**Session 2003-1190**

# NEW MASTER IN ARCHITECTURE AND DESIGN WITHIN THE AALBORG PROJECT BASED LEARNING MODEL

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**ABSTRACT:** Aalborg University's thirty years of experience with project-organised and problem-oriented studies has proved by continuous assessment to be an important innovation in higher education. The curriculum in engineering as well as in natural science is project-organised from the day the freshman arrives until graduation. In the design-oriented project work the students deal with some degree of know-how problems which involve a great part of theories and knowledge acquired from lectures. In the problem-oriented project work the students deal with know-why unsolved problems in science and profession. The new master programme in Architecture and Design will be used as a case example with its unique use of problem-based learning methods. The programme started in 1997 and admits 110 students every year, it consists of a 2-semester basic programme, 3- semester common ground study-programme and a 5-semester specialisation programme. In the specialisation the students choose one of the following four specialisations: Architecture, Urban design, Digital design or Industrial design. The benefit of the problem-based learning method is given by some considerations about project work carried out within Industrial design and from continuous evaluation results.

## Introduction

Aalborg University (AAU) was established in 1974 as an innovative experiment in higher education starting with 2,200 students from three different schools. It is the newest university of the six universities and institutions of higher learning in Denmark and now it has more than 13,000 students. It was established to explore the project-based educational approach to overcoming some of the problems of the traditional course-based educational system [1], [2].

The majority of universities in the US are similar to each other in their educational, financial, and administrative approaches [1]. Aalborg University is significantly different in its educational, financial and administrative approaches to the operation of the university. Some of these differences are unique to AAU, but many are common to the Danish educational system and others to the European educational systems [1], [3].

The university will have grown approximately six fold in the first 30 years. Few doctorate institutions can claim this degree of success, and AAU is one of only two technical universi-

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ties in Denmark, which grant the doctorate degree. The four main goals of the project-based system are:

1. Efficiency: Reduce the waste as observed in the traditional educational programmes by reducing student attrition rates and by making the programme requirements such that most students graduate on schedule.

2. Quality: Increase students´ self-confidence, flexibility, creativity, and communication skills as well as increase their ability to work in teams.

3. Flexibility: Emphasise integrated problem solving, considering the social, economical and political aspects as well as the technological aspects.

4. Innovation: Improve faculty leadership abilities to supervise student project teams to solve interdisciplinary problems, as project advisors become "coaches" rather than lecturers.

The AAU model of project based education comprises of the concepts of problem-based learning and project work including:

- Problem orientation
- Experience-based learning
- Interdisciplinary learning/projects/lectures/courses
- Gradual specialisation
- Project work in groups

To emphasise learning instead of lecturing is the main idea behind both project work and problem based learning. Learning is the active process of investigation and creation based on the learner's interest, curiosity and experience and should result in expanded insight and knowledge skills.

Many US universities [1] have problem-based learning as part of their program, but this is not project-based education. Problem-based learning is a technique which utilizes problems in specific courses (modules, courses, programs, or curricula), but typically in courses at the undergraduate level to promote active learning. These problems are to cause application of the materials presented in the course and are in a team setting to promote discussion and alternative solutions. The problems, often called projects, are only portion of the individual courses and thus only a small portion of the total undergraduate program.

Project-based education at Aalborg has major projects throughout the program. The Freshman year has three projects and one of the primary goals is for the students to learn how to do group project work and work in teams. The projects after the basic year (freshman year) are evaluated at halve of the total semesters work, the dissertation at the hole semester work

As with more traditional educational systems, some of the important questions are:

- How to motivate the students?
- How to determine the elements in a curriculum?
- How to balance the different elements in the curriculum?

Some of the important questions related to the role of the lecturers are

- How can we make the lecturer-student contacts most efficient?
- How does the lecturing task comply with the research task?
- How can we connect different lecturing subjects?

The questions listed above are all open-ended; and we are also open-minded about the problem-based learning method. For more detailed information about this, I can strongly recommend [1], [2], [3], [4] and [5].

**Case: The new master programme in Architecture and Design and its study curriculum**

The new master programme is considered innovative and a combination of the best from traditional architecture and design curriculums and the best from traditional engineering curriculums within the frame of the AAU problem-based learning model.

| Name | | **Urban design** | **Architecture** | **Industrial design** | **Digital design** |
|---|---|---|---|---|---|
| Phases | Semester | Theme | Theme | Theme | Theme |
| Final | 10 | The dissertation project | The dissertation project | The dissertation project | The dissertation project |
| | 9 | Values and methods of urban design | Values and methods of architecture | Values and methods of industrial design | Values and methods of industrial design |
| Specialisation | 8 | Urban design in practice | Architecture in practice | Industrial design in practice | Digital design in practice |
| | 7 | Urban restructuring | Large buildings | System design | Augmented reality |
| | 6 | Urban development | Architecture and ecology | Integrated design | The digital space, virtual reality |
| | | | Courses | | |
| Common ground | 5 | Product design | Design methodology, Ergonomic, Mechanics, Strength analysis, Engineering design and mechatronic, Manufacturing, Choice of materials | | |
| | 4 | Settlement and urban planning | Consumption of energy and temperature conditions in buildings, Architecture, Town plan and history of design, Planning, Cad2 | | |
| | 3 | The urban building | City-house, Static and construction of buildings, Materials, Loss of heat and energy consumption, Light, Form and colour, Cad1 | | |
| Basis | 2 | Implementing a design | The body-anatomic adventure exploration, Shape and colour, Techtronic, Croquis, Mathematics | | |
| | 1 | Assessing a design | Space, Human and context, Co-operation, learning and management of projects, Architecture and designs, Information technology, Design | | |

**Table 1. Phases, semester themes and (some) courses of the M.Sc.; Programme in Architecture and Design**

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The main element of the pedagogical concept is study plans, which for each semester describes courses and prescribes a theme. Within the semester theme each supervisor together with a student group can choose a project. The project duration is calculated theoretically to cover half of each semester except in the final semester in which the project covers the whole term. In practice the students spend more time on their projects. The five years of education for a master degree is divided into four phases for gradual individual choice of specialisation. Table 1 shows the phases and the semester themes with examples of semester courses [6].

Most of the projects are carried out in groups of students; this allows for practising interpersonal communication skills. Unfortunately, resource constraints at our university often lead to relative large groups of students.

The use of the problem-based learning approach especially in engineering suggests that co-operation with private as well as public enterprises should play an important role for strengthening the link between academia and the professional world. Over the years personal and industrial relations have led to a number of different modes of co-operation of mutual benefit in other areas of M.Sc. programmes.

**Basic curriculum**

The main purpose of the basic year is to learn the basic skills for problem solving i.e. to work in a group, to understand that the team can help learning, clarifying the objectives. "The educational aims are to obtain a general project competence and to achieve a general methodical awareness, whereas in the rest of the engineering education the aims are focussed on specific technical and scientific objectives using the project work as a learning strategy" [7].

The first year comprises basic courses and project work with special focus on design. The basic curriculum includes core courses; two major projects, minor projects and several subjects which support students' project work.

Students determine a design in the first semester. The projects are based on the design of such objects as an industrial product, a building, an urban district or a multimedia product. The quality of this design and the ideas behind are assessed based on several different parameters, such as utility in practice, the aesthetic expression and the technical quality and durability.

In the second semester students design a product for a specific purpose based on the needs of a selected user group. This can be an industrial product or a product series, a small building with a narrowly defined purpose, an everyday object, an exhibition or an interactive multimedia product. Examples of projects

- design of an exhibition space,
- design of a product series for exhibition purposes,
- open urban space – idea, form and furnishings,
- a chair,
- furniture and the landscape and
- web design – a multimedia product.

The two semesters cover several core courses which are prerequisites for advanced study. These include design methods, form and colour, use of information technology, three-

dimensional computer modelling and multimedia. There are also courses in mathematics and mathematical modelling.

**The common ground curriculum**

Architecture & Design includes three semesters of common advanced study. Students learn fundamental skills in architectural design based on the interaction of function, aesthetics, technology and environment. The project work develops a solid spatial sense and the ability to provide elegant and durable solutions to complex problems through the synergy between systematic analysis, intuitive thinking, creativity and the art of construction.

The third semester moves on to the spatial scale of settlement and urban planning. Students work with the theory and methods of urban design, laying out of a district-plan, the design of urban squares, green spaces and residential areas. Courses focus on such subjects as community environments, analysis of urban architecture, settlement planning and geographical information systems (GIS).

The theme for the fourth semester is urban building. The projects address form, function, construction and building ecology, and include theory, methods, sketching and technical skills. The major project is supported by numerous core courses in theory and methods, design, building construction and three-dimensional modelling using computer-assisted design.
The fifth semester is devoted to product design, and particularly the process of design. The projects comprise the design and development of products and everyday objects at the human scale. The major project is supported by core courses related to design methods, and students achieve fundamental skills in ergonomics, construction, materials science and product development.

**Minor projects in the common curriculum**

The advanced courses currently offer the following minor projects, which are completed individually and supported by lectures and supervisors:

- residential lighting, emphasising the design of lighting fixtures,
- designing open urban space, focusing on furnishing squares in a new settlement plan and
- water and the bathroom, which addresses bathroom fixtures.

**Four lines of specialisation**

After the fifth semester, students decide whether to specialise in architecture, urban design or industrial design. Specialisation ensures that students acquire professional competence within their chosen field, and it aims at ensuring them a scientific basis for professional methods, as well as at acquiring insight into the science and art of management needed in their future occupations. Students become skilled designers and they can master the methods and tools of the trade. Nevertheless, they must also develop a critical perspective of their profession and seek new ways of creating cutting-edge excellence in architecture and design.

Each specialisation generally includes a major project and a minor project each semester. The specialisations continue an interdisciplinary focus through joint projects, courses, lectures, seminars, visiting professors and field trips.

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**Architecture**

The specialisation of architecture furthers professional work within the classical field of architecture and construction engineering. This includes applying creative architectural methods to large development projects, project design and construction management. The key is to learn professional methods for integrated project implementation from the artistic conception to the finished project.

The sixth semester focuses on architecture and ecology. Architectural principles are integrated and applied to commercial or residential construction with the themes of adapting architecture to energy and climate parameters, solar architecture and passive ventilation.

The seventh semester addresses large buildings. The target is the architecture and construction of such large buildings as concert halls, atria, railway stations or sports facilities which must fit into a sensitive urban context; for example, the town centre or a waterfront.

Architecture and building construction in practice is the theme of the eighth semester. The project is executed jointly with an architectural firm or public authority, and parts of the project can be carried out there as an apprenticeship. The purpose is to impart thorough knowledge of implementing a construction project, and the practical steps this requires. The project can also be completed outside Denmark and combined with enrolment at another institution.

The ninth semester is devoted to the values and methods of architecture. Students work together in groups on a theme chosen in close co-operation with a faculty supervisor. The project is required to innovatively tackle the methods or practice of known architectural issues and to deal with key theoretical or methodological issues within the chosen field.

The tenth semester has no instruction and is reserved for the dissertation project.

This specialisation prepares students for a career in for example architectural or engineering companies, public authorities and consulting companies.

**Urban design**

Students choosing the urban design specialisation work with urban development, urban restructuring and architecture at the city scale. This includes planning of new urban districts, technically and aesthetically renewing dilapidated residential or disused business districts, and applying architectural design to streets, squares, parks and large landscape features in and around the city.

Urban development is the theme of the sixth semester. The focus is development on a large spatial scale in the towns and city districts of the future. The focus is the architectural expression of the city, its functional aspects, the pressing urban-ecology issues and the relationship between the city and the landscape. This is an opportunity for students to advocate their vision of urban society in the future, in a frame of continuing growth of the world's population and of needing to drastically reduce the consumption of resources.

At the seventh semester, students consider urban restructuring and urban renewal in Denmark or northern Europe. The focus is narrowed to city centres, waterfronts or dilapidated residential and business districts, with analysis of urban architecture and urban renewal planning that

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promotes the participation of residents, owners and public authorities. The projects address the challenge of architectural and functional renewal in cities, and the protection of preservation-worthy buildings and districts.

At the eighth semester, students address urban design in practice. They prepare a project together with an architectural firm or a public authority, and part of the project can be carried out as an apprenticeship or trainee period. The aim is to develop professional skills, knowledge and attitudes in preparing and implementing urban plans. The project can also be carried out outside Denmark and be combined with enrolment at another university or school.

The ninth semester is devoted to values and methods in urban design. Similar to the other specialisations, its purpose is to reinforce abilities in mastering theory and methods, and in developing professional concepts.

The focus at the tenth semester is solely on the dissertation project.

This specialisation prepares students for working in the planning divisions of large municipalities, in architectural and engineering companies, in urban renewal companies and in consulting companies.

**Industrial design**

Industrial design is both a creative process and a professional method of work that integrates skills in aesthetic design, analytical ability and technical competence in developing products from idea to production and marketing. Skills in, and knowledge of, design are combined with a broad knowledge of technology, ergonomics, materials, environmental protection and management.

Integrated design is the theme of the sixth semester in this specialisation. Students develop and innovatively explore the design of intelligent products or workplaces that integrate a consideration of human physiology and sensory capacity with new information technology and the use of environmentally benign materials and manufacturing processes.

The seventh semester takes up system design. The students focus on a design series or line which explicitly draws on the resources and needs of a specific cultural group. The programme addresses lifestyles and design as pillars of human culture. The specific product designed should further develop the integrated design process by optimising functional, technological and aesthetic parameters.

Students focus on product design in practice at the eighth semester. The project is prepared in co-operation with a company, and part of the project can be carried out as an apprenticeship or trainee. The purpose is to develop advanced knowledge of the preliminary stages of product development, and of how to organise product development in a company in practice. The project can also be carried out outside Denmark and be combined with attendance at another university or school.

The dissertation project is completed at the tenth semester, which has no courses.

This specialisation prepares the student for professional tasks in architectural and engineering companies, public authorities and consulting companies.

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**Digital design**

Digital Design is a new specialisation under planning. Focus will be on design of virtual space and architecture, interactive 3D images of real world and intelligent products. It embraces interdisciplinary subjects within 3D modelling, virtual reality, simulation and animation. The specialisation addresses against a fast growing information and media industry but also the education's possibilities of employment.

The sixth semester deals with the theme; the digital space, with focus on interactive virtual reality models, animation etc.

The theme at the seventh semester is the augment reality, with focus on simulation, interface and interaction, primarily looking at intelligent products.

The eight semester covers with the theme digital design in practise. The project elaborates in co-operation with an enterprise or a consultant enterprise. A minor part of the projecting period can be carried out there. The aim of the semester is to create basic knowledge about the practical organisation of virtual design and media production.

The ninth semester deals with values and methods in digital design. The substantial demands of the project are to look for new ways, or solutions to complex ways of presenting problems of design related to key theoretical or methodological issues within the chosen field.

The dissertation project is completed at the tenth semester, which has no courses.

**Minor projects**

At each semester one or two minor projects are offered to all three specialisations. Recent minor projects include

- space and form in relation to such tasks as exhibitions,
- urban architecture and design outside Denmark, with field work in Thailand and other countries,
- multimedia design and professional communication, in which the students design an electronic portfolio,
- bionics, with design based on nature's own principles of construction and
- the impetus in which students develop proposals to improve public and private townscapes.

**Internationalisation**

To reinforce the international dimension of their education, students can spend a semester or more at a recognised university or school of architecture outside Denmark. Aalborg University has agreements with more than 150 universities, so the opportunities to study abroad are good.

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**Project work within industrial design**

Industrial total design is [8], [9] seen as a broadly based business activity in which specialists collaborate in the investigation of a market, in the selection of a project, in the conception and manufacture of a product, and in the provision of various kinds of user support.

Total design [9] incorporates an understanding of creativity, innovation and design, the design of organisations, open systems theory, the effects of environments, design as a collective decision making, stages in design, stages in contexts of innovation, the business design boundary, models of small group performance etc.

The condition for establishment of product development is the creation of enterprise goals and strategies. The strategy creation is in itself a design activity – the student represents a "one-man enterprise" with own goals and strategy.

Experience shows that you have to be careful not to press the students too hard in the practical choice among possible projects, because if you do, the final result will seldom be good. On the other hand student projects will often form a research project or it can be a part of an already running research project. Therefore, apart from the good relationship between the supervisor and the students, the supervisor will often have a personal interest in the project.

When working with basic science problems e.g. physical problems, the result is independent of time. The result is either right or wrong. This is not the case with solutions to projects.

A project, however, deals with the future stated or explored. Projecting is to "throw something forward" (Project from Latin, Pro- (forward) + iare (throw)) [10]. The demands to a project solution always include requirements from the future in which the solution shall be carried out by manufacturing or implementing processes. The demands include requirements also from that future in which the solution is expected to be useful. The projects themselves include the future again also even if the whole work is made in the laboratory of the university.

However, about the future nobody knows except by forecasts, by hypotheses, in the form of theories eventually in the form of extrapolations of statistical material.

That gives a completely different role to the supervisor of students' projects than the traditional role of a lecturer spelled with capital L. A supervisor of a project is like an older scientist working together with younger persons with less experience, like the situation known from supervising Ph.D.-students for example. In both cases we are within an open - and for the supervisor as well - partial new area.

The demand from the project work is [10]:

- Ability to perceive a complex situation in a systematic way, and from those observations identify and envelope the main elements.
- Ability to identify possibilities and limitations of methods usable to maintain those elements together with their interactions.
- Abilities to handle such methods in a scientific way.
- Ability to look for additional knowledge also outside subjects taught in courses.
- Ability to use such knowledge, perhaps with help from the supervisor.

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- Ability to include calculations or evaluations of consequences and hereby find the optimum among the potential solutions.

As seen the conditions are very much like those in research work, only the level is lower, depending on the stage of the student's studies.

That means the lecturing must include a high methodological training, and the subject/courses must include consciousness about methods belonging to the subjects together with possibilities and limitations of the methods, e.g. using a dynamic approach dealing with four central design and manufacturing concepts [11]: Contingency, problem solving, knowledge and learning.

Always remember that the project is not the goal, only a means to strengthen student excellence.

The project evaluation at AAU is a rather unique process. The students give the project evaluator the report at least two weeks before the project defence. This gives time for the students to prepare for their defence and the project evaluator (external at least in connection to four out of 10 semester's evaluations) time to thoroughly review the project. The defence starts with each team member preparing a part of the oral presentation, which takes a total of one hour. After the oral evaluation, the project evaluator gives the project an overall grade while the students take a break. The evaluator goes over the report and the project course materials and asks the students individual questions, and depending upon their responses will raise or lower their grade from the overall project grade. This questioning takes at least two hours and often three to five hours before the evaluator makes his final decision on the individual grades. The students take a break while the evaluator discusses his evaluations with the project supervisor. The students come back and the evaluator tells the students their final grade and responds to any comments the students may have.

**Experience and results**

The engineering education in Aalborg [5] has been evaluated and compared with traditional engineering education. This was done by two international panels, as well as by external examinators, alumnus and their employers and undergraduate.

The evaluation assessed that there were no differences in quality or level between engineers' graduate from Aalborg University and The Technical University of Denmark. But, the evaluation also assessed significant differences between the profiles of the graduates from the two Danish engineering universities. The engineers from Aalborg were assessed to be stronger in problem solving, communication, co-operation and general technical knowledge, while the traditional engineers from DTU were assessed to be stronger in specialist knowledge and technical methodology.

As mentioned above, the curriculum in architecture and design as well as in engineering and in the natural science is project-based organised from the day the freshman arrives until graduation.

The university-industry interactions have great potential for mutual benefits when keeping in mind that there are two different worlds; industrial enterprises and academia. The benefit of the problem-solving approach contributes to the identification of the core competence of the university and thereby raises new problems to solve. Most of the projects are carried out in groups of students, which allows for practising inter-personal communication skills. Unfortunately, resource constraints at our university often lead to relatively large groups of students.

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The projects on which the students work how different they may seem have some common characteristics with the professional world's projects [12]:

- they are complex – in the outline to take complicated systems connections and the interplay between people and technique into consideration,
- they are characterised by development – in the outline of finding new solutions and try new ways,
- they demand a interdisciplinary effort, where students and supervisors with different professional knowledge have to be involved in the solution of the project,
- they demand an interorganised effort from different departments and orders in the outline of resource contribution, acceptance etc.,
- they are subject to a multi-organised interest, i.e. that more departments, institutions, groups of employees take interest in the project and the solution,
- they have a considerable extent according to human resource, expenses and economic results,
- they are guided to a result of essential extent and importance – in the light of relations to a number of people who will be affected, and to the result's functionality (lifetime) and economic influence.,

The above characteristics naturally involve special attention to reflection and awareness of the potential possibilities and resources in connection with human, social and technical dimensions in a necessary interplay between innovations, development, decision and executing processes.

The risk of a close co-operation between university and enterprises is that the studies and student groups can seem like free consultative partners and with short term solutions only. The risk would be a lower scientific but more pragmatic level of the studies.

In general, the enterprises have a considerably shorter strategic perspective than that necessary at a university or other higher educations. Many small and medium size enterprises have a high degree of product development and product adaptation. Here, the expression 'product' is used in a very broad meaning which includes also service-products.

However, by nature such small and medium size enterprises have only little tradition of doing research work, if any at all. Even rather big enterprises are looking for solutions ready to cook, or at least solutions developed from already existing results of basic research.

That means, if a university is based on enterprise projects alone, the basic research together with the students´ training in fundamental scientific methods will come to starve

The general conclusions we have reached are as follows:

- Students are well-motivated to work harder and achieve success.
- Student progression rate in the project-led education is more rapid and decisive than with the existing traditional education. Suitable students progress faster through the curriculum, and unsuitable students are identified early on and encouraged to follow other more suitable courses.
- Nearly 80 percent of the students graduate within the planned 5 years
- We have almost met our target for progression of suitable programme through the first graduates.

- There remain a few lecture courses where the success-rates of even the able students is not satisfactory: this is being handled by a fundamental review of the teaching of these subjects, and we are confident that the situation will improve.
- We are not entirely satisfied with the range of projects: there is substantial support for 'design' and for 'push-and-pull', but 'hot-and-wet' projects are under-represented. To some extent this situation represents a balance of interests and available resources.
- The graduates achieve great experience in interdisciplinary teamwork and they will normally posses the latest scientific and methodological knowledge, which is thus spread quickly and free of charge to both public bodies and industry, due to the employment of new graduates.

We can until now state by continuous evaluation by examinators, alumnus and their employers that the new master programme in Architecture and the Design is an innovative supplement to traditional education in these areas.

## Summery and conclusion

The Aalborg problem based learning educational system [5] has over nearly 30 years proved to have great internal flexibility and adaptability. It has not been difficult to adjust and change the educational programmes in accordance with developments in technology, society and economy. We can now contribute with a new integrated programme of Industrial design and digital design with architecture and engineering. The system is in it its approach innovative and should be able to cope with current problems in professions and in society.

The system has also shown great external adaptability. The graduates are well prepared to solve unknown problems of the future and to extend their professional work outside their major.

The results and experience of the research which is carried out at the university is easily incorporated in the teaching programmes because of their close relationship to problem-solving, and because of their direct integration with the educational systems and its programmes.

The graduates achieve great experience in interdisciplinary teamwork and they will normally posses the latest scientific and methodological knowledge, which is thus spread quickly and free of charge to both public bodies and industry, due to the employment of new graduates.

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