ash in concrete to evaluate and test the possible lab procedures. Following different compositions of project families have been tested:

Spring 2012: One standard group (BEng) testing the approach in order to later organize later projects.

Autumn 2012: Five project groups (one BSc project and four BEng) formed a project family, dealing with sewage sludge ash and municipal solid waste incineration (MSWI) ash. Focus was on strength development. Here the concept was tested on projects with fairly similar focus and with students at the same level of their education.

Spring 2013: Two BSc groups worked with co-combustion ashes from wood and straw in relation to strength development. Again the students were on the same level and the projects topics similar, but the number of groups less than the semester before thus the size of the project family could be evaluated.

Autumn 2013: Three project groups in the family (Two MSc projects and one BEng), dealing with use sewage sludge ash and corrosion of reinforcement steel in the concrete. Here the concept of project families was tested with students at different levels and projects of different numbers of ECTS.

Spring 2014: Five project groups (Two BSc projects and three BEng) – these groups are working on their projects at the time the present paper is written. The overall topic is on workability of freshly mixed concrete and early strength development. The groups are working with sewage sludge ash and wood ash.

The concept of project families has been and will in the future be reviewed with a questionnaire to the students at the end of a semester. The involved supervisors and lab technician have a focused meeting at the end of the semester in order to incorporate the gained experience.

## **OVERALL ORGANIZATION OF PROJECTS**

To obtain a structure of project families with individual projects but with closely related topics, the projects are separated in two major parts, see figure 1. In the first part the students learn how to perform different experimental standard procedures and evaluate the results, which enables them to detailed plan what they will focus on in the second part of the project. The transition from part 1 to part 2 is marked with a poster presentation. As the poster presentation is a common event for all projects in the family, all projects follows the same overall organization.

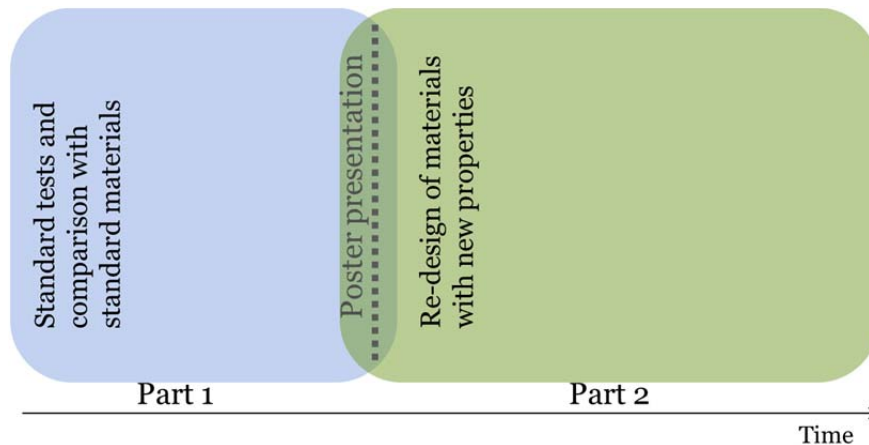


Figure 1: Overall organization of each project in two parts.

In the first part of the project, all projects in the project family follow the same overall predesigned pattern. The students follow standard procedures and compare their special concretes with a reference concrete (standard mix). The experimental procedures are taught to all students at the same time, and it is compulsory to the students to be present when the procedures are taught. Following the students conducted the experiments with their own materials. The students plan themselves when they want to carry out their experimental work, but there is a fixed deadline as the results must be presented at the poster presentation by all projects in the project family. The poster presentation has participation of all students from the project family, supervisors and possibly other staff and PhD students from the department.

The second part of the projects is designed by the students on basis of the poster discussions. It follows individual approaches, where each group decides an approach to utilize their initial results to design a new concrete recipe focusing on specific qualities and to overcome any shortcomings in their concretes performances.

### ***Purposes of poster presentation***

The purpose of the poster session is to support the mid-term assessment, including discussions with peers and supervisors of the projects. Another purpose is to establish a good basis for the students planning of the second part of the project. The poster session marks the movement from part 1 to part 2 of the projects and promotes:

- Mid-term evaluation of own results
- Peer discussions
- Communication strategy and focused aim
- Communication of results and problems
- Comparison of own results with others helping identifying interesting points for further investigation
- Students as project leaders
- Choice of individual focus for the second part of the project

## **CDIO PRINCIPLES AS BACKGROUND FOR THE CONCEPT OF PROJECT FAMILIES**

Engineers engineer is the underlying background for the CDIO Syllabus' content; that is, they build systems and products for the betterment of humanity. The basic principles of CDIO were chosen for the organization of the project families and support the wished student project approaches. With basis in the CDIO Syllabus (Crawley, 2002) the projects were organized so Part 1 focused mainly on “technical knowledge and reasoning” and Part 2 mainly on “personal and professional skills and attributes”. The overall organization in project families supports “Interpersonal skills; Teamwork and communication”. The building blocks of knowledge, skills and attitudes necessary to conceive, design, implement and operate (Crawley, 2002) are hereby built into the structure of the project families.

### ***Technical knowledge and reasoning***

In the first part of the project technical knowledge and reasoning were major headlines. A knowledge platform was created from where untraditional ideas and engagement grew. The concept of the project family provides the students with a good and effective start on their experimental work as the initial, basic investigations are similar for all projects and involves an initial characterization of the materials and provides initial, experimental results.

### ***Personal and professional skills***

In the second part, the students' personal and professional skills and attributes were developed. They learned time and resource management, used engineering reasoning, took initiatives and were willing to take risks. This can also be met through single projects, but in addition the organization of project families strongly supported development of interpersonal skills; teamwork and communication. The students continuously compared and discussed results and became comfortable in using professional engineering language, a point which was very clear at the final oral defenses. Through mutual discussions the students reached higher academic levels.

The major student skills developed in relation to the CDIO syllabus in relation to the overall project organization can be seen in figure 2.

The approach with a project family enabled the students to become familiar with more methods and techniques than with a traditional, individual project. A new behavior was also observed in the students activities, as peer-instruction took place in which the experienced students (who had already used the test setup) instructed the less experienced students (who had not used the test setup). The increased number of methods and techniques used, combined with the peer-instruction have no doubt improved the students learning and their communication of the activities.

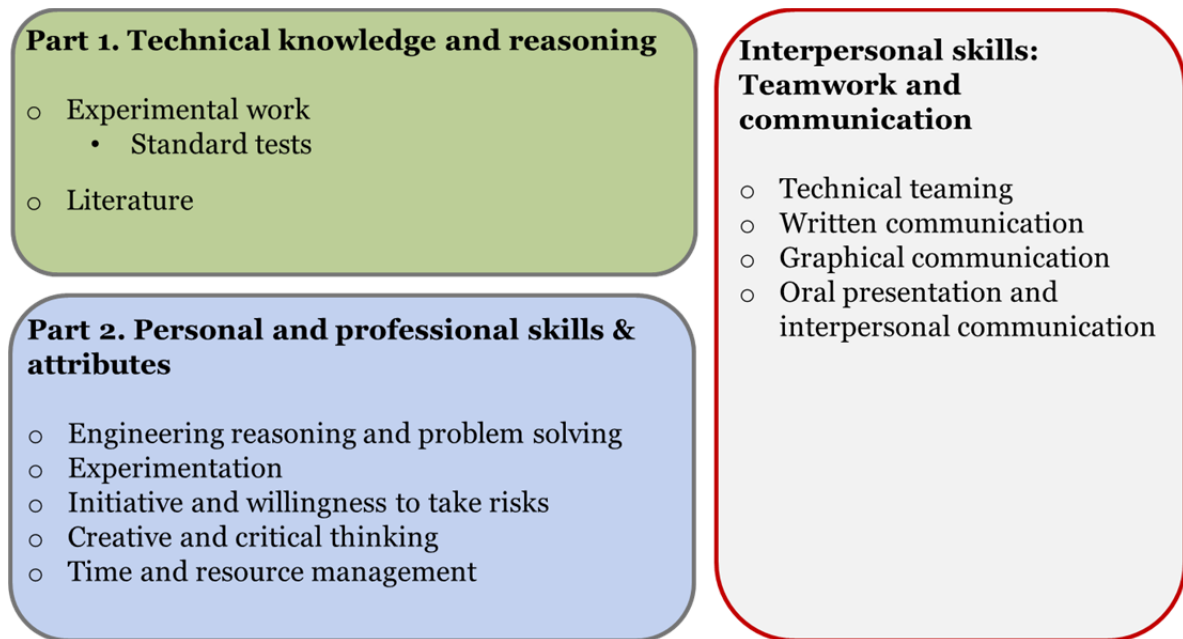


Figure 2: CDIO and organization of project family

Christensen & Hoffmeyer (2009) discuss the major requested competences from the newly educated engineers from the Technical University of Denmark. Both employers and graduates agreed that engineering reasoning, personal skills and communication are major competences. Actually this is in agreement of what was reported in (Crawley 2002). These competences are strengthened by organizing the projects in families.

## SUPERVISION OF PROJECT FAMILIES

Three major types of supervision were used: (1) Group supervision for all students in the project family, (2) Individual group supervision and (3) peer-supervision internally between students.

### **Group supervision**

Weekly group meetings are held with the project family. For some of the meetings the focus have been decided on beforehand e.g. lab work – what, why and how (in brief), the projects in a larger perspective, how to write the thesis. The students (and supervisor) set the scene for the remaining meetings.

The basic theory, societal relevance of the project as well as innovation related issues are presented and discussed with all students in the project family during group supervision. Also lectures about poster presentations and structure of a thesis are given to the whole group. Experimental procedures are taught to all students at the same time. This essentially lead to a reduction in the time spend by supervisors and laboratory personnel in instructions, supervision and organization of basic activities, test setups etc. As a result of this significant resources are saved and can be used for specialized, individual supervision, just as it created a good basis for peer-review and peer-instructions.

At the first meeting in the project family it is important to underline the necessity for the students to be open-minded towards cooperation in the project family to obtain optimal learning. It must in this sense be very clear from the beginning that there is no competition between the different groups in the project family. They are evaluated on the same scale of grades as all other students at the university and not on a special grading system for the project family. This means that they all can get the highest grade if they all reach this level. By knowing this, the students are fully open to cooperation and mutual exchange of knowledge.

### ***Individual supervision***

The need for individual supervision (one project group) is insignificant under the first part of the project, but right after the poster presentation the need is on the other hand pronounced as the specialization in each project is formulated here. During the second phase of the projects weekly meetings as well as individual meetings (ad hoc) are held. The supervisors collect the more generalized questions from these individual meetings, so they are brought to the group supervision meetings to involve all students in the discussions.

### ***Peer-supervision***

The students spend much of the project time at the university as the projects are experimentally based. In order for them not to waste time in between different lab experiments and in order to enhance the possibility for the students in the project family to fully utilize the possibility for collaboration, they are offered an open office close to the relevant lab. The office is open to all project students at the department, but has mainly been used by the project family students in most of the semesters. This facility forms a good physical environment for growth of a common enthusiasm among the students. Leadership from students in mutual planning of access to the lab facilities, peer-supervision of procedures some groups have performed others are going to. The students continuously share knowledge and experiences, which means that they get used to talk about the work (using the right technical words) and relate the results to others.

## **PROJECT FAMILIES FROM THE STUDENTS PERSPECTIVE**

From the very beginning the students are presented with the very clear research goals of the ZeroWaste Byg group (ZeroWaste Byg, 2014). They are welcomed into the research environment by the supervisor team and know that their results are of great importance and interest to the researchers, as they are heading into an uncharted area. They have expressed that this was a highly motivating factor for their choice of project and their activities (Questionnaire 2014).

The students found it also beneficial to have a project setup with two parts, one which secured an efficient start of their project with basic investigations to characterize the materials and a second part with full freedom to work independently, based on acquired knowledge in the first part. The students appreciated the concept, including the shared supervisions and the use of their peers.



The students have reported that their work and activities all benefited from the other projects and project students in the project family. The shared open office helped the peer review and peer instructions significantly.

The students did, of course, also enjoy their high grades (of those finished at the moment of writing this paper 14 students received an A and 2 received a C), which the approach helped them obtain. The students' performance in the rest of their study reveals that they have in average, received average grades in the rest of their courses and projects. These students are in other words average students and they have obtained grades for their projects above what that group would normally have achieved.

## **PROJECT FAMILIES FROM THE SUPERVISORS PERSPECTIVE**

The organization of projects in families has different distinct benefits. The supervision is always interesting as the students are enthusiastic and generally precise in their formulation of questions or points for discussion. They are very focused in especially the second part of the project. The teaching and learning atmosphere is inspiring.

The human resources used on the supervision tasks are much less with a project family of 5 groups compared to 2 groups, which again is less than supervising two standard groups (with different topics). The less human resources are a result of fewer meetings (as group supervision is used) and the peer supervision by the students themselves. As much as possible of the basic teaching (theory and experimental procedures) is taught in the project family and this releases more time for individual academic and targeted supervision.

The use of project families has been a great success. It will in 2014 be tested in all the department sections (at DTU Civil Engineering) in order to gain a broader experience in as many areas as possible.

## **STUDENTS WORK AS PART OF RESEARCH**

The project families have been a very substantial source of experimental results, testing of new approaches for improving and upgrading the ashes and the concretes. Scientific conference papers have already been published based solely on the results from the work in the project families. All project reports have so far contained interesting new information and have partly been used in these conference papers. The comparison of results in the project family of both reference experiments and experiments with the specific ashes allows a continuous quality control of the obtained results.

The use of project families have not only lead to improved learning, stimulation of peer-review and instructions, but have also established the student projects as a potential, major resource in the scientific work. The use of project families has accelerated the development in the ZeroWaste area as the students have conducted an extensive screening on the influence of different ashes with different characteristics on important concrete properties. Each student report is by the researchers regarded as a puzzle piece to build a broad knowledge on the topic. The use of project families have actually lead to results of such a magnitude that a semesters project family has a substantial impact and that it will be able to contribute, to change or even in cases solve real problems.

## CONCLUSIONS

Experiences from four closed and one ongoing project family each with up to 5 individual thesis projects (1-2 students in each) have been compiled. The organization in project families was organized so on one hand the projects are individual with students as project leaders and open problem formulations and on the other hand have well-defined frames requiring answers to specific questions.

The project in a family follows the same overall pre-designed pattern with two parts. Part 1 focused mainly on “technical knowledge and reasoning” where the students learn standard procedures and compare their results to standard materials and Part 2 mainly on “personal and professional skills and attributes” where the students assert themselves as project leaders. The overall organization in project families supports “Interpersonal skills; Teamwork and communication” and adding to this is a mid-term poster presentation which forms the basis for the specific problem formulation for each project’s 2. Part.

Both students and supervisors have positive experiences with project families. The students have reported that their work and activities all benefited from the other projects and project students in the project family. The supervisors experienced very enthusiastic students and that the requirement for human resources was less when running the projects in a family than as standard individual projects. The learning process for the students has been optimal, seen from the high grades given for the reports. The students were as group average students (when comparing their grades in other classes and reports to the rest of the departments students), but the grades for the reports conducted in the project families are higher than the average.

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## BIOGRAPHICAL INFORMATION

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**Pernille Erland Jensen**, Ph.D. is an Associate Professor in the Department of Civil Engineering at the Technical University of Denmark. Her current research focus is on environmental electro kinetics and technosphere mining. Her teaching activities focus on environmental engineering in the Arctic including curriculum development, and mentoring of young students on project management skills.

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