LINKING RESEARCH EDUCATION AND EDUCATION FOR SUSTAINABLE DEVELOPMENT VIA PROJECTS

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Abstract

One of the main tasks of universities is to prepare students for an academic or professional career, and to make them responsible members of society by giving them the motivation and skills to create a better future. Education for Sustainable Development is a core feature of education in a university of the 21th century and in society. In a university, it has two aspects: firstly, to educate students and to help future academics to contribute to sustainable development, secondly, to contribute to sustainability and to spread education for sustainable development in the community. We consider examples of successful cooperation between the university and its stakeholders via projects that are relevant for education for sustainable development. We analyse the success factors and the educational and sustainability impacts of these projects.

Keywords: Education for research; Sustainable development; Project management; Tertiary education; Experiential learning; Project learning Education for sustainable development; UNESCO; Welcome to science

1. INTRODUCTION

Education for research is an important and challenging task for the New University (Lategan 2007). Research projects of all level and size are important tools of education for research (Holzbaur 2007, Holzbaur/Lategan 2009).

Sustainability is the central challenge for the 21st Century (UN 1993) and also universities all over the world have decided to integrate sustainability into their focus and strategy (see e.g. Hart 2007) and the websites www.ulsf.org, www.emsu.org).

The notion of Sustainable Development goes back to the so-called Brundtland report of the World Commission on Environment and Development: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987). Sustainable development is based on three pillars: ecology, economy and social issues (triple bottom line) (e.g. Rogers 2007). The Brundtland Definition means that all people (intragenerational justice) and future generations (intergenerational justice) can fulfil their needs.The vision of sustainable development was stated in the Rio 1992 declaration of the Agenda 21 (UN 1993). The aim of a local implementation of Sustainable Development was stated in chapter 28 (local authorities´ initiatives) while universities and the scientific community are addressed in chapter 31 of the Agenda 21.

Projects play an important role in practical work, in education, and in science. The use of projects in university comprises the teaching of project management and of the special subjects, the preparation for research and practical work, and the achievement of relevant results within student's projects. Projects can contribute to education for sustainable development and can also have a direct impact on sustainability (Holzbaur 2008; Bühr/Holzbaur 2012).

The important question is, whether these aims of education for research and for sustainable development and sustainability impact on the community can be integrated within students´ projects. In this paper, we analyse a set of projects that integrate these aims. We show the outcomes and problems and analyse the success factors of projects in education for research and sustainability. This paper is based on (Holzbaur 2010).

The state of Baden-Württemberg is supporting a research project on "Experience Science and Practical RElevance and learn Sustainably by means of Sustainability prOjects" - ESPRESSO within their programme on "welcome to science" for the years 2012 to 2015.

2. PROJECTS IN EDUCATION

The Prepared Projects Method (Holzbaur 2008) is the basis for an efficient use of students´ projects to achieve training and educational effects as well as tangible results. The following considerations about projects in education are also valid for the special topics research and sustainable development.

2.1 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.

Table 1: Combining theory and practice in teaching

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

This integration requires some effort in the preparation, but gives a rewarding outcome for the trainer and the student. The integration of theory (dedicated course subject) and practice (including project management) can be done via the sandwich principle which is enhanced to a fractal structure integrating theory and practice: into each theoretical/practical block of the double-decker, a practical/theoretical part is inserted. Additional theoretical insertions may also be initiated by students´ presentations. Of course, the basic blocks for the course subject will use more lecturing time than the project oriented ones.

Table2: Phases in training with projects

	core	insert	core
Theory	1. Course subjects	2. Project management methods	3. Project description in terms of course subject
Practice	4. Project definition Project assignment	5. Relation of project to course subject	6. Project start Kick-off presentation
Theory	7. Course subjects	8. Linking projects to the course subjects	9. Course subjects
Practice	10. Project work Project controlling	11. Project analysis wrt. course subjects	12. Stakeholder project presentations
Theory	13. Course subject Project research results	14. Final presentations	15. Reflections on findings wrt. course subjects

2.1.1 Research projects in tertiary education

There is a sequence of projects in tertiary education that leads students from freshmen's projects to research.

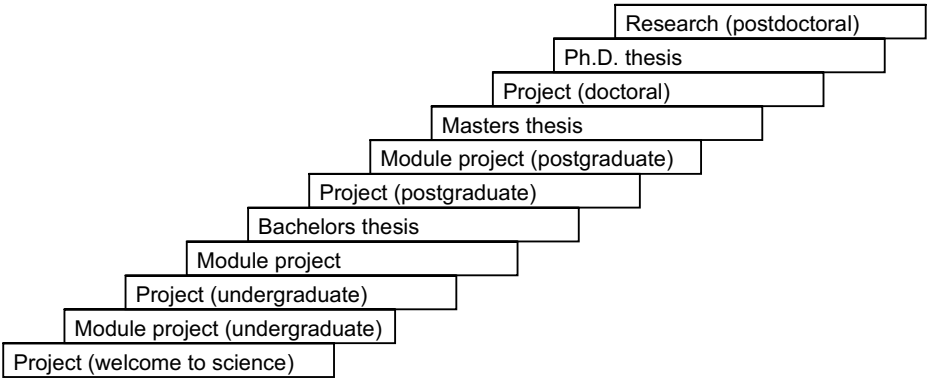

Figure 1: The stairway of research projects

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

2.1.3 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 (Holzbaur 2007).

2.1.4 PPM 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.

Table3: Generic PPM Project Schedule

Week	Activities
- 150	Collect ideas for potential projects
- 100	Plan the very long term projects (more than one year) Identify stakeholders
- 50	Plan the long term projects (one year or less). Contact potential project partners
- 30	Define series of projects for one or several semesters.
- 14	Assess the previous semester's projects and define follow-ups
- 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 their customers and stakeholders
+ 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
+100	Publication of project outcomes and evaluation results

Prepared Projects Method (PPM) can be used to achieve several results simultaneously:

- to train project management and research methodology,
- to teach practical aspects of any course subject,
- to gain tangible results in real world projects.

2.1.5 Curricular prerequisites

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.

There are two main principles of integrating subjects like project management, soft skills, ethics, research methodology or sustainability into a curriculum: either in a dedicated course or within a special course subject. The following typical module descriptions show the basic feature of lecture or project based course units on a special subject (e.g. Technology, Marketing, Sustainability) and a project based unit on project management.

Table4: Module description for a special subject oriented course integrating projects

Method	Lectures and presentations Learning by doing in a practical project and from all projects		
Exami-nation	Type and internal weightings	Examination (oral or in writing) Project plan, work and presentations Project result and subject reflection	50 % 20 % 30 %
Work-load	Contact hours	22 x 2 h course subject 4 x 2 h project management 3 x 2 h presentations 2 x 1 h project meetings	60 h
	Self-Organized work	Project work and research in the team	50 h
	Self-Study:	Theory (course and project subject)	40 h
	Sum:	5 Credit points	150 h

Table 5: Module description for a project oriented course on a special subject

Method	Lectures and presentations Learning by doing in a practical project and from all projects		
Exami-nation	Type and internal weightings	Project plan and project work Subject related project work and reflection Project result documentation and presentation	10% 70% 20%
Work-load	Contact hours	8 x 2 h course subject 2 x 2 h project management 3 x 2 h presentations 2 x 1 h project meetings	30 h
	Self-Organized work	Project work and research in the team	90 h
	Self-Study:	Theory (course and project subject)	30 h
	Sum:	5 Credit points	150 h

Table 6: Module description for a course on project management

Method	Lectures and presentations Learning by doing in a practical project and from all projects		
Exami-nation	Type and internal weightings	Examination or individual project report Project plan, work and presentations Project result documentation, deliverable items	30 % 40 % 30 %
Work-load	Contact hours	14 x 2 h project management lectures 4 x 2 h presentations 4 x 1 h project meetings	40 h
	Self-Organized work	Project work and research in the team	90 h
	Self-Study:	Theory (project management, background)	20 h
	Sum:	5 Credit points	150 h

Note that the total project oriented workload per students comprises the project work and project related research done in the teams and individually, the presentations and the project meetings with the supervisor and stakeholders. The number of students may vary from 3 in a homogenous team to 12 in projects that integrate several sub-projects or teams from several courses. Hence, total project size may vary from 180 hours (one person-month) to 1800 hours (one person-year).

2.1.6 Project Partners

External partners as stakeholders or customers for projects are important since they give sense and challenge to the project. The course responsible himself can take the role of a customer in a limited number of projects.
There are two main types of partners:

- Industry can provide 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.

- 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.

Stakeholder communication is important in the preparation and definition, in the implementation and in the evaluation of the project.

2.2 The Project Portfolio

To have success in research education and in education for a dedicated subject, projects have to cover the whole range of skills and subjects. This applies to the projects of one year (or semester) as well as the projects that one student's cohort.

There are two detailed portfolios that show the subjects and competences throughout the projects. An integration is given by the following portfolio; it gives a very condense aggregation despite the fact that a project may cover various subjects and skills.

Table7: Generic project portfolio for one semester (excerpt)

project subject focus project skills focus	quality	sustainability	energy	environment
Literature survey	X			
Questionnaire	X			
Concept development	X	X	X	
Stakeholder analysis	X			
Quantitative analysis	X	X	X	
Statistical analysis				
…..				

2.3 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.

Table 8 Examples for project structures integrating several grades

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

3. PROJECTS IN EDUCATION FOR RESEARCH

The following considerations are valid for all types of projects, but are especially important in research projects and with respect to research skills.

3.1 Steps towards research competence

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 project planning and control; 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; theory of errors and statistical decision methods 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.

The metaphor of a stairway is adequate to describe the various skills for doing research and the steps to be taken in research education.

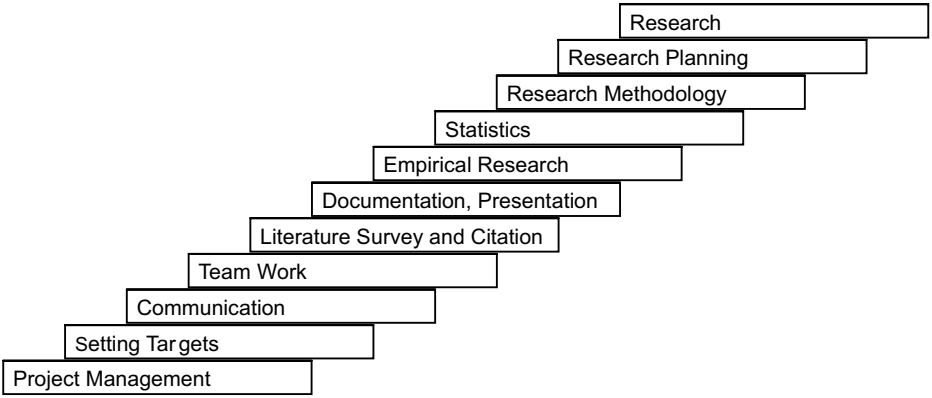

Figure 2: The stairway of research skills

3.2 Research 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 all 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
- Project management documentation
- Project result (according to the scope of the project)
- Publications (press release, scientific paper) and posters.

3.3 From task to target

The task of defining goals and setting targets for the project is an important part of education towards research and project management. 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 students´ involvement in their own project. Moreover, it trains them to define the goals in cooperation with the customer and the teammates. In (Holzbaur 2007) we have analysed this process of defining the project within the framework of the magic triangle. In the context of research education, we also have to consider the question of an adequate level of research and creation of new and reliable knowledge. 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.

4. PROJECTS FOR SUSTAINABLE DEVELOPMENT

The considerations about projects in education in the foregoing chapter are also valid for education for research and education for sustainable development. In this chapter, we give several examples for projects related to education for sustainable development.

According to the considerations on optimal project structure and partner, many projects have been initiated in cooperation with local government and police, with groups of the Local Agenda 21 and also with partners from the university. In this paper, we concentrate on projects that are directed towards the support of sustainable development in the community.

In all cases, projects are defined by the supervising professor, and an external customer is identified. Projects cover aspects like environmental management, resource saving, security feeling, regional marketing, process quality, and stakeholder management. The project portfolio of each semester is designed to cover all important aspects of the course topics.

The use of projects to integrate education and to make a real world impact within the courses on "quality and sustainability" and “excellence and sustainability” has been designated as official Decade Projects of the UNESCO Decade "Education for Sustainable Development" for 2007/08, 2009/10, 2011/12 and is in the application process for 2013/14.

4.1 Overview

Several examples for projects have been given in (Holzbaur 2008). The following Mind Map© 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.

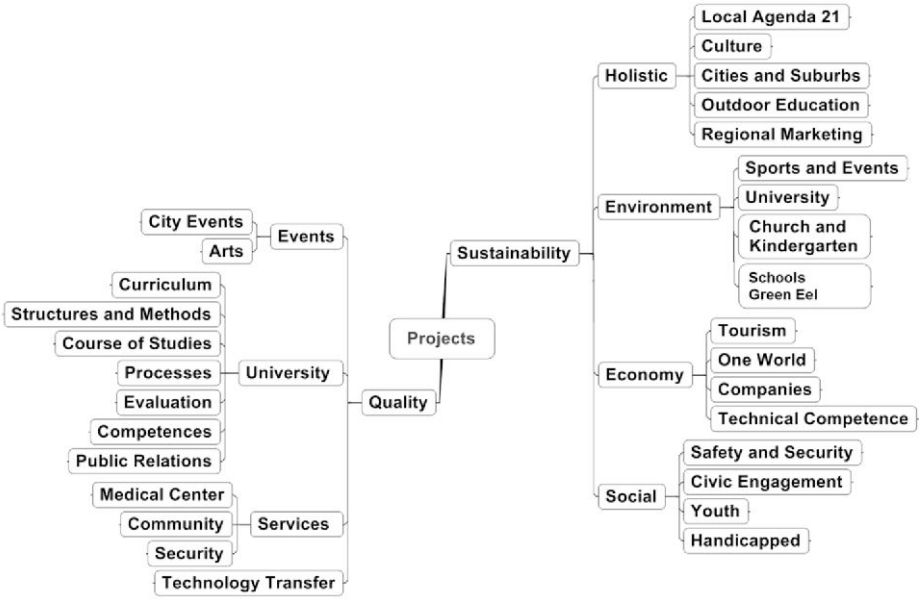

Figure 3: Mind Map of project categories

4.2 Environmental Management for Schools

Education for Sustainable Development (ESD) is an important issue for sustainable development since education has a multiplier effect and from that is much more effective than direct measures. School learners form an important target group for education for sustainable development.

The Green Eel is an Environmental Management Systems (EMS) for Schools developed at AAUAS, with support from several students´ teams, and in cooperation with the department of environment of the city of Aalen and the Local Agenda 21 of Aalen. It is named after the eel (Aal) in the coat of arms of the city of Aalen. Green Eel has the same level and content as the European Eco Management and Audit Scheme EMAS but is based on a peer review. Hence, the system replaces formalism by expert knowledge and social control and focuses also on the involvement of the learners. Concept development and implementation of the environmental management system “Green Eel” was done by about 20 students´ projects.

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 frosm 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. Evaluation of the system and of the outcomes was made in several projects.

If and when the school fulfils the requirements of this standard, it will receive the “Green Eel” certificate. The criteria and supporting documents are given in www.gruener-aal.de

- An environmental policy serves as the foundation for the EMS, and provides a unifying vision of environmental principles that will guide further actions of students, teachers and management.
- An environmental programme must cover technical (energy, resources, waste, water, materials), environmental (greening the campus) and pedagogical (teaching, environmental subjects, projects) issues.
- 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).

Up to now, twelve schools have participated in the project. The concept “green eel” was awarded as project of the UNESCO decade education for sustainable development for 2006/07, 2008/09, 2010/11 and 2012/13.

The students´ contribution was

1. Formalisation of the idea of an EMS with peer review
2. Documentation of the green eel system (throughout the years of system development)
3. Creation of templates for the environmental statement, structuring the ES in XML
4. Support of the schools in the implementation process, contribution in the auditing process
5. Evaluation of the system
   The projects gave them insight into the assessment process; moreover, the EMS documentations were important contributions to the students´ ability of documenting project results.

4.3 Events for Sustainability and sustainable events

For the 10th anniversary of the Local Agenda 21 with the slogan “Aalen nachhaltig-er-leben” – meaning “experience sustainability in Aalen” and “live more sustainable in Aalen” – an event concept and a detailed plan and schedule (including communication) have been developed via subsequent 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 concept was awarded as project of the UNESCO decade education for sustainable development in the years 2008/09, 2011/12 and is in the application process for 2013/14.

Teams of students also evaluated the events. Event management is based on two fundamental issues: the psychological effects of emotion and experience and the careful and risk reducing preparation based on the application of project management. Projects with respect to event management consider mainly the project management aspect, the quality of services, and customers´ satisfaction. Nevertheless, students are very creative and have good ideas for special events effects. Several events with respect to sustainability have been prepared and evaluated by students´ teams.

Examples of such events were:

- A dedicated “action week for education for sustainable development” including
- Panel discussions of various aspects of sustainability with professionals from education, administration, church and industry.
- Events in the forest to promote the use of wood in building and heating.

- Guided “energy-tours” to houses and power plants using regenerative energy
- The annual day of region promoting regional products and services.
  For 2010, a students´ project developed several additional ideas for the “action week for education for sustainable development” including
- A football tournament with kids from different nations in one team
- A cooking course where you can learn to cook with local products
- A Band contest with local newcomer bands
- A bicycle tour to motivate people for sports and nature
- A workshop on the improvement of the diet for the cafeteria in relation to regional products

The students´ contribution was

1. Formalisation and communication of the idea
2. Planning of the series of events
3. Stakeholder analysis and identification of potential participants

The projects gave them insight into the process of (event) panning and the various aspects of sustainable development. Moreover, several student´s projects also analysed and planned special events of the university with respect to sustainability issues such as energy, food, accessibility and participation. The results were integrated into a guideline on sustainable events (Abele/Holzbaur 2012).

4.4 Regional marketing and tourism

Projects for fostering regional marketing and tourism are conducted within the Agenda 21 process or in direct partnership with local authorities and enterprises. The projects cover aspects of sustainability (social, economic and ecological aspects) as well as quality of services. These comprise the following main groups of projects:

- Regional Marketing and development of a regional brand: The Local Agenda 21 of the region Ostalb started in 1999 with two major projects: A set of “green tours”, bicycle tours through the countryside in order to promote local tourism and direct marketing for farmers was implemented. Studies for a regional brand and analyses for the use of regional and organic food in catering and cafeterias for university and government have been performed. 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 and an interactive website for marketing regional products were 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.

- Barrier-free tourism is one of the focuses as it has impacts on the mobility of a high percentage of the population, the success of event management, and on the adaption to demographic development: Supported by student's teams, a status analysis of Aalen City with respect to handicapped people's mobility leaded to a guide for handicapped visitors that was published in print and via the WWW. It also contributed to the above mentioned guideline for sustainable events. Several projects aim on implementing a barrier free city as a contribution to tourism development.

- 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.

The students´ contribution was

1. Formalisation and communication of the idea
2. Planning of the series of events
3. Documentation of the event
4. Documentation on a systematic planning procedure

The projects gave them the insight into the systematic planning of special events and the relation between requirements and success.

5 SUMMARY

The analysis of these projects shows that in all cases, the students learned to plan the research and the projects, to conduct and control the work in a systematic way, and to evaluate and document the results.

In parallel, the students learned about the subject of sustainable development in at least one of the core aspects of the triple bottom line, and they also made a direct contribution to the sustainability of the community or the university.

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