4th International Symposium on
Product Development in Engineering Education'98
Lohmar, Germany 10-11 December 1998.

Experiences with the new educational model "Integrated Product Development" at the University of Karlsruhe

Prof. Dr.-Ing. A. Albers and Dipl.-Ing. Norbert Burkardt

Institute for machine design and automotive engineering,
University of Karlsruhe (TH), 76128 Karlsruhe , Germany, www-mkl.mach.uni-karlsruhe.de

Keywords: Engineering Education; Integrated Product Development

Abstract

The increasing complexity of product requirements combined with a customer tendency to more simple and profitable solutions needs the integrated use by the design engineers of targeted combinations of organisational, technical and systematic tools based on an holistic view of the entire product development process. The education of design engineers has to react to these new professional requirements and excellence in professional competence must be generated. The education of mechanical engineering students in machine design can make decisive contribution in obtaining technique and social competence for later success in study and profession

At the University of Karlsruhe the Institute of Machine Design and Automotive Engineering has constituted the new central subject called "Integrated Product

Development" in order to take up these challenges and to translate them into an educational concept. This paper will present the basic course content and methodological approach and will describe our initial experiences with this new educational concept.

1. Introduction and Motivation

Successful product development leads to competitive products and safeguards both the existing and future market position of an industrial concern. The present market situation can be described as having

- Short product life cycles
- Lower price expectation for even higher standards of quality
- Growing requirement for more specialised products
- Short product launch cycles

The conditions for a successful product under these demands is a complete holistic view of the total development process from market demand to product launch (Fig.1) described with the term **"Integrated Product Development"**.

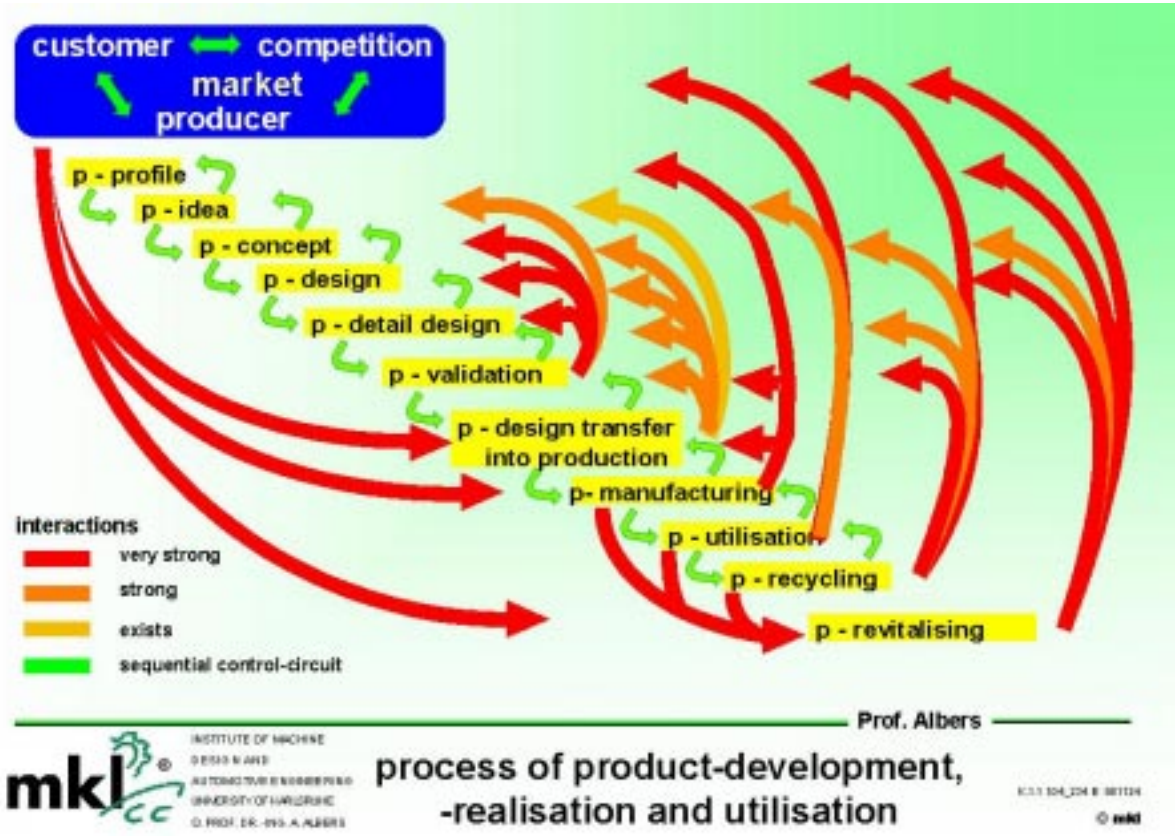

Figure 1: Product Development Process

This development philosophy is based fundamentally on the creation of multi-disciplined project teams with the ability to quickly adapt to the step changes in a dynamic marketplace and to possible fundamental changes in base technologies. This requires all the members of the development team to personally identify with the development process and to be organised so that all relevant data is to hand. Therefore new requirements are growing up for qualification, particularly to the combination and the weight of competence by design engineers (Fig.2). Required is an outstandingly creative and flexible engineer, able to think about the task “in the round” and fitted out with management skills – a specialist with the ability to act as a successful generalist. Competence in the fundamental technologies, social interaction, and design techniques are the essential core qualifications of a design

engineer which up to now have not been taught in a traditional university curriculum in the broadness required.

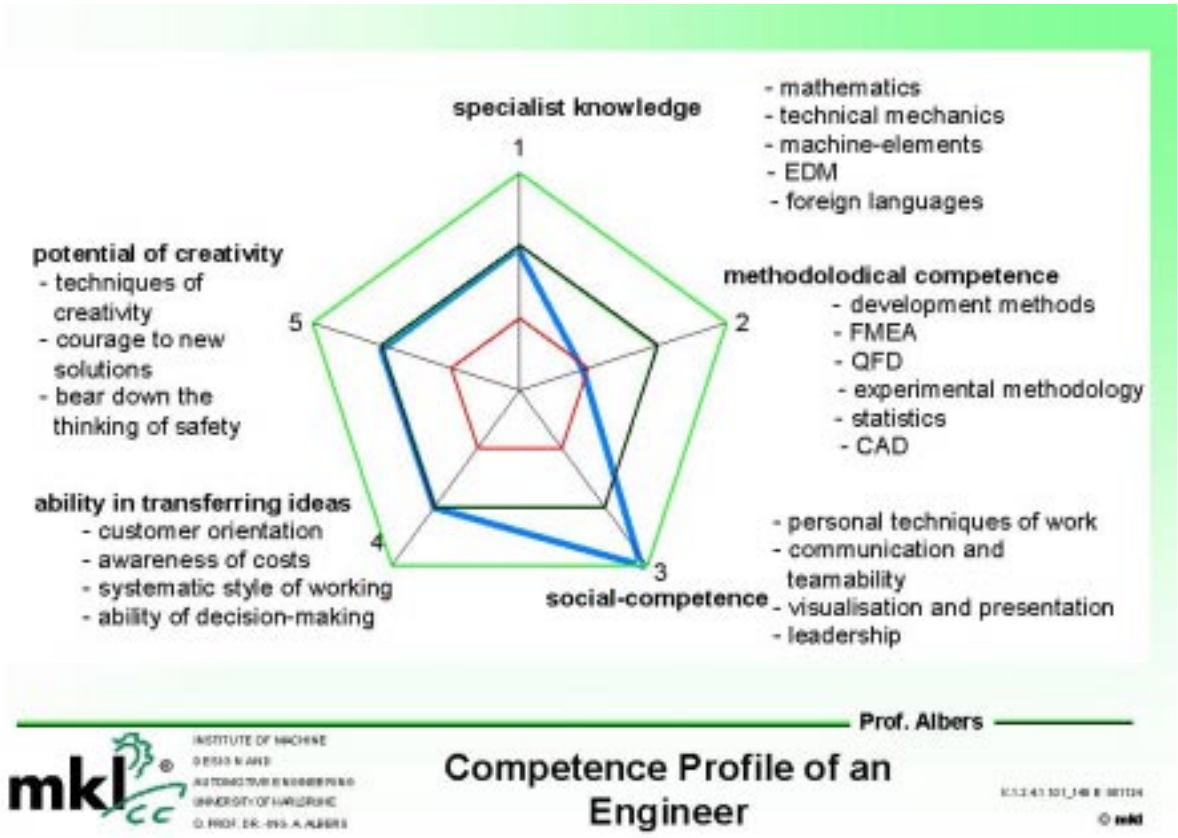

Figure 2: Competence Profile

The university education of design engineers has to react to these new professional requirements and an adequate professional competence must be generated.

At the University of Karlsruhe the Institute of Machine Design and Automotive Engineering has constituted the new central subject called “Integrated Product Development” in order to take of this challenges and to translate them into an educational concept. This paper will present the basic course content and

methodological approach and will describe our initial experiences with this new educational concept.

2. Education Objectives

The education objectives can be structured as follows according to the core competencies required for development engineers:

2.1 Competence in Fundamentals:

The traditional university education provides a broad fundamental engineering knowledge and offers discipline specialisations. The limits of these specialisations must to be reconsidered and varied, where necessary, to achieve an integrated process of development. For the development engineer it is necessary to consider technical, economic and organisational systems in terms of the complexity of the product, heterogeneity of product components (mechanical, electronic, hydraulic, data processing etc) and their combination into a superior marketable product.

The ability to analyse problems, develop solutions, fashion work stations and processes is an essential part of the competence in fundamentals.

The continuous updating of information about development relevant materials and components from trends in market and research requires an efficient strategy for information procurement, data processing and the readiness for a Life-Long-Learning even beyond all “Comfort Zones” of individual specialisations. The split between a product specific specialisation on the one hand and the integrated development process on the other hand requires an efficient management. Internal processes regarding information, planning, decision making and execution are to be co-ordinated in order to avoid loss of time, misunderstandings and errors which can

appear across specialisation interfaces .This management task is not the job of the project manager by himself but part of the working process of the whole team.

The following educational objectives have been derived competence demands outlined above at the Institute of Machine Design and Automotive Engineering. They are developed to teach the following ways of thinking and their correlation:

- Process thinking - Product development as a process chain
- System thinking - Product development as a systematic process
- Innovative thinking - Product development as an innovative process
- Problem thinking - Product development as a problem solving process
- Integration thinking - Product development as an integrated process
- Organisation thinking - Product development as a management process
- Cost thinking - Product development as a cost optimised process
- Time thinking -Product development as a time optimised process
- Customer-/Quality thinking - Product development as a customer-oriented process
- Market Thinking - Product development as a market-oriented process

Social Competence

A successful integrated product design is based on a goal-oriented and innovative culture of dialogs in enterprises with the following kinds:

- Problem-solving culture:

  Seeing problems as a chance and challenge to think of possibilities instead of difficulties

- Constructive error culture:

  Solving conflicts co-operatively, analysing causes, initiating perspective variation

- Creative culture:

  Promoting flexibility in thinking, creating bases for cross-functional thinking, imagination, creativity and inventive chaos

- Fractal culture:

  Employees as responsible, self-controlling, closed-loop control systems in the product development process

- Courage-of-conviction culture:

  Promoting constructive obstinacy and courage of conviction, breaking moral cowardliness and hasty uncritical acceptance.

- Comfort Zone culture:

  Application of the employees in accordance with their talents and interests, Promoting fun

A distinct communication behaviour of employees is necessary for a dialog culture described above. Decisive here is the outwardly directed behaviour of the participants in co-operation with other colleagues involved in the development process. The educational objectives which cover all these requirements are:

- Communication ability

- Co-operation ability

- Ability to resolve conflicts

Methodological competence:

The Institute of Machine Design and Automotive Engineering defines “Method” in this context as tools (Fig.3) required for the technically and socially competent development engineer to convert steps of the product development process into real concrete progress in the generation of a target product

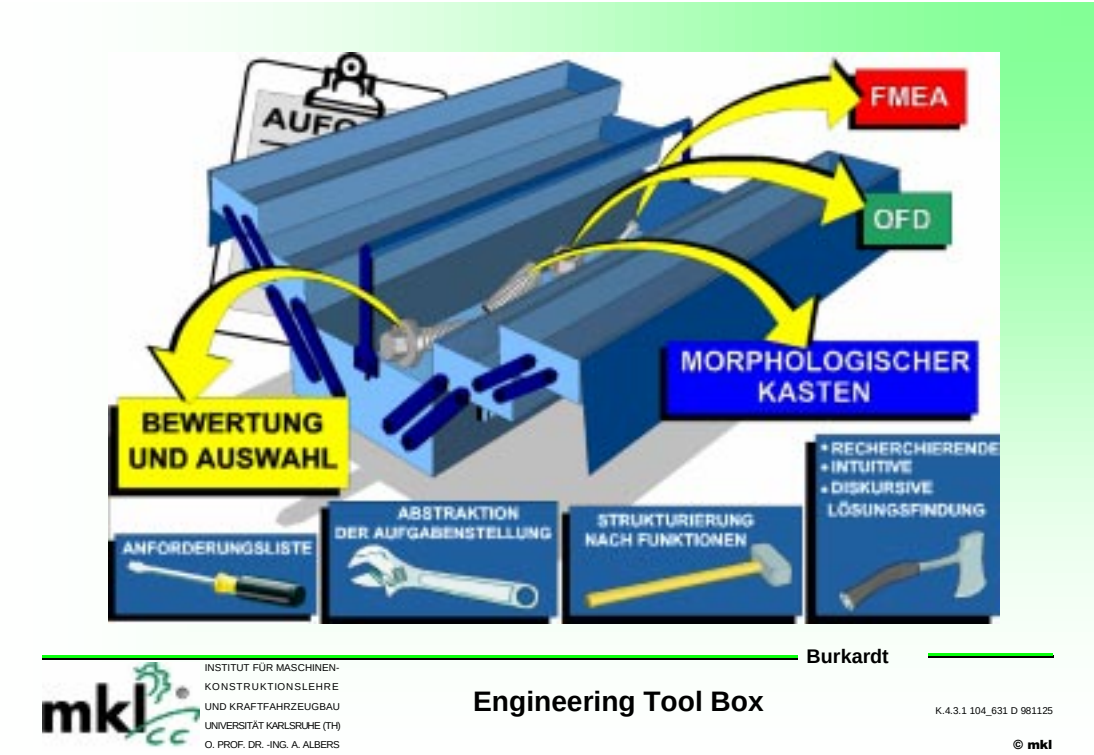

Fig. 3: Engineering Tool Box

The support of these tools to translate the product idea from the product concept and -design to product manufacturing and -recycling is an important requirement for an efficient treatment of the development processes

Therefore the following education goals are defined by the Institute:

- Teaching approved techniques in compatible to each process step of the product development process

- Teaching criteria to select efficient techniques

- Teaching application experience and safety

3. Conversion of educational goals.

The education model “Integrierte Produktentwicklung / Integrated Product development“ of the Institute of Machine Design is structured in three units:

1. Lectures (4 hrs / semester week)
2. Workshop (3 hrs / semester week)
3. Project work (120 hrs total)

They are offered parallel in the winter semester as a main subject. The education schedule is shown in Fig. 4.

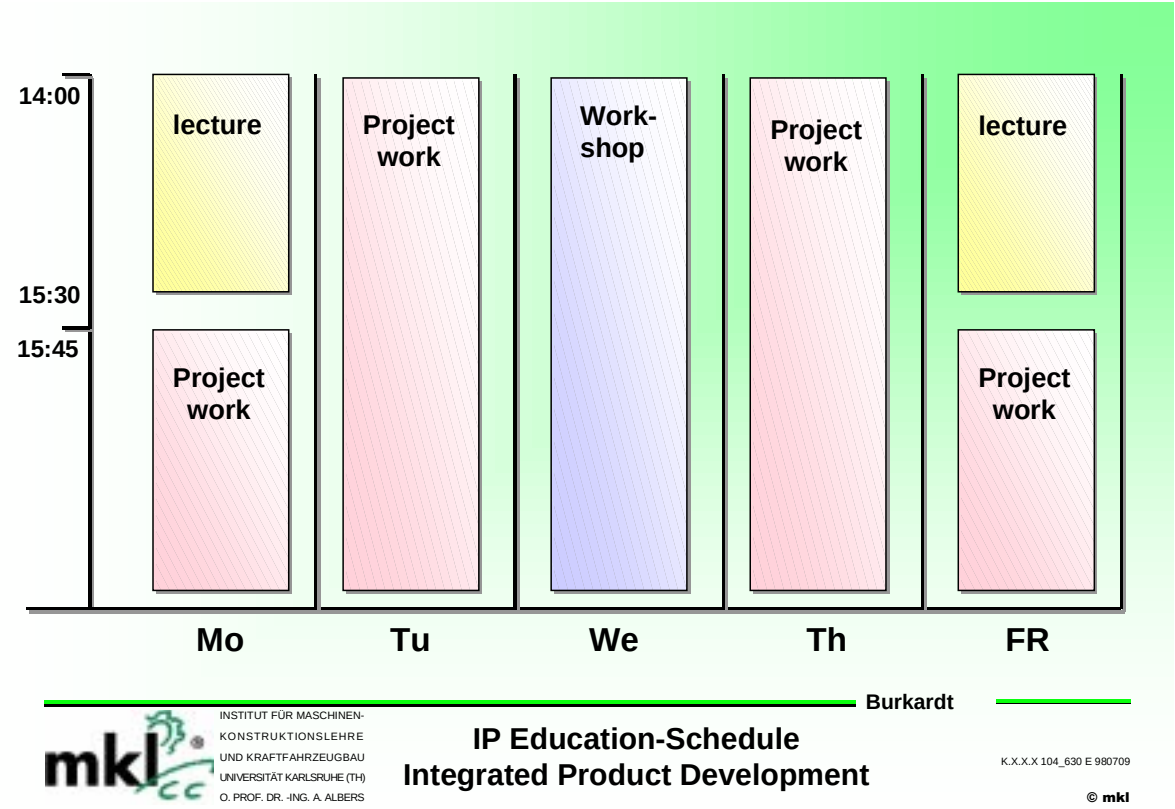

Fig. 4: Educational Schedule

3.1 Lectures

The Students are introduced to product development of enterprises in lectures with particular reference to the requirements of small and medium sized companies.

Based on practical experiences and examples from industry, the theory of systematic planing, design, cost control, and management of the development and innovation process is introduced and discussed as a team-oriented adoption of effective techniques viewed a problem solving process (Fig. 5).

Strategies of development and innovation management, system analyses and team leading are presented and discussed. The lecture is designed for a limited number of participants (est. 20 students). and is a break from traditional lecturing

arrangements. This offers the possibility of teaching in discursive form with the use of multimedia tools to aid presentation of the lecturer subject. If necessary the official time allotted to lecture can be relaxed to enable open-end discussions.

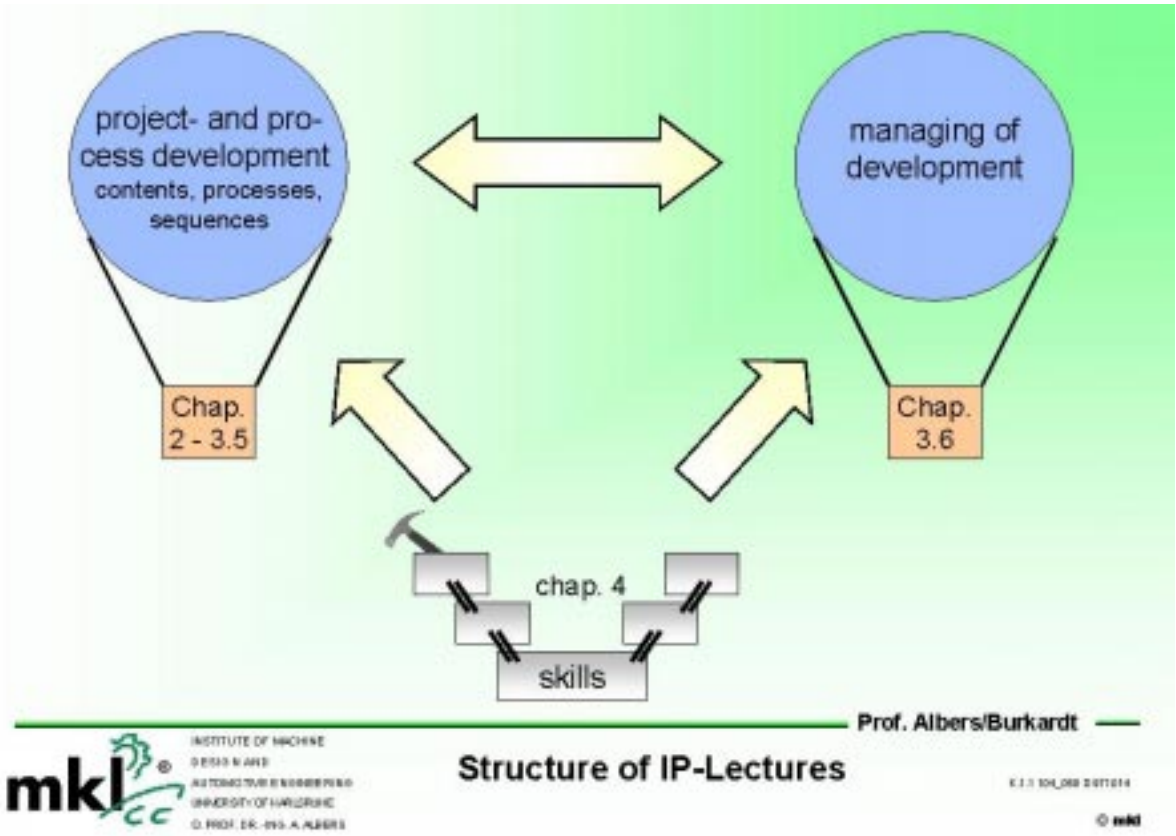

Fig. 5: Structure of IP Lectures

3.2 Workshops

In the workshops knowledge is actively built up and developed with the first real application experiences. This is achieved through:

1. A direct and practical translation of the leant Methods directed to the development process.

2. A simulation of group-dynamic processes by means of exercises. This requires a flexible timetable for the “Methods” and their application for each workshop.

A total of 13 Workshops covers the following topics:

- Team processes
- Hosting- and communication techniques
- Product profiling, list of requirements, project design
- Application oriented creativity techniques
- Online-research
- 3D – hand drafts
- TRIZ, ARIS, Invention Machine
- Introduction to patent law

Single workshops are accompanied by guests from industry as required (e.g. SAP, CAD-Manager, STN and other). A 3D-CAD education is given supplemental to the workshop in a 5-day crash-course.

These workshops are set up to deepen and extend lecture knowledge and are not used for the direct concurrent support of the student project work.

3.3 Project work

The content in this project is the development of a product from the idea up to the virtual prototype (3D-CADModel) with an independent student development team. It is shown here as an example of an mid-sized enterprise at the Product-

Development-Centre of the Institute with the attendance of the head of Inst. and his assistants as a simulated management and respective development teams (Fig. 6)

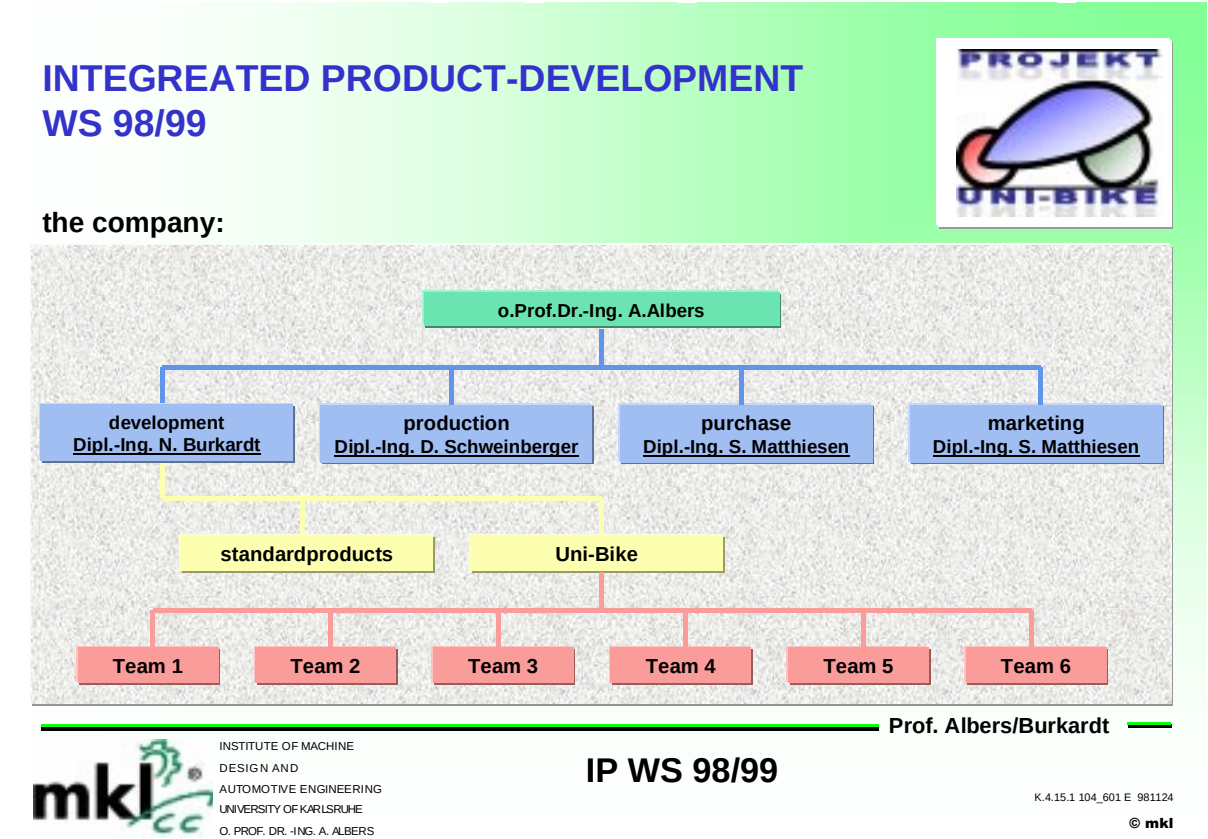

Fig. 6: Structure Project Work

Each team competes in a set up task given by the management (Fig. 7). They get information about the present position of the enterprise in the market at the same time. The communication to the management is set up by E-mail and there will be announced briefings in special cases. It is be reported and decided about the present develop progress and ongoing projects. (3 briefings / project).

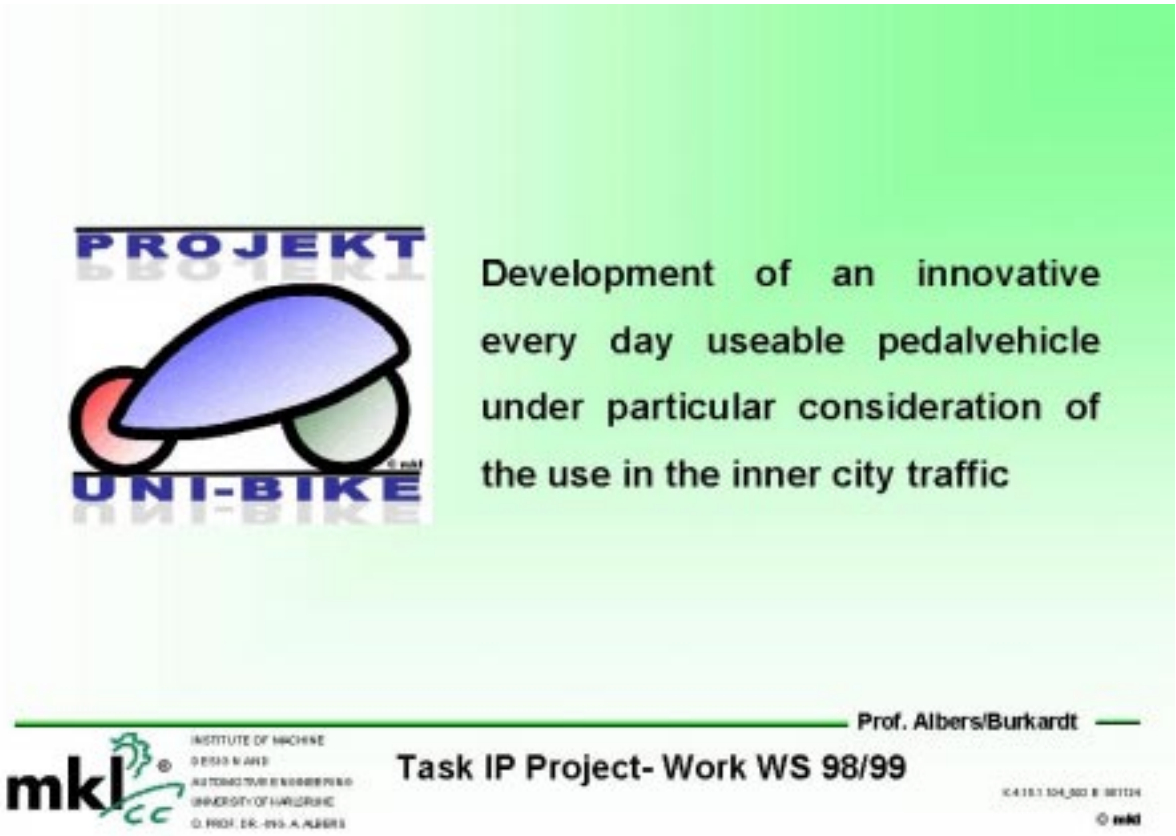

Fig. 7: Task IP Project-Work 1998

Hardware and software equipment (MS-Project ©, Pre/Engineer, Invention Machine, IM-Phenomenon, Access to the Internet/WWW and Databases) is set up in closed working areas for each the project team (Fig. 8).

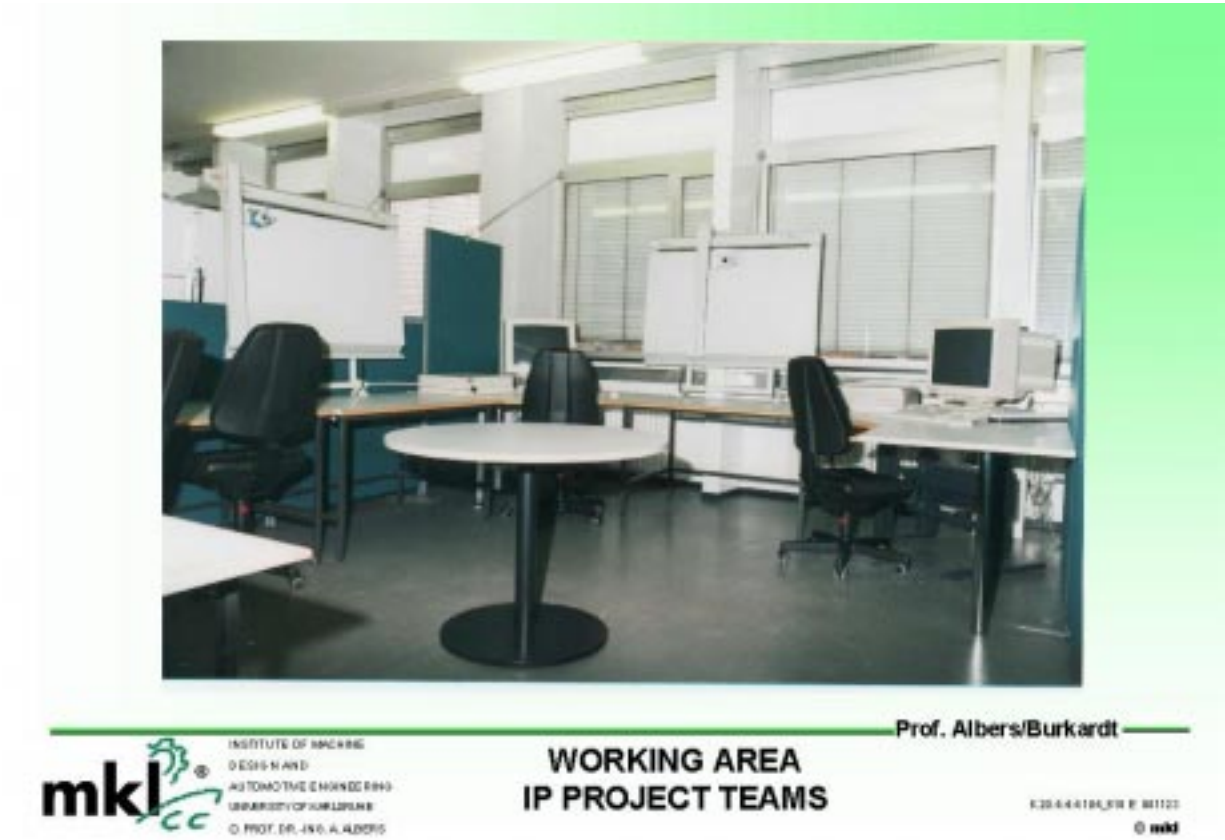

Fig. 8: Working Area for Project Teams

At the end of the project a presentation is given in front of the management. In certain cases the management awards prizes for the best solutions. A each team makes an evaluation of their group performance and their individual team members in a feed-back briefing. The results are handed to the management for a assessment.

4. Organisation

The number of participants is limited to 20 students. The selection of students is made in an assessment with the head of Institute and the responsible staff members Participation in this selection process in a duty on all teaching staff.

This education module closes with an oral examination which is evaluated as a main subject within University course

5. Experiences

A tremendous interest on this educational model is present within the students, in spite of the very high work-load required so that a candidate selection must always be made. A high motivation and keenness is shown by the students. The project work produced patentable product developments, the product presentations were to a professional standard including a number of functional prototypes. The most innovative and unconventional solutions have surprisingly translated into concrete product ideas (Fig. 9 – 10).

Fig. 9: Example of a Result of Project-Work

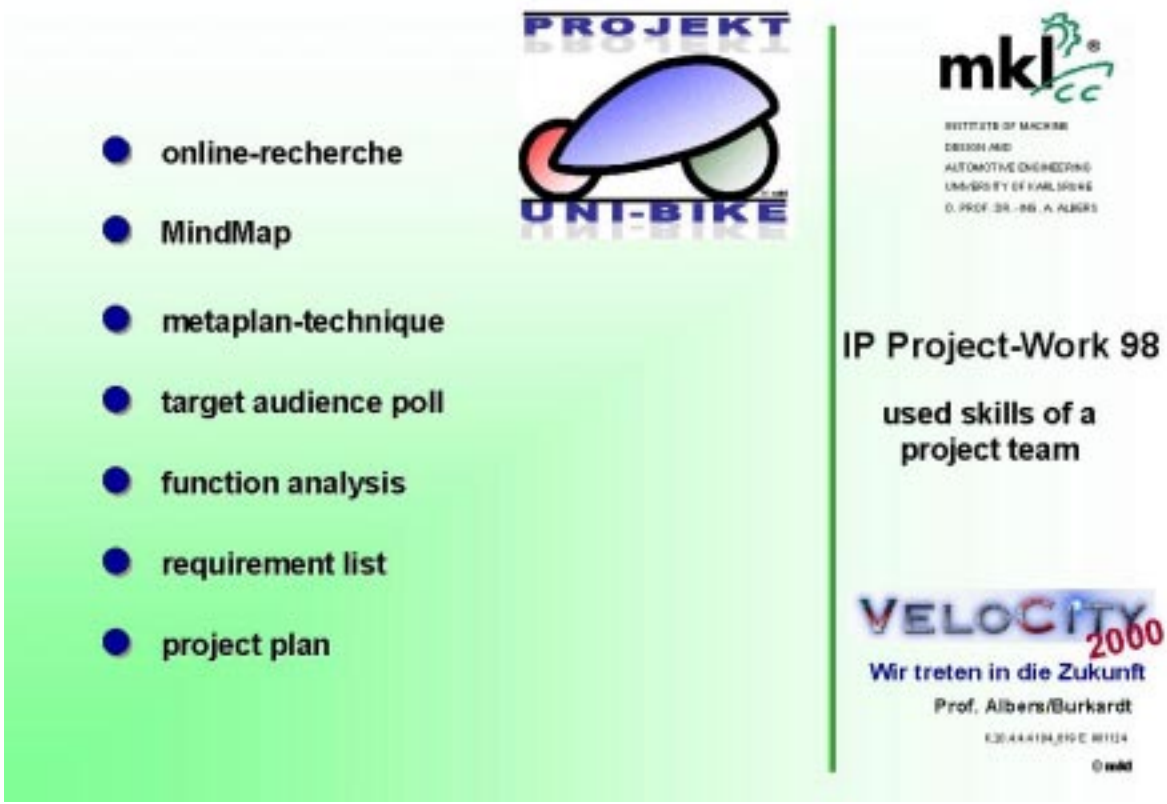

Fig. 10: Example for Used Skills in Project-Work

It shows that graduates of this subject, who carry out their Diploma work in industrial companies, are able to translate their knowledge directly and successfully as the relevant feedback shows. Also the initial evaluation discussions with Graduates of this module showed a tremendous acceptance by all kinds of industrial companies.

Therefore it can be stated that **This Karlsruhe originated education model promotes a professional competence for graduates.**