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Projects as a Method of Training, Teaching and Research Education

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1. Introduction

Projects play an important role in practical work, in education, and in science. The use of projects in university comprises several tasks that are usually perceived as separate units: to do research and transfer projects, to teach project management and dedicated subjects, to educate students for research and practical work, and to achieve relevant results within student's projects. The integration of these aims with limited resources causes a lot of synergetic effects but is only possible with a systematic approach.

To teach students the skills of project management and research methodology, it is necessary to provide them with tasks that offer a high amount of practical impact as well as a high chance of success. To teach special course contents, the project must also be matched to the course curriculum and to the students´ level of knowledge. To lead students to scientific thinking and to enable them to do own research, a sequence of own projects is required, in which the scientific level of the research and the degree of self organisation of the teams increase successively. In addition, the integration of students with different levels of knowledge in each individual project gives additional challenges and chances through peer learning.

To integrate all these challenges and to meet the requirements of all stakeholders, Prepared Project Method (PPM) treats projects with a planning games approach using experiential learning, didactically selected tasks, and carefully prepared project settings. This makes it possible to carry out projects that have a real-life training effect of the self organisation and research capacities of students as well as excellent chances of success and positive impact on project customer organisations and university. PPM uses a well established template for project planning and meta-planning and concentrates on the preparation phase to ensure project success. We reflect on the results achieved with PPM in teaching subjects like project management, quality and environmental management, sustainable development and computer science projects as well as in preparing students for undergraduate and post graduate research and in doing practical research in several areas of management, engineering and economics to give a practical guideline to using projects as a method of university training, teaching and research education.

This chapter is based on the results presented in (Holzbaur 2008).

2. Project Management in Higher Education

A study of Deutsche Bank (DB Research 2007) points out that the twenty first century will be the century of "project economics" replacing classical companies conceptualised for a potentially infinite continuous work for centuries by short termed result oriented enterprises. According to this study, in 2020 those project companies that are dedicated project organisations will contribute to 15% of the value created in Germany. Looking at successful classical companies, we also find that projects are ubiquitous: projects are essential part of the business in management and technology, and any routine job is at least complemented by some reorganisation or quality improvement project.

For university education and research this is one reason to concentrate on project management – not only for management faculties. Projects can be an object of research; they are a critical criterion for professional success and an important tool for research and management. Project management will be a must for any student in higher education. The other reason lies in the fact that with an increasing importance of research in modern universities, projects become even more important: research is project oriented since it is outcome oriented. Any enterprise which aims at a predefined result (not necessarily in the form "what should be the result" but "of which quality should be the outcome"), wants to get results in a final time (either within a project thesis or a professor's active time) and has to deal with limited resources (which we have in university and industry) would rather use project management than just hope for the divine enlightenment.

The Bologna process (EU 1999) aims to create a European space of higher education and research. The most important impact on curricula and courses is given by the following aims:

- Adoption of a system essentially based on two main cycles, undergraduate (Bachelor) and graduate (Master). This means that especially the Universities of Applied Science and the former (poly-) technical universities face an increasing amount of postgraduate research.
- Establishment of a system of credit points as a means of promoting student mobility and flexibility. This also allows to define credits according to the workload of the student and to increase the amount of project work.
- Establishment of a European Space of Research. Within projects, students can overcome language barriers easier, be integrated faster and more intensively, and become more involved to the culture of a country than in lectures. Supervising projects in a foreign language is much easier and more effective than giving lectures in this language.

As a consequence, research and project aspects will become more interweaved with higher education. As research is outcome oriented and project based, researchers must learn to work in a result-oriented environment. Moreover, projects can also lead them to the methodology of research. The issue of managing research projects is e.g. addressed in (Holzbaur 2009). Management of research organisations is e.g. addressed in (Jain/Triandis 1997). The knowledge generated by research in universities is e.g. analysed in (Gibbons 1997).

Research with respect to projects in education has mainly been done with respect to the use of the "project method" in schools. There are a lot of reports on successful projects in education, but few remarks on the method of training. Project oriented approaches are e.g. "TheoPrax" that collects potential projects in industry and distributes them to the participating schools (Krause 2007) and "Schüler-Ingenieur-Akademie" where industry, school and university guide learners of school grade 11 through one year of an engineering project (Südwestmetall 2009).

2.1 Project Management Skills and Knowledge

Project management is an important skill for academics and is taught in a variety of courses in engineering and economics. An important basic and quasi a standard for project management is the Project Management Body of Knowledge (Project Management Institute 2004)

Project management is the systematic approach for executing and leading projects. The project approach has the goal of achieving the result (project aim) certainly and efficiently, especially to prevent the explosion of costs and the delay in time; and to reduce uncertainty and risk.

Managing a project involves:

- defining vision, goals and targets in terms of results, quality, time, and resources,
- structuring the work to break down a big task to portions that can be delegated,
- preparing, planning, evaluating, and organizing assignments,
- executing these tasks in goal-oriented team-work,
- communicating with everyone involved (team, stakeholders),
- monitoring task fulfilment and ensuring goal achievement, and
- bringing the project to a successful ending and completing it to everyone's satisfaction.

A project manager's task consists – in contrast to that of a line manager – of

- thinking in terms of results and phases, rather than time periods and sequences,
- being able to deal with uncertainties,
- being able to lead team members, even when (s)he is not their superior.

The success factors for any project manager lie in an overall combination of

- expertise: knowledge of the field, the matter at hand, and the facts,
- methodological competence: methods, applications, problem solving ability,
- social competence: dealing with people, responsibility, and assertiveness,
- personal competence: personality, motivation, self-management.

Projects effect a temporary reorganization and reassignment of responsibility within the organization. The centre of every project is the project team that leads the project and is responsible for the success.

The magic project triangle or triad is formed by three corners each representing one of the project determinants. At the start of the research project, student and supervisor should be clear about the elements of the project triad regarding expectations from both sides. Their expectations have to match; otherwise the project will not be brought to a satisfactory end.
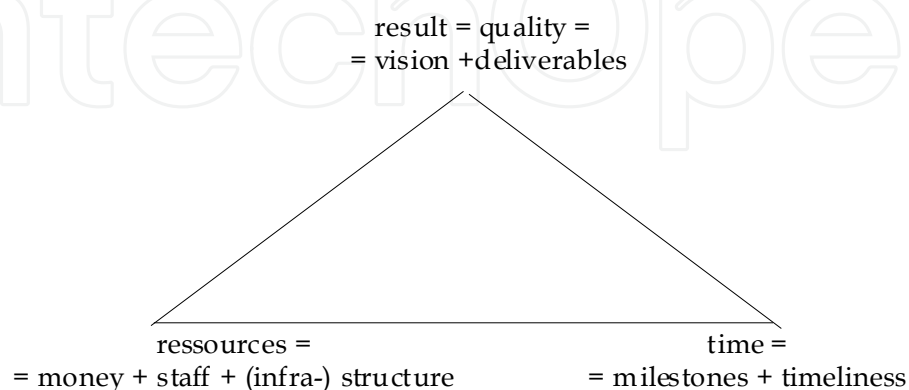

Fig. 1. Magic project triangle

The determinants of the project are the corners of the project triangle:
- Quality, result (qualitative and quantitative)
  - Vision: change in the state of some system.
  - Aims: final product, project result.
  - Value: positive contribution of the project.
  - Quality: measure of aim achievement, product quality.
- Resources
  - Personnel: training, knowledge, motivation, availability.
  - Staffing: working time (product of personnel and time).
  - Materials; hardware, software, infrastructure.
  - Support with respect to technical, financial, managerial and political aspects.
  - Money: costs of resources (free market prices or internal cost accounting).
- Target date
  - Calendar time (months, days).
  - Precision: probability of time overrun, quality and reliability of timeline estimates.

No corner on the project triangle can be altered without affecting the other two.

2.2 Visions and Work

A project starts from a vision: it is initiated to achieve some results and to change something- The vision is the link between the external project sponsors and the internal project team and the glue that binds the project team together.

From the vision, the project manager derives the project mission and work. To cite Thomas Alva Edison on genius, also success *"is one per cent inspiration, ninety-nine per cent perspiration"*. This means that the vision has to be transformed to aims, mission, work plans, criteria and deliverable items.

The projects manager must be able to develop a vision, create a mission statement and a viable project plan, and communicate these to the sponsors and the team. The sponsors must be convinced to trust in the project team and to support them in all aspects as financial, managerial, technical and political promoters. The team members must be convinced to form a team that is motivated and that implements the project plan efficiently. The project vision, mission and plan are essential to guarantee project success.

2.3 Project planning skills

Project planning is the core business of project management and requires some technical skills. Project planning is based on the work-package structure (Work Breakdown Structure, WBS) and on milestones. Networks and cost estimates are based on this WBS. Teaching project management involves the training of all planning aspects. These planning aspects are needed to plan research and real life projects as well as to apply for projects and grants.

The Work Breakdown Structure (WBS) defines the total task and divides it into a hierarchical way down to small work packages. The term Work Package (WP) applies to the lowest, irreducible level of the WBS, but sometimes is used also for the packages on the intermediate levels. This makes sense since any work package can be divided in several sub-packages in the course of planning and project controlling.

A milestone plan can be created from the network plan (best by using closing dates). Slip times (float, buffers) can be determined from the project schedule network diagram. Even if

no network plan is created, a milestone plan should be defined. It can be based on the work structure plan. A suitable basis can also be provided by a simple division of the work into phases. Fixed dates should be arranged for the phases. The length of the phases, of course, depends on the tasks.

Milestones have to be well defined, i.e., it has to be clear what result or criterion has to be met at the milestone. A criterion such as "six weeks reflecting" defines neither a phase result, nor a valid milestone. The most useful milestones are reviews or audits. They can be performed formally or simply in the form of a presentation for colleagues (peer review).

The basis of effort estimation is the personnel resource, the product of time and personnel. The person-day may be a controversial measure of productivity in industry, but for research it is the only viable basis. An important foundation for this is laid by measuring requirements and resources according to the same unit of measurement, i.e., either working days or hours. Estimating on the basis of hours tempts one to add up the net working time (productive work time) and then to divide it by a working time of 8 to 10 hours. In this way, it is easy to overlook "resource hogs", with the result, that the timetable cannot be maintained. Before creating the work structure plan, it is helpful to consider whether the work packages should be estimated in net hours or gross hours, and whether the recalculation in days, weeks, and years will be done on the basis of standard employee data (e.g. 5-day-week) or on the data for a researcher or students (with a higher workload per semester but possibly with further duties) and whether vacation times and weekends should be explicitly included in calculations.

The total resource consumption in terms of staff hours and costs of the project can now easily be obtained by estimating the resource consumption for each Work Package and adding up the partial costs in the hierarchical Work Breakdown Structure.

2.4 Project Controlling Skills

Controlling ensures the successful completion of projects. A project not only has to be planned, it also has to be monitored constantly, and brought to a successful conclusion by taking appropriate control measures. Estimates have to be constantly adapted to changing circumstances, so that, with time, planning becomes better and more precise.

In addition to the paths of communication, responsibility has to be regulated for communication (push/pull meaning the obligation to provide / to ask for information). Reporting paths must be structured around the project structure. Reporting has to include:

- information on work packages completed or in progress, as well as milestones,
- information on allocated resources and determinations regarding resource allocation,
- information on unusual events and problems.

Control measures should be taken as soon as possible. In contrary to classical control theory, project control can not be done by just increasing the value of some input variable (staff, money) since this is also part of the magic triad. Hence, project control involves replanning and rescheduling.

2.5 Excellence and Quality

Any organisation that is interested in a long term success must deal with the issues of quality and sustainability. Excellence is an attitude towards running a business or any operation than strives to do the best job and to the job best. This includes the notion of

sustainability in both meanings: sustainable yield as the basic idea in business that makes sure that the company is increasing its value continuously and sustainable development that makes sure that also future generations will have the ability to meet their needs. It also includes the notion of quality in the external (or product oriented) notion of customer satisfaction and in the internal (or process oriented) notion of total quality management.

There are also ethical aspects in the business objectives that link excellence to the external effects of an organisation. Corporate social responsibility and sustainability are also part of the EFQM quality model (EFQM, 2009) that has an explicit part on "Society Results". Although there are many definitions of quality, we can define a common core: Quality is the ability of a product or service to fulfil customer's needs. Following a short-sighted approach of maximising sales and turnover, a company will concentrate on their given set of products and customers trying to optimise quality attributes with respect to their wishes. For a long-run success, it is necessary to fulfil the potential needs (which may not exist up to now) of future customers (whom we do not know) and of the company's stakeholders.

For a university, excellence is the key factor for success. Science is defined by a high standard of accuracy and exactness and needs excellence to perform adequately. Hence, quality and sustainability play an important role in the education in economics and engineering.

3. Projects for Education

Projects are used in education as a tool of teaching and as a method of achieving results. They can also be used for acquiring various skills.

3.1 Teaching with Projects

In Universities of Applied Science it is good standard that all subjects are taught with a sound theoretical background and a close look on the applications and applicability. To achieve an optimal learning success, it is helpful to integrate practical aspects into the individual courses. This means that theory and practice are not taught in parallel but are integrated.

The learning effect is best when there is a balance between theory and practice, and it can be improved by carefully preparing the projects.
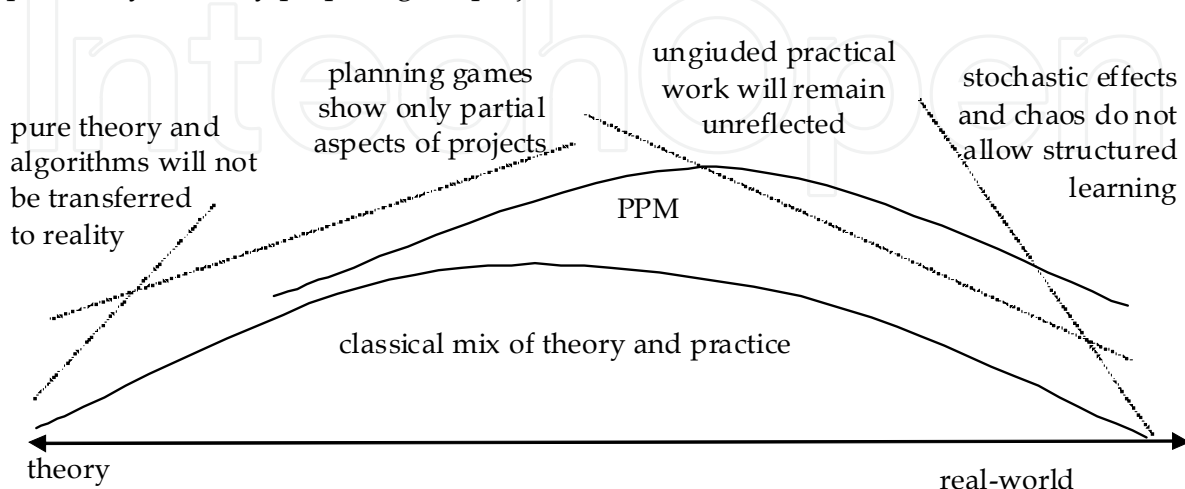

Fig. 2. Training success via theory, practical tasks and prepared projects

Focus	Theory	Integration	Practice
Method	Classroom lectures Textbook based learning	Combination of lectures and projects	Learning by doing Students´ projects
Theoretical background	High – but without any connection to practice	Good (depending on the lectures)	None
Practical experience	None	Good (depending on the preparation)	High – but without any connection to methods
Effort for the responsible	Like in other lectures	High (preparation + implementation)	Depends on the degree of preparation
Learning success	Moderate	High (integration +reflection)	Depends on chance

Table 1. Combining theory and practice in teaching

This integration requires some effort in the preparation, but gives a rewarding outcome for the trainer and the student. The integration of theory and practice can be done via the sandwich principle which is enhanced to a fractal structure integrating theory and practice. This may be visualised by a sandwich-in-double-decker structure: into each block of the double-decker, a practice/theory part is inserted. In fact, more theoretical insertions may be planned or initiated by student's presentations, and practical insertions may be added by dedicated project tasks.

	Core Subject	Insertion	Core Subject
Theory	Course and project subject	Teambuilding	Project planning
Practice	Project definition	Project management	Project start and kick-off
Theory	Course subject	Project planning	Course subject
Practice	Project work	Project analysis	Project presentations
Theory	Summary of course subject	Final presentations	Reflections on projects

Table 2. Phases in training with projects

3.2 Main Competences

General competences gained via projects and needed in research comprise:

- To plan in a result-oriented way considering the requirements with respect to quality, resources and timelines and their interactions.
- To structure the aims and the tasks to be accomplished in order to achieve these aims in order to organise the work.
- To model the problem and the systems under consideration, select or develop adequate models as a basis for problem solving, explanation and communication.
- To argue and preview argumentations and counter-argumentation in advance making sure that the result can be and argued in a written documentation and defended in an oral presentation.
- To document the results and processes leading to these results.

3.3 Scaling the project

In preparing a project the course responsible must consider

- the customer within his/her organisation or even the set of customers, stakeholders and sponsors, (in some cases, a lot of hierarchical levels are involved),

- the students´ team and the individual student, (the students have restrictions regarding their time and knowledge),
- the university with their rules and limited resources and the supervisor's own limited resources (with respect to time and money).

The scaling of the projects is an important task since it makes sure that the learning effect and project outcome will be optimal. There are two phases of calibration:

The first calibration phase takes place in the forefront of the project definition. Here, the trainer has to match the projects aims (quality) and the number of team members (resources) to the requirements of the various project stakeholders and the expected level of performance of the students.

The second calibration phase takes place in the starting phase of the project when the students have to match the expected outcome, schedule and resources to the stakeholder requirements and to their own capabilities. Very similar to a research proposal, the students define the project outcome in a paper which must be agreed by the trainer (professor) and the stakeholders.
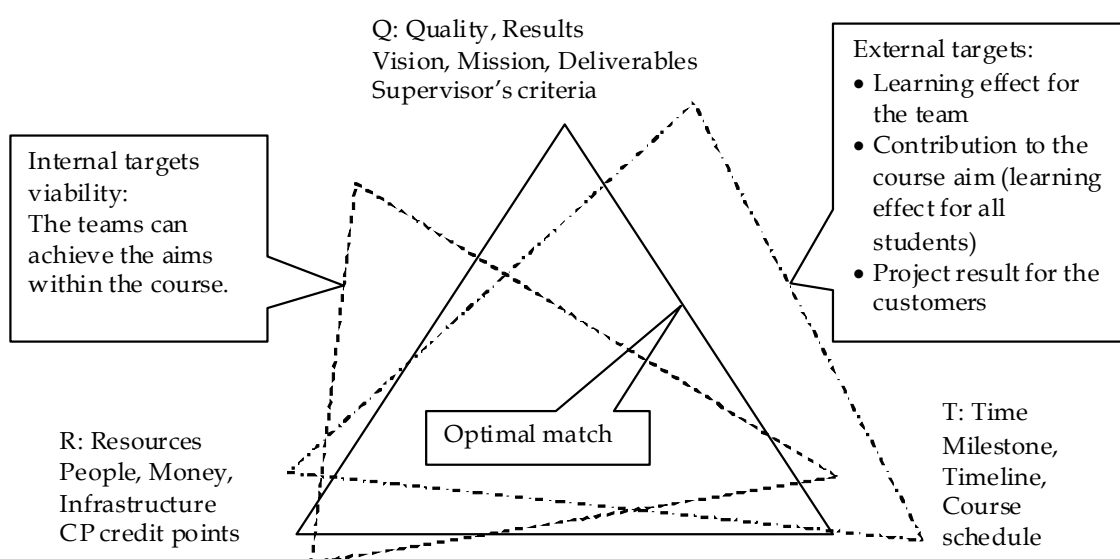

Fig. 3. Calibration of the projects

Throughout the course of the project, calibration of the project triangle is done in the context of project controlling.

3.4 Project Control and Responsibility

Controlling must make sure that the total project target (within the magic triangle) is achieved. The best way of project controlling is good project planning. For the methods of project controlling we refer to the literature. It is important to consider not only the technical aspects of project controlling but also the interactions between supervisor and project team. In the course of the project, the role of the supervisor changes from a team-mate or leader to a formal examiner.

In the beginning, the supervisor is supposed to guide the project team and to help them in finding the right project definition. At the end of the project, the supervisor has to evaluate the project and to grade the students´ work.
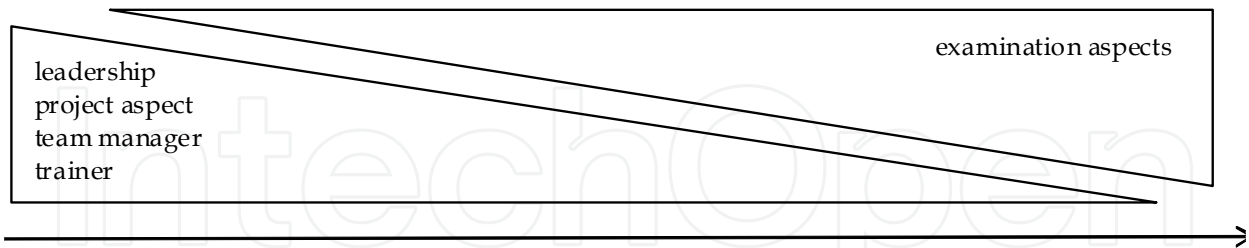
Fig. 4. Tasks of the supervisor in the course of the project

According to the changing tasks within the project, the focus on different roles and the type of interaction change. The relation between student and supervisor changes from a team to an examination situation. The student has to know this and has to accept that the initial co-operation will finally lead to an assessment of the result. To make this evolution clear to the student, formal or informal presentations can be used to show the focus of the actual phase of work.
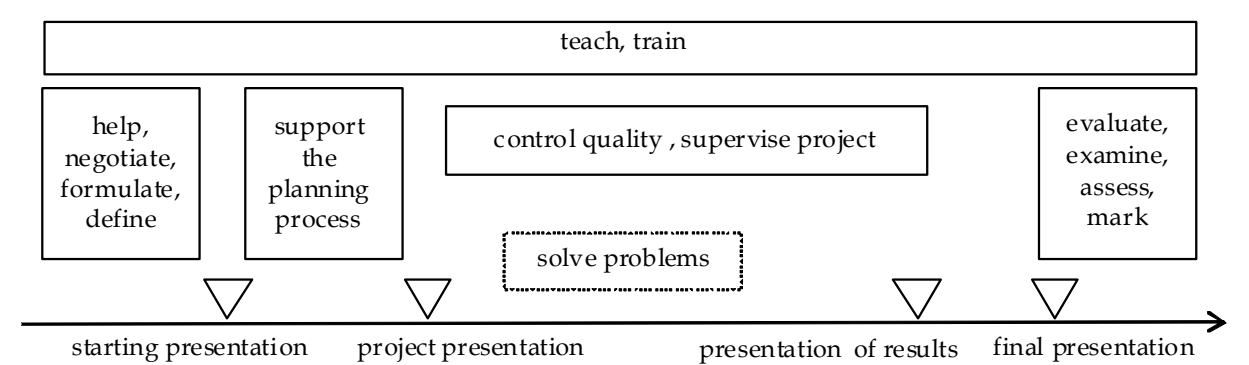
Fig. 5. Presentations as milestones as indicators for the changing roles of the supervisor

3.5 Modelling Skills

In any project, students use models: as a means of planning, a tool for working, or as an object of their research. Sometimes, students also develop models – in most cases not a formal mathematical model but an informal one with a "soft" syntax and intuitive semantics. Modelling skills are very important competences in research. Here, we give some basic definitions and explanations:

* A system is any – real or mental - part of the real world that is identified by giving either the parts of the system and the relations between them, or the boundaries of the system and relevant aspects to be considered. A system is also something abstract since it is not something that can be identified in reality and the consideration of parts of reality is an idealisation in itself.
* A model is a representation of some system that is used for a special purpose. This means that the model itself is a – more or less abstract – system tat has some purpose and some relation to another system.

The criteria for a model are that the model maps the relations which are valid in reality. The result from the image of an action (analysis, transformation, measurement) in the model must be the image of the result of this action.
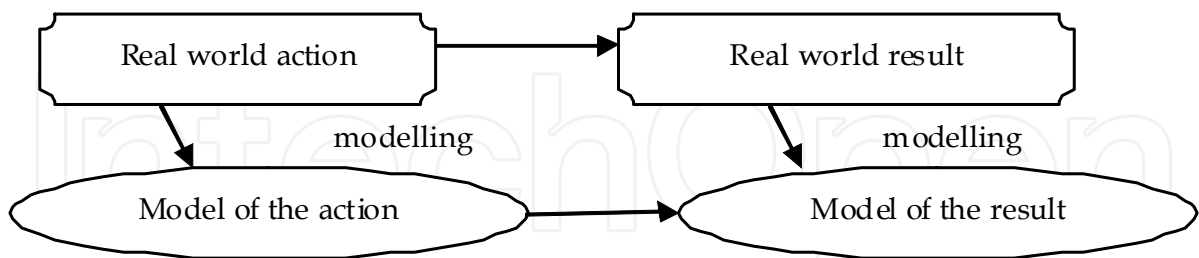

Fig. 6. Criteria for a model

Using the (ambiguous) notations for modelling m and for the effect e of an action, the diagram commutes, i.e. for any real world action a we have m(e(a))= e(m(a)). In fact, the mappings for the effects in the real system and in the model are different since they are defined on quite different structures. Moreover, we also have to take into consideration that neither m nor e can be modelled formally.
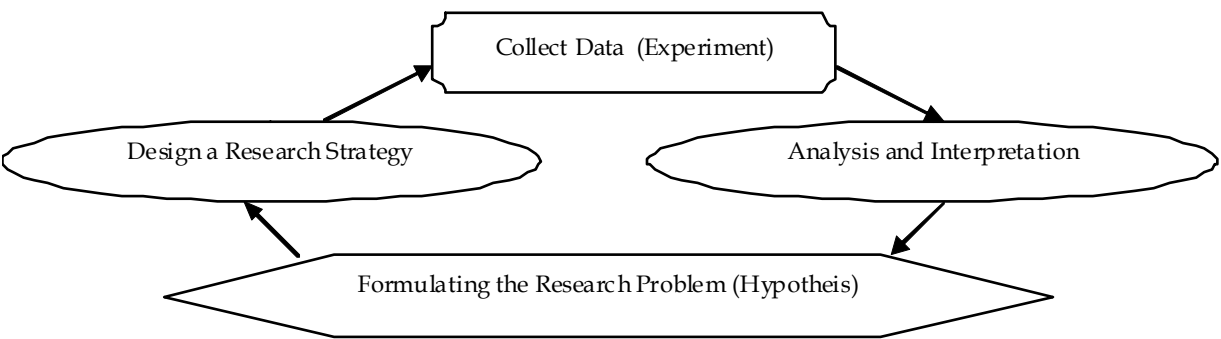

Fig. 7. Models in the Research Cycle

Students must learn to select adequate models, to determine the model's structure and parameters, and to analyse models and relations in order to test and improve the model. To use the model, formal analysis, informal argumentation or simulations have to be used, and the results have to be interpreted correctly.

4. Prepared Projects Method

The Prepared Projects Method (PPM) is a method for planning, defining and conducting a portfolio of projects in order to simultaneously educate students and achieve results in a systematic way. PPM is based on project management and planning games.

4.1 Action oriented learning
In all cases, projects are defined by the supervising professor, and an external customer (in most times being more a stakeholder than a sponsor) is identified. This challenges the

communication and cooperation skills of the students, since they get a coarse outline and a person acting as a customer instead of a well-defined list of criteria. The students must define the project vision and scope, the level and method of research, expected outcome and deliverable items, resource allocation, timelines and the way of publication. This must be communicated to and agreed by the customer and the supervisor.

In this type of experiential learning, the students learn facts and skills such as planning, use of management tools, documentation and scientific work. But even more important are the "soft skills" such as leadership, self-confidence and communication skills. These skills cannot be acquired within a classroom lecture; but the practical project urges the students to communicate among each other and with other groups of people. They must come up with common goals and a common plan and must co-operate with other students. They must also think about the consequences of their actions and the possible outcomes of a project for other people.

4.2 Planning Games

A planning game is a teaching method that is mainly based on a situation and some dynamics, in which the trainee has to make decisions and will experience their consequences. Planning games are a very effective and efficient way of teaching and training.

Planning games can be seen from different points of view (Holzbaur et al. 2005):

- a model of the real world used for didactical purposes,
- a simulation with didactic background,
- a controlled experiment,
- a method of teaching close to reality,
- a method of learning by making decisions and experiencing the effects.

The definition of a planning game can start from different aspects:

- Didactical aspect: A planning game is a training procedure that consists of a dynamic system, in which the trainee has to make decisions that influence the system.
- Model aspect: A planning game is a dynamic model in which decisions are required, and which has a didactic purpose.

The core aspects of planning games can be transferred to Planned Projects.

Aspect	Planning game	PPM
Model	The learning situation cannot take place in real. Decisions cannot be tried in reality.	Planned projects are selected prototypes of projects. By means of intensive preparation, the risk is reduced.
Decision	The decision aspect is crucial for management, planning games and projects.	
	The decisions and their consequences and implications stand in the foreground. The decisions are evaluated in the course of the game.	Decisions are necessary to achieve the goals. The quality of planning and decision making is analysed in the projects evaluation.
Dynamics	The learning situation is embedded into a dynamic and changing scenario.	
	Dynamics are implemented by a script or software, by a trainer's intervention, or by the players´ interactions.	Dynamics are given by the project phases and the evolution of the project.
Didactics	The planning game and the planned project have a purpose in training and education. They are adapted to a specific training situation (trainees, targets, available time and resources) and must be adapted to the situation and guided by an experienced supervisor or trainer.	
	Training oriented (no impact on reality)	Outcome and education oriented

Table 3. Planning game aspects in PPM

4.3 The Method

The Prepared Projects Method (PPM) treats projects like planning games and makes it possible to carry out projects that are real-life for the students but have a good chance to succeed and a positive impact on Sustainable Development. Hence, PPM can be seen as Project Learning based on a planning games approach. Prepared Projects Method can be used to train project management, and to teach practical aspects of any course subject in real world projects.

Prepared Projects Method bases on the following approaches:

- project learning based on a planning games approach,
- planning a set of projects for each semester,
- planning the projects to incorporate different grades and courses of studies,
- planning each project to match the skills and workload according to the module description,
- planning each projects to ensure a maximum probability of project success and benefit for students, university and customer,
- planning the project portfolio to give good insight to the course subject,
- preparing each project and the contact with customers and stakeholders to ensure project benefit,
- planning the project aim to give students the skills and knowledge according to the module requirements.

The projects must give benefit to the students (for each individual student, for the team and for the whole semester group), to the university and to the customer.

Benefits for the partners are:
- Problems are analysed and researched methodically
- Solutions are assessed independently, future activities are analysed holistically.
- Projects that require specialized skills or planning competence are addressed.
- With a project, customers also buy into the skill and knowledge of the supervisor.
- University projects have a high public visibility and positive perception.

Benefits for the students comprise:
- Students learn to apply project management and dedicated course skills.
- Students learn about and solve practical problems, learn about their future environment.
- Students´ team can influence decisions and future development.

The University benefits from prepared projects are
- Effective and efficient education.
- Project portfolios that cover the course subjects.
- Public perception via successful projects, relevant project results and publication.
- Chance to improve internal performance and to solve internal problems.

The project portfolio is the sum of all projects. In subject oriented courses, this portfolio must cover all important subjects according to the course module description. In courses on project management, the portfolio differentiates projects with respect to various focuses or skills (e.g. research, statistics, stakeholder management, project presentation, use of electronic media, intercultural competence).
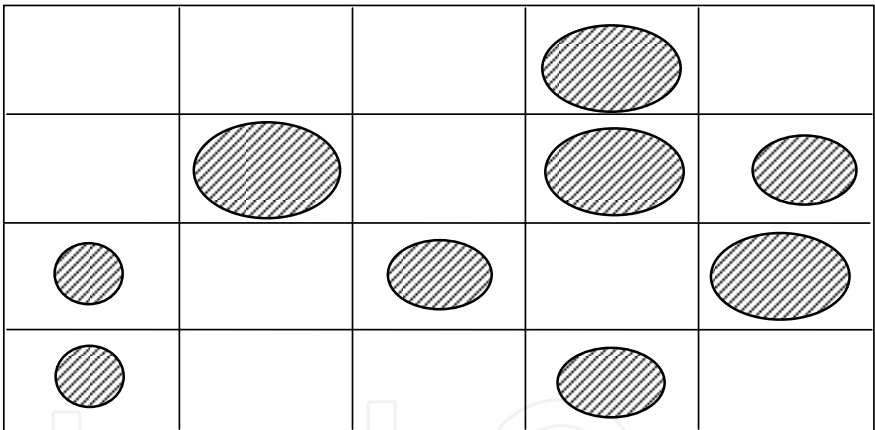

Fig. 8. Visualisation of the project portfolio with different subjects, objects and size for the students´ projects.

4.4 Schedule
The following schedule gives a coarse overview over PPM projects. The dates (weeks before/after the start of the relevant semester) are typical numbers that can vary according to the projects and other circumstances such as semester schedule, holidays, and professor's schedule.

Weeks	Activities
- 110	Collect ideas and get into contact with potential projects partners.
- 105	Plan the long term projects (more than one year) Contact potential project partners
- 55	Plan the long term projects (one year or less). Contact potential project partners
- 30	Define series of projects for one or several semesters.
- 14	With the previous semester's project finalisation ideas for subsequent projects arise.
- 9	Select the projects for the forthcoming semester.
- 8	Develop a concise project understanding including scope and deliverables
- 7	Fine tune project with the projects partners, customers and sponsors.
- 6	Publish a preliminary list of projects to get feedback from the students
- 2	Adjust number and scope of projects according to the expected number of students
-1	Publish the formal project definitions including partners and preliminary aims.
0	Open the projects for enrolment.
+ 1	Adjust number and scope of projects according to the actual number of students
+ 2	Kick-off-presentations and internal project definition
+ 3	Teams get in contact with customers and stakeholders: external project definition
+ 5	Project presentation (definition: aims, vision, deliverables, resources, schedule)
+ 8	Intermediate presentation (Project controlling)
+ 12	Final presentations for project partners
+ 12	Define subsequent projects
+ 14	Joint final presentation of all semesters and projects
+ 15	Press release on project
+ 16	Regular due date for deliverables
+ 22	Planning for subsequent projects
+ 23	Final due date for deliverables
+ 24	Aftermath, improvement of materials, press release on project consequence
+ 26	Next generation of projects starts

Table 4. Generic PPM Project Schedule

4.5 Curricular prerequisites

Prepared Projects Method can be used to train project management, and to teach practical aspects of any course subject in real world projects. Projects can be integrated with lectures, run in parallel, or be a separate course unit. For the sandwich principle and for PPM, it is important that lectures and projects are integrated. This should be facilitated by a module (or course) description that assigns workload to classroom lectures as well as to the project. In order to assure the learning effect from each project also for those students that participated in another project, project presentations should be included as a considerable part of the workload (credit points) and evaluation (marks), and they should be attended by all students.

The following typical module description shows the basic feature of a course unit using PPM as a method of teaching.

Teaching Method	Lectures and presentations: Learning by doing in a practical project (defined by the lecturer) including plenary project presentations and supervisor's meetings with the individual project teams		
Remarks	The project subjects will be announced at the beginning of the semester. Since the experiences of the other teams are an essential component of the learning process, participation in the project presentations is mandatory.		
Semester schedule	Within the semester (weeks relative to the start of lectures) Introduction and presentation of project subjects week 0 – 1 Project selection and team building week 1 – 2 Presentation of project plan week 3 – 5 Intermediate Presentation week 8 - 11 Final presentation week 14 – 16		
Examination	Type and internal weightings	Project plan in written form 20% Presentations 20% Project management report and project reflection 20% Project result documentation, deliverable items 40%	
	Accreditation Requirements:	To be present in the introduction, the team building, the assignment of project subjects and in the final presentations.	
	Accepted materials	All (The rules for intellectual property and scientific citation have to be obeyed.)	
Workload	Contact hours	Lectures and presentations (active/passive)	36 h
		Supervisor meetings	4 h
	Self-organized	Project	120 h
	Self-Study	Theory	20 h
	Sum:	6 Credit points	180 h

Table 5. Typical parts of a module description for project based learning via PPM.

4.6 Project Partners

External partners or customers for projects are important since they give sense and challenge to the project. Although the course responsible himself could take the role of a customer, this is only possible in a limited number of projects. There are two main types of partners:

• Industry can provide small tasks to improve products or processes or to analyse markets and systems. Real world industry projects are mostly critical in time and resources. Moreover, confidentiality imposes severe restrictions on the project documentation. Nevertheless, industry and business can provide interesting projects especially for marketing and product design.

• Government, public organisations and non-profit organisations (including universities and parts thereof) often have a lack of staff; hence, project management itself and a lot of standard competences (surveys, marketing, modelling, and management) can be applied in a very helpful way. Moreover, the problems would not be addressed otherwise; hence, the projects are not time critical and can be easily matched to the semester schedule.

5. Projects in Education for Research

Prepared Projects Method is well suited for education for research since is provides insight and action oriented knowledge. The following considerations are valid for all types of projects, but are especially important in research projects and with respect to research skills.

5.1 Vision and Deliverables

In pure research, we consider the published paper as a main output; in applied research, we have several additional categories of outcomes (Holzbaur 2009).

Part of the envisioned project outcome may be a change in the state of some project partner or project object. These types of effects are mostly contained in the vision of a project but the effects cannot be measured directly. In most cases, the assessment of the effect – if possible – will be a task for a subsequent research project.

The directly measurable outcomes are those results that can be physically delivered to the customer. In commercial projects, these deliverable items are subject of the project contract; in university projects they are agreed upon between the project team, customers, stakeholders and the supervisor.

In addition, the scope of the project must be agreed, and it defines which items will be part of the project and which will be left aside. E.g. a technical development project may comprise each of the following results:

- A problem analysis and stakeholder identification
- A requirements analysis for the stakeholders identified
- A systems concept or a systems specification defining the functionality
- An analysis of the interaction between product, user and environment
- A design specification or a detailed development specifications
- A product description and implementation/production specification
- A life cycle impact analysis of the product and its use
- A prototype or a product from series production
- A set of documentations e.g. design or compliance documentation
- A set of manuals e.g. user's manual, maintenance and repair manual
- Test specifications, test results and review protocols on various levels

Deliverable items also comprise:

- Presentations and the documentation thereof (file)
- Project management documentation
- Project result (according to the scope of the project)
- Publications (press release, scientific paper) and posters

5.2 Setting targets as a part of the game

Traditionally, in an educational environment, projects are defined by giving a task to the learners. The mission has to be accomplished and some items have to be delivered at a predefined minimum quality.

In an analogy to a research proposal, students in a project should rather submit the project outline that comprises vision, mission, scope and deliverable items for the project and that must be agreed by the stakeholders. This will guarantee involvement in a project which really is "their own"

The above mentioned definition of the project within the framework of the magic triangle must also consider the question of an adequate level of research: "Is it research? Is it on an adequate level?" (Holzbaur 2007). If the benchmark is set too low, the result will not be sufficient for anybody. If the benchmark is set too high, the risk of failing increases.

Figure 9 analyses this by displaying the two major factors:

- Success:
  The probability of success is usually decreasing with the level of expectation since a lower level will be attained more easily. The dropping tail in the probability density for success for projects with a very low level of expectation was not proven empirically. It should reflect the fact that if the level is too low, the task will not be taken seriously which can in effect decrease the success rate (at least, the success rate does not increase if the level of expectation is lowered). The sharp decrease of success rate at the higher end is due to the fact that these projects are limited in time and resources (student-hours).

- Benefit:
  The benefit from a project is manifold: the learning benefit for students, for local and scientific community, and the public perception will go hand in hand with an increasing level of project expectation. The research benefit for the university will only start at a certain level and be strongly tied to the challenge the projects provides (as well as its chance to fail). Nevertheless, most projects may be part of an empirical basis for some studies – as part or as object of the research. The benefit depends also on the utility function of the person in charge: The utility function for a senior researcher is quite different from that of a student or a partner in industry.

Both ends of the scale of expectations bear major risks that should be avoided:

- Push the envelope and risk failure due to a high level of expectation
- Shoot at sitting ducks and waste resources

The optimal expected benefit is then given by a trade-off between risk and reward considering the various stakeholders´ value systems as indicated in figure 9.
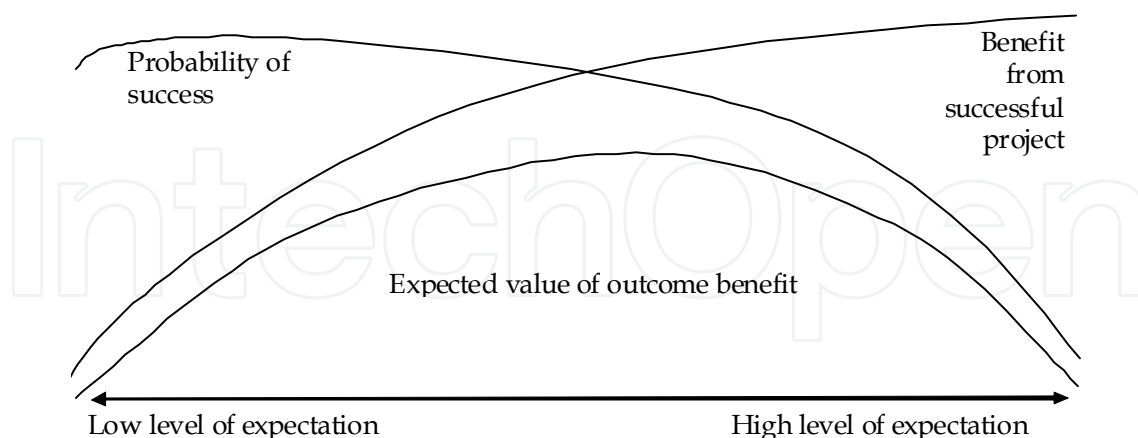

Fig. 9. Project and scientific result according to the level of the project aim

The diagram applies

- For any research project. It is the responsibility of the research leader or supervisor to ensure that the level of expectation matches the actual competence level of the team.

- For any project within the educational system. Not only in the education of researchers in a higher education institution but from kindergarten to professional training we face the challenge to find the right trade-off between challenge and viability.

Any qualification framework (in education systems) or maturity model (in development organisations) gives a scale that can be used (in a conceptual way, not in a numerical way) to define the starting point and level of expectation of the project.
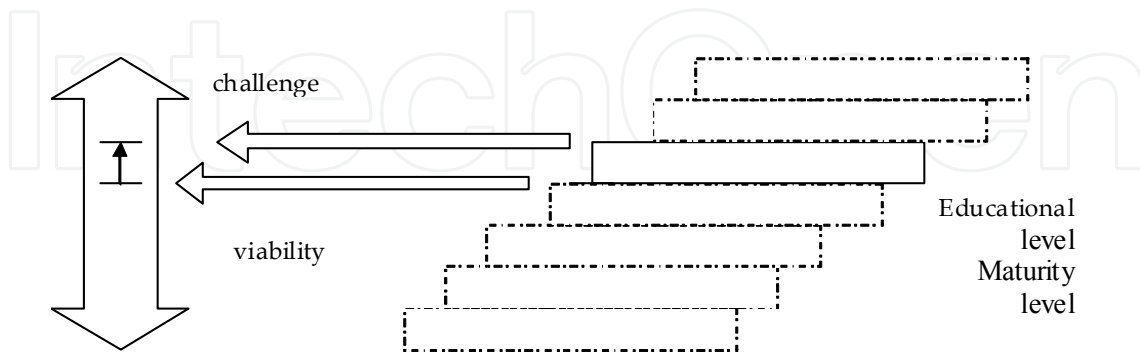

Fig. 10. Setting up project targets to be viable and challenging

5.3 Failure and statistics

To fail in a project usually means that the aims of that project (e.g. a development task) could not be accomplished. In a project in applied research also the unwanted (or unexpected) result is a result and hence a project success. The falsification of a theory or model is as valuable as another supporting piece of evidence in favour of this theory. It is necessary to note that the failure of proving the research hypothesis is not a failure of the project. In this case, it is important to analyse the reasons and consequences of this "failure".

This can be best explained by a project based on hypothesis testing, for which we add some explanation to make things clear also for people without a statistical background:

The basic question of the research is whether the research hypothesis H1 or the null-hypothesis H0 holds. The desired result from the point of view of the research team, sponsor or partner may be either H0 or H1 (for the following, we assume, that two properties A and B can lead to two effects X and Y and we want to know, whether A influences the probability for X). A statistical test will now either

1. Show that H0 can be rejected on the given level of significance (e.g. 5%) with means that with a probable error of 5% H1 must be accepted.
2. Find that H0 can not be rejected. This does NOT mean that H0 is valid. It just means that we are unable to reject H0 with the test chosen and the data give. There are several possibilities:

- Maybe there is some evidence that H1 is valid, but the test was not adequate (we should have tried a better test, e.g. sequential testing instead of comparing mean values) or we had too few data to make a decision, H1 may be valid but the amount of data was not sufficient (e.g. 6 out of 8 As had X compared to 2 out of 8 in the control group). If it could be anticipated that the amount of data would be too low, this is a failure of the project team.
- Maybe, the statistical data are so that a decision is not possible. The effect which we want to observe may be too small.

- Maybe, there is some evidence that H0 is valid, but our survey was not designed properly to prove that. (In the example above, imagine that 4 out of 8 A had X). Note that a statistical test can only falsify a hypothesis. Then, we are dealing with an error of type II (beta error).

Expected result	H0	H1
H0 is rejected	This is a new and unexpected finding.	This is the desired result with a probable alpha error.
The data are not sufficient to make any decision.	The result cannot be used to argue in any direction.	
H0 can clearly not be rejected	This is the desired result with a probable beta error.	The result does not imply that H1 is false.

Table 6. Error of type alpha and beta in research projects

A student that fails to discern between the different outcomes or to interpret the statistical outcome in a correct way will not be able to do research correctly. Hence, education for research must not only teach students the methods and formula of statistics but also give them the ability to draw the right conclusions – even if this means that a survey will end up with the result that no valid statement can be made. The ethical implications that arise from the misunderstanding or manipulation of statistical test must not be underestimated. It is present in research at all levels and also in the press at all levels.
Student should be prepared to analyse what is means that a (clinical) study has shown that smoking does not cause cancer, a significant increase of UFOs is detected in several states, or cold fusion has succeeded in lab scale.
In any case, the statistical analysis also shows that graphs – which students like to draw – are sometimes misleading. A bar- or pie-chart does only show the percentages. Hence a pie-chart for the absolutely irrelevant result "2 out of 3" has the same display as the relevant result "24 out of 36".
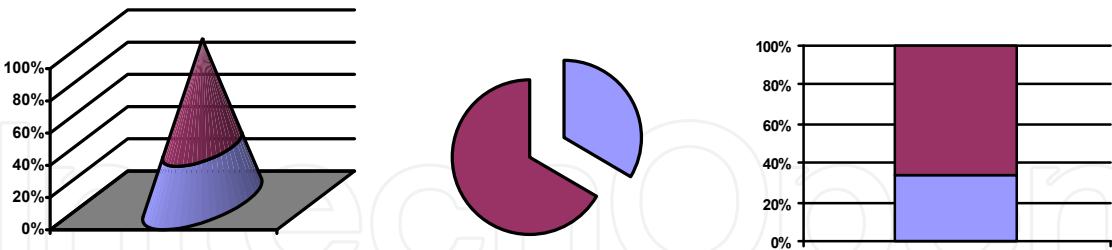

Fig. 11. Several diagrams that can depict either "2 out of 3" or "24 out of 36".

5.4 Competence building
Areas in which a competence is built up gradually from secondary school to first year students up to a professional level inside or outside the university comprise the following:
- Insight into the reasons and criteria for scientific work.
- Attitude towards systematic analysis and the creation of new reliable knowledge. Literature work and referencing, attitudes towards intellectual property.

- Project management competence, methods, tools and attitudes in planning, administration and controlling. Leadership and team management.
- Communication skills and systematic reporting. Teamwork and social competences such as reliability, accountability and trust. General professional competences such as managing, auditing, assessment, writing reports
- Linguistic proficiency and foreign language proficiency in literature studies, written documentations and oral presentations. Sensitivity for definitions and the use of notions and notations in science.
- Quality management competences. Insight into the importance of quality; and motivation and skills for the implementation of excellence in enterprises and projects.
- Statistical methods for estimates in project management and science, e.g. qualitative and quantitative descriptive methods; statistical decision methods (hypotheses testing) and their limitations and risks.
- Basic methods of research such as experiments, questionnaires, and model based working, understanding the problems of verification, validation and falsification.
- Basic mathematical methods especially working with scales and dimensions, using formal logic, estimating and assessing orders of magnitude, using formulas correctly, analysing graphs.
- Special subject oriented methods and knowledge.

6. Publication as part of project work

Publication and documentation are important parts of scientific work, and in most cases they also create the most important deliverable items from project work.

6.1 Project documentation

The project documentation is the result of the project. It is important for the project's customers and sponsors. The documentation gives the following information:
- project results, deliverables,
- reflection on project aims and achievements,
- documentation of the approaches and methods
- basic data, results of experiments and surveys,
- summary in a concise form and as elevator pitch (management summary).

The project management documentation comprises all information and documentation that is necessary for project evaluation. It is important for the projects sponsors and for the organisation. The project management documentation provides the following information:
- Achievement of project aims. Final timelines and work structure.
- Deviations from the project plan in terms of quality, resources and milestones.
- Assignment of resource consumption (staff) and cost spending.
- Correlation between research plan and experiments
- Planning and performance of surveys
- Assessment of tools and methods.
- Evaluation of the contributions from teams, individuals and partners.

The research documentation is an ongoing documentation in the form of a more or less formalised laboratory protocol. It documents the considerations, work, and findings. The

research documentation via a lab protocol is also important to cope with issues of intellectual property (by documenting the sources of information and ideas) and research ethics (by documenting e.g. the reasons for starting experiments).

6.2 Research publication

Publication is the most important measure of bringing research results to the public.
Although most students have learned to write an essay in school, there is a long way to write a research report for a dedicated target group.

- Give a structure to the report
- Use definitions, notions and notations properly.
- Write an abstract and summary.

Moreover, the publication of the research results must be adapted to the relevant target groups including:

- Scientific journals addressing specialised scientists.
- Contributions to books or conference proceedings.
- Press releases and contributions to more general or even popular journals.
- Internal memos and summaries on various levels.

6.3 Presentations

Any researcher needs to communicate his results. The most immediate and effective contribution to scientific community and the ultimate test for any result is the oral presentation of the results e.g. on a conference. Presentations are also given in the research team or for all groups (research seminar). They provide peer review and help to share ideas. Forwarding knowledge by means of presentations is one of the most important ways of knowledge management since is initiates a two-way communication with immediate feed-back and the chance of a direct response to questions.

6.4 Posters

The challenge and limitation of presenting project results is never as present as with a poster. It is also a good means to present a huge amount of information about several research projects to the public. Posters are mainly used within conferences, exhibitions or days of open university; they can also be used as a permanent exhibition on the campus.
By this means, information about project results is passed to forthcoming generations of students, allowing them to base their projects on the results achieved by former teams. Hence, posters are an efficient way of university knowledge management.

7. Integrating PPM into the curriculum

7.1 Programmes and lectures

Projects link the individual student's career to the research programme of the research group. This integration was described in (Holzbaur/Lategan 2009).
Considering research education it is important to note that students from all level can be integrated in projects and programmes.
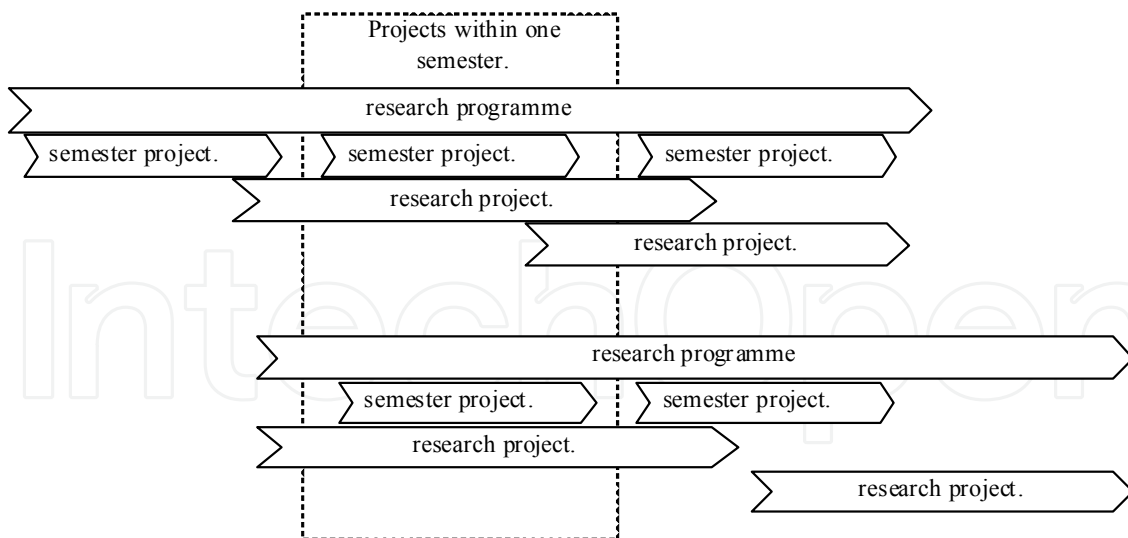
Fig. 12. Fitting general research plan and individual projects

The knowledge transfer goes via internal communication within a project team and within the research group, and via project presentations and research seminars held for all research groups.

For the integration of students within the projects there are several possibilities:

- First year students can concentrate on project management and can do field studies and questionnaires.
- Undergraduate and postgraduate students can be involved within lectures and course-related projects to plan, conduct and evaluate research.
- Final project theses and research projects involving postgraduate and research students and staff will form the highest level.

7.2 Integration of different grades

In the examples considered within this paper action oriented learning takes place within several lecturing units. One effect of training project management is the integration of teams with different background. Some aspects of intercultural training can also be achieved by integrating students from engineering and economics into one team.

For the integration of different grades we have several possibilities including:

- undergraduate and postgraduate students in lectures and projects
- final project thesis work.

Examples for joint projects	Under-graduate lower grades	Under-graduate higher grades	Under-graduate final thesis	Postgraduate studies	Postgraduate Thesis
Joint thesis project			▓		▓
Joint thesis project with students support	▓	▓	▓		▓
Postgraduate Projects				▓	▓
Postgraduate research with students support	▓	▓			▓
Joint under-/postgraduate projects	▓	▓		▓	
Undergraduate Thesis with students support	▓	▓	▓		
Undergraduate project	▓	▓			

Table 7. Examples for project structures integrating several grades

7.3 Examples

Several examples for projects have been given in (Holzbaur 2008). The following MindMap© gives the categories of projects conducted within the last years within the modules project management and quality and sustainability. For any category, five to twenty projects have been conducted by students´ teams.
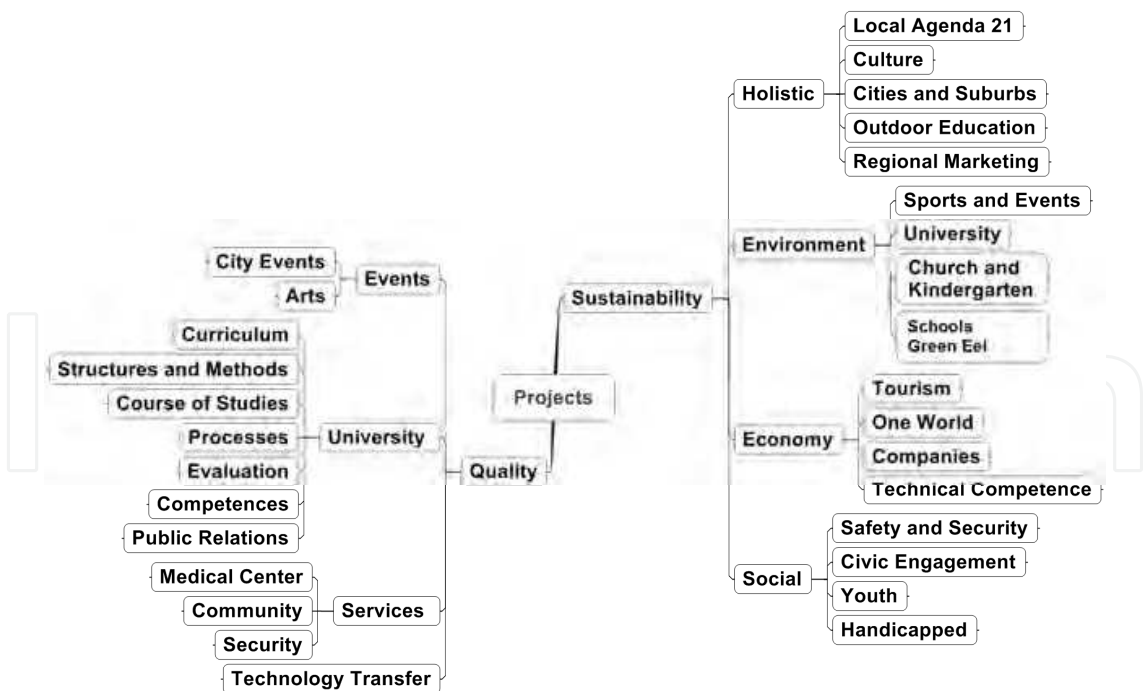

Fig. 13. Mind Map of project categories

Some examples for cooperation (same time, different students), evolution (same students, different time) or sequence (different time, different students, same subject) of research from first year students to final project theses is given below:

- Integrated management system for optical production: A student did her practical term, a joint project with some co-students of grade 7, and her final thesis on the conceptualisation, implementation and evaluation of an integrated management system for environment, quality, health and safety for a plant producing top quality aspheric lenses.

- Quality management and process optimisation for the university. Several students´ projects involving undergraduate students (project management, quality management and computer science projects) and final project theses analysed and optimised processes of the university, and implemented improved processes. Undergraduate teams used dedicated methods of quality management such as workshops, evaluation and development of questionnaires to analyse and improve the quality of the university. Concepts for marketing, communication and event management were developed for the university. Workshops on quality used various methods such as future workshop or open space and considered various subjects such as quality factors, resources, and motivation. Project comprise: analysis and optimisation of processes in selected parts or aspects of the university, analysis of the quality of university, faculty or departments using the EFQM model, definition of questionnaires for assessing the quality of the university (not only for teaching), event planning for open day and alumni events at the university, analysis and development of planning games. Projects for university quality may also be combined with or lead to computer science projects that implement processes or databases.

- Concept development and implementation of the environmental management system "Green Eel" by several students´ teams. School learners form an important target group for education for sustainable development. This environmental management system is adapted to education and equally concentrates on technical and pedagogical aspects. An environmental statement has to be prepared by the school. It should contain all relevant information about ecological impacts and education for sustainable development. The audit is performed by peers from three independent organisations (staff from city government, experienced teachers from other schools, staff and students from the university, members of environmental organisations). Learners support the participating schools in the implementation of the environmental management system and the preparation of the environmental statement. The project was awarded by UNESCO as a project of the UN decade for education for sustainable development. Evaluation of the system and the learning outcome was made in several final projects.

- The series of events in Aalen themed "Aalen nachhaltig-er-leben" – the words can mean "live more sustainable", "experience sustainable events" or "experience sustainability" – was developed within student's projects. Individual events were connected by a joint motto and special series of events were organises during weekends. Each quarter, a dedicated programme was issued. The project was awarded by UNESCO as a project of the UN decade for education for sustainable development. Teams of students also evaluated the events.

- Regional marketing and regional markets were analysed with respect to their impact on the local economy and with respect to customers´ satisfaction. A regional event for marketing regional and green products and services was developed, implemented and

evaluated. In these subjects, several students´ team and final thesis projects were integrated. Ongoing projects analyse the catchment areas of special events and develop an interactive website for marketing regional products.

- City Event Management: An analysis of the events within the medieval core of the city of Aalen (markets, concerts, sports events) was conducted; a guide for planning and organizing events on public places within a city was compiled. City marketing and development comprises: studies for city management, status and image analysis and concepts for several cities and suburbs, analysis of several aspects of sustainability for the city centre, concepts for making a city more attractive to students. A complete analysis has been made for small historic town with 4000 inhabitants.
- Special focus was laid on experiential concepts to foster regional tourism and on the impact of barrier free tourism. These projects link regional marketing with sustainable development and city management.
- Research on the security feeling and the causes of fear (population survey and expert interviews) was conducted in cooperation with the police department and city department of law and order. Population survey (15000 questionnaires, 4500 responses), expert interviews, cooperation with police city administration, polls to test the validity and acceptance of the main survey. Special research was devoted to the intercultural aspects of security feeling and to selected suburbs. Surveys were conducted on the protection of juveniles from alcohol abuse with respect to the law for the protection of the youth. Management and sales persons have been interrogated about the instruction of sales personnel according to the duties of due diligence and quality management.
- Planning games for education in subjects like project management and economics have been adapted to various target groups, and deployed at several occasions by various students' projects. The planning games "LegoTower", "Economics for dummies" and "Leonardo Bridge" have been developed, adapted and tested by teams of undergraduate students and final projects.

8. Conclusion

We have seen that projects can be a powerful method for teaching, training and research education. But there is also a lot of effort and academic and pedagogical challenge, which calls for a systematic approach to the planning and conducting of projects.

All in all, the success factors of prepared projects are:

- Long term Stakeholder management
- Professionalism in defining, planning and conducting projects
- Careful preparation - which means a lot of work
- Mutual trust among stakeholders, university, students and professors.

The experiences with several courses of studies show, that a careful preparation of the projects following an approach similar to planning games gives a high probability of success and a rewarding outcome for university, staff, students, customers and stakeholders.

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