

Multidisciplinary projects as learning tool for sustainable approaches

Experience and some critical assessment

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1. Introduction

Importance

For our modern society to develop to a true sustainable society some necessary transitions will have to take place. Such pioneering changes will partly be realized on traditional, monodisciplinary grounds, partly be the result of developments that go beyond separate disciplines and require an interdisciplinary collaboration. Such a collaboration, a multidisciplinary project, makes stringent demands on the participants who must have good human relations skills next to flexibility and a feel for each other's language. And those last two skills in particular are not explicitly taught in the traditional engineering educations.

To be adequately prepared for the future practicing of their profession as engineers, students in any (technical) discipline will have to learn through multidisciplinary projects:

- a. to understand each other's language
- b. to start thinking in systems
- c. to dedicate their specialism to a systems approach

Due to the developments in higher vocational education toward competence-based learning, making increasingly higher demands on the student's ability of self-reliant learning and regulation of their study, teaching methods such as project teaching and problem-based learning become more and more important. Multidisciplinary projects fit in seamlessly. They are essential for a professional education that focuses on the future, and are efficient.

The framework

Since 1998 there has been a project at the Faculty of Technology and Science of Hogeschool Brabant (Brabant University of Professional Education) to introduce sustainable development into all study programmes of the Faculty: the Cirrus project.

The novel approach chosen for this aims for an integrated focus on sustainability in all the Faculty study programmes by integrating necessary knowledge, insight and competences in the different subjects, courses and projects. Specific attention paid to 'sustainable development' in dedicated courses and projects, merely serves to explain the background and main issues of sustainability and to give a framework for all further 'sustainable aspects' treated elsewhere. The main aspects of this integration are creating an awareness of and a vision on sustainability as well as learning a systems approach when assessing issues and developing possible solutions.

Objectives of our multidisciplinary projects program:

- to gain experience with multidisciplinary projects.
- to develop an integrated course.
- to develop a protocol for multidisciplinary projects.

The most important problem definition:

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1. How can we have students from various disciplines truly cooperate?
2. How can we make sure that multidisciplinary collaboration leads to sustainable solutions of the problems posed?

2. Practical approach

At the time of the start of the CIRRUS project, not much experience had been gained with multidisciplinary projects within the Faculty. Only occasionally had students from different study programmes worked together. Contacts with other institutes (e.g. through the Dutch Committee on Sustainability in Higher Education), descriptions of approaches in literature and reports of successful projects on the Internet, supplied us with sufficient inspiration and practical information, or so we thought.

A major obstacle for us was that the structure of the different programmes differed quite a lot. Not only did the planning in time for practical work and projects differ, but also the actual set-up for preparation and the way students selected projects. This is changing now with the new clustering of studies and a broader introduction and integration in the study programmes of learning projects and problem-based learning.

So we started with proposals for multidisciplinary projects during the practical work and the final year project planned in the final semesters of the study, usually in the fourth year.

In time, the activities developed as follows:

Directly at the start of the CIRRUS project a multidisciplinary project (ENO) was carried out, based on the insights we had from the sources given above. That proved to be an excellent learning experience.

The results of that formed the input for a protocol we made with the objective to attain better coordination with all parties involved, within the Faculty and in the field.

That protocol was used in three further projects and the results were evaluated.

3. Protocol

A great number of parties are involved in a multidisciplinary project, students and lecturers, but especially different departments, each with their own organisation, and parties in the field acting as principals and their contacts.

Because of this, sound agreements and a clear thematic approach are essential for the preparation and execution of such a project.

To that end a manual or protocol has been set up, initiated by the CIRRUS project, which has been used and tested in a number of projects.

The protocol comprises the acquisition and assessing of new project assignments, the recruitment of the project team and the appointment of the project leader who is responsible for the execution of the project according to the plan, a verification of the project targets and if necessary an adjustment of the plan of approach.

Commitment of the board of the Faculty was necessary and December 1999 we got that commitment to organize multidisciplinary projects under supervision of the CIRRUS-project team.

The protocol distinguishes two phases:

- the 'intake' phase
- the actual execution phase

Both require continuous tuning within the Faculty as well as in the field.

The first phase takes place within the Faculty, the second to a large extent in the field, involving a change in the tasks of the supervising lecturers and the supervisors of the principal.

The protocol serves to align those responsibilities and tasks to prevent the project being disrupted and hampered by organisational and tuning problems. As it is, the multidisciplinary character alone requires a lot of time.

The complete text of the protocol is available at www.projectcirus.net.

Working group Multidisciplinary Sustainable Projects

To make sure that multidisciplinary projects will work according to that protocol, and to help getting the program going especially in the beginning, a small team was called into being:

“working group multidisciplinary sustainable projects”, consisting of lecturers from the CIRRUS project team. The first projects were set up, supervised and evaluated by that group.

As later the interests of the collaborating parties have to be brought into line, time can be a limiting factor and the assessing and safeguarding of the quality of the sustainable assignment calls for knowledge and experience, a special working group was introduced. This group consists of people who can shape the preparation of a sustainable assignment.

Protocol preparatory phase.

The ‘intake’ or the preparatory phase has been set up as follows:

Assessment project subject
Allocation people & resources
Acceptance people & resources / Project management document

During the preparatory phase the suitability of the subject is assessed concerning weight and extent. The assignment must be of a suitable university level and be sustainable, multidisciplinary or interdisciplinary. Further at least 2 people need to be working on it for at least > 40% of their weekly hours and have an expected duration of * 10 [work placement] or n* 20 weeks (final project and work placement) respectively.

In particular attention is paid to staffing next to the necessary resources. The project members must have good communication skills and dispose of sufficient knowledge of, insight in and skills in the fields they represent. In addition to this, it is essential that they have the willingness and ability to be able to think along with their colleagues from different fields about subjects from those fields.

Crucial is the matching of the expectations of the participating students and the willingness to truly ‘behave in a multidisciplinary way’.

The departments concerned will have to adjust and possibly accept the fact that the coaching and assessment may be a bit different from the way they are accustomed to in monodisciplinary projects.

Further the agreements on the targets and expectations concerning the project with the external parties are of the utmost importance. First and foremost work placements and final year projects are learning projects, i.e. they must serve an educational purpose. Sometimes this seems to be forgotten by parties from the field who have expectations the project group cannot possibly live up to.

Protocol project execution phase

This phase comprises the following steps each with their own specific focal points. It is the project team that is concerned with the execution of the project according to the project phasing mentioned below.

Project phase	Location
D0 Start project	Faculty
D1 Orientation phase	Partly Faculty, if possible partly in the field
D2 Problem definition phase	If possible in the field
D3 Approach definition phase	Idem
D4 Design phase	Idem
D5 Implementation phase	Idem
D6 Project finalising and evaluation	Idem

Here the orientation is especially important. In this phase the students familiarize themselves with the problem at hand and more importantly with each other's possible contribution. Teambuilding has to take place. From the following cases this turns out to be crucial.

The next steps are in fact 'normal' phases in a project.

At all times, however, focus must be on the contents being the guideline for tuning. It should not be a couple of monodisciplinary subprojects carried out in parallel.

The project procedure is described in a separate document.

4. Projects and learning experience

4.1 ENO project

Sustainable Energy in the Province of Noord Brabant, inventory of need for knowledge

The student team consist of four participants from the study programmes of Electrical Engineering (E), Mechanical Engineering (ME), Information Management (IM) and Production and Operations Management (POM).

The objective of the project was to assess the need for information on sustainable energy options that exist in households and in small and medium enterprises in the province in which our university is located. Based on such insight, a more effective strategy to inform and motivate people and business could (hopefully) be designed. The study was requested by the provincial working group "Brabant Energy 2050" whose task it is to promote the use of sustainable sources of energy.

The study was done in the form of a questionnaire sent to 850 small and medium enterprises in six different sectors and to some 750 households randomly chosen from two sets of households, one for those renting houses and one for house owners. The response was satisfactory and some interesting conclusions could be drawn. Nevertheless, it can be considered to be a failure as a project, although quite a success as a learning experience.

It was the first multidisciplinary project carried out within the framework of the CIRBUS project. There was much enthusiasm but no protocol and much confusion about how to manage such a project and about the relation with the external 'client'.

A wise move was to assign one of the students to follow and evaluate the 'project process' and the problems encountered.

Major conclusions from this project concerning the students, their attitude and the way they cooperate, the project structure, organisation and the relation with external parties and ‘customers’ involved, are:

- the duration of the project must be equal for each participant
- the level of the participants must be more or less sort of equal
- the participants must dispose of an equal amount of time for the project
- the cohesion of the group of students is important and they must be willing to understand the various roles and be able to compromise;
- interactivity: there must be sufficient time to recruit and select students and to select a project
- the relation with an external party who proposes the project and often pays some fee, is not just that of a ‘client’ expecting ‘value for money’. A university with students is not a commercial consultancy. They should be willing to take responsibility for the educational aspect and have a contribution in that.

These experiences were the input for the protocol developed by the Cirrus team. As this protocol called for a collaboration between the various departments in bringing in line certain aspects of their programmes, the protocol was submitted to the Faculty management for approval, after which it was used and tested in three projects.

4.2 Improving energy efficiency of a new home for the elderly.

The subject: Energy economy of a home for the elderly still to be built. The student team consisted of three students from Constructional Engineering (CE), Building Management (BM) and Mechanical Engineering (ME). The approach for the acquisition of the assignment and the recruitment of students followed the protocol that had just been developed.

The project result exceeded all expectations. The design of the sun lounge has been adjusted on energy-technical considerations. It was a redesign, an intervention in the original architectural design. Apart from this, other energy-saving measures have been looked into. The project has actually been realised in practice.

The results:

	<i>Summer</i>	<i>Winter</i>
<i>Original design</i>	<i>Forced cooling necessary</i>	<i>Heating necessary</i>
<i>Altered design</i>	<i>Cooling through natural ventilation Photovoltaic solar energy</i>	<i>Heating necessary (less heat loss)</i>

Normally it is “not done” in construction to meddle with an already approved design. In consultation with the architect, who was open to this experiment, the design itself was subject to analysis with the above result.

At the start of the project at ECN Petten there was no clearly defined assignment. Apart from this there were problems with the possible approach of the project and the mutual cooperation. The student from Mechanical Engineering used a project model. The other two students were not familiar with working in projects. After agreements had been made on the procedure (according to protocol) and the mutual cooperation and the responsibilities had been laid down, the project went well. There was a lot, sometimes too much, consultation. The

coaching of the teambuilding in the initial phase of the project turned out to be too labour-intensive for ECN, also through a lack of experience with teambuilding. This was largely taken care of by the Faculty.

Experiences gained:

1. The main lines of the protocol worked well.
2. Coaching of teambuilding is too hard for supervisors in the field.

However, it has been very instructive and encouraging that the students have reached such a good result as it means that a group of budding engineers are able to radically improve a 'good' design made according to a traditional approach, by working in a multidisciplinary way.

4.3 Xerox, Venray: Re-use of a new generation of copiers.

The assignment was: design a process to re-use parts of a new generation of Xerox copiers. The team consisted of four students of Electrical Engineering (E), Environmental Oriented Materials Technology (M2), Mechanical Engineering (ME) and Production and Operation Management (POM).

Project result: recommendations for a changed set-up of re-manufacturing (due to a change of policy within Xerox not implemented.)

From the start there were problems within the team due to differences in background. In addition to this, one of the students turned out to be an outsider who initially did not carry out his part of the project sufficiently. After a fine-tuning of the division of tasks, the process improved. Due to a long time spent on 'problem definition' it was not possible to get to a sufficiently worked out problem resolution as the time that was left for developing and underpinning the problem resolution was too short. Such a long introductory period was intentionally chosen to have the team members get used to each other, to enable the team to explore the complexity of the field and to figure out a demarcation of the problem area fitting the possibilities of the team.

Experiences gained:

1. The most important issue turns out to be the willingness and ability of students to collaborate, apart from the level of the students. This must get more attention during the project preparation as well as during the entire education.
2. With large projects there is a risk that the demarcation of a problem definition that can be realised by students, is too time-consuming.

4.4 ECN-project: Integration solar panels in wall.

Eventually the team consisted of two students: Constructional Engineering and Electrical Engineering.

It concerns a limited "MD-project". Cause: lack of interest from students. The assignment developed too scientifically and became too much for the students involved. The E-student refused to look any further than the field of Electrical Engineering. Ultimately the project was carried out in a strongly adjusted form.

Experiences gained:

1. The attitude is crucial.
2. The complete freedom students have in choosing assignments for work placements and final year projects proved to be fatal for the recruitment of students.
3. The time at which work placements and final year projects are positioned in the various study programmes, is too diverse.

After these three projects, no more (final year) projects were undertaken due to a lack of student interest. This was another reason to properly evaluate the entire procedure.

5 Observations, Conclusions and Recommendations

Based on the cases described above and the observations made, several conclusions and recommendations in general are apparent.

Those concern the students, their interest in such projects, their attitude and the way they cooperate, the project structure and the internal organisation and the relation with the external parties involved and of course the way the protocol could cope with all that.

5.1 The students

Main observations were:

- recruitment of students is hard
- 'equivalence' requires a lot of attention
- collaboration and the realisation of the process within the group is hard

The recruitment of students was very difficult. From interviews with students, coordinators of final year projects and lecturers it appears that:

1. A lot of good students do not want their final grades to be influenced by fellow-students. They have too often experienced that they had to do the work for others and because of that scored lower grades for their achievement.
2. As soon as some students hear that they are responsible for the technical know-how from their own specialism, they pull out.
3. The great amount of projects during their entire education with the resulting impact of consultation repels the boffins (the 'makers') among the students.

Whichever way you look at it, equivalence is essential to bring about a successful project: an equivalent command of their own specialisms and a nearly equivalent power of persuasion. "Equivalent arguments" of various natures will have to be equally valued during discussions and decision-making processes (so head off one-sided dominance).

Some teams had problems of various nature at the start-up: division of roles, communication, tasks and responsibilities, etc. They must be tackled right at the start. As soon as the team goes out into the field, this can hardly be efficiently done anymore.

Because of this a special procedure concerning the process of teambuilding was developed. Core of the procedure: during the orientation phase of the project a coaching of the teambuilding takes place within the Faculty. That involves a better training and instruction for the students right at

the start: enabling them to co-operate in a team, to learn each other's way of thinking, to see the profits of co-operation and to accept results as a team effort.

Group processes usually know several phases: Forming, Storming, Norming and Performing [1]. It appears wise to allow students to go to the company only after clear procedural agreements have been made (Norming-phase).

Further having the students take a Belbin test seems necessary to make sure that all the team roles that Belbin recognized are performed collectively by the group of students; well-balanced composition [2].

5.2 The organisation

Main observation was:

- the bringing in line of department programmes remains a problem

This proved to be a constant problem. For this there were two causes: phasing and the different ways of preparation. There are departments where final year projects only take place once a year. In other departments, however, these projects can be done twice a year. And then there is the preparation. Constructional Engineering has a 'preparatory final project' (in semester 7), during which the student produces a problem study and problem definition for the final year project. A potential project should then be a long way into the preparatory phase. As a result of this it is hard to realize a correctly composed student team in time.

Internal adjustment of procedures and timetables of the various study programmes involved is a must. This will require increasing attention when broader multidisciplinary is sought and other faculties and other universities get involved.

Due to these and other aspects it could be considered that training through multidisciplinary projects had better not coincide with the final project and thesis, certainly in this phase of introduction of sustainability in the study programmes.

To be able to make use of the positive experiences, we feel therefore that multidisciplinary projects should be planned throughout the Faculty at an earlier stage in the curriculum, e.g. in the second or third year of study. This would also meet the earlier mentioned resistance of students, especially against this kind of projects in the final phase of their studies.

5.3 External parties

Main observations were:

- parties in the field having too high hopes
- companies are usually quite taken with multidisciplinary projects, but think the impact of supervision to be too much for their own organization.
- inexperience/ unfamiliarity of external supervisors with tackling problems in teamwork.

Sometimes external parties have too high hopes of the results. It is not sufficiently recognized that the main objective is and will be education. An adjustment of expectations of companies and institutes hosting the projects and the constraints inherent to a project as an educational tool is therefore necessary. That implies larger involvement and less guarantees, e.g. in comparison with individual projects.

ECN, Xerox (onetime) and Rockwool were able to define multidisciplinary assignments. Van Melle and NEDCAR could not. The main objection of companies is the impact three to five

students have on a project positioned within the organization. The internal departments are not prepared for this and the supervisors are not properly trained to cope with such a project team.

Recommendations:

- have the teambuilding process take place within the Faculty. This has been planned for future projects.
- have assignments of a multidisciplinary nature acquired in the field, take place as much as possible within the Faculty by means of a multidisciplinary project. This will take away the fear companies have for large groups of students that have to be in and out of the company for a long time; this approach is successful – see: Production and Operation Management, Hogeschool Brabant, semester 7 - strategy projects.

5.4 The protocol

In general the protocol has served its purpose well.

The various observations and conclusions will have to lead to an adjustment of the protocol.

As shown previously, this will have to concern:

- the tuning with regard to the planning of the study programmes
- agreements with the parties in the field, especially concerning the (im)possibilities of supervision
- the teambuilding, a balanced composition of the student team and the division of roles and tasks within the team.

5.5 Further proposals

Specifically for our own situation some actions are envisaged.

As said, smaller multidisciplinary projects are being considered at an earlier stage of the study. As such they can be made obligatory and also have an ‘integrating’ function to combine the various sustainable aspects that have been taught in the different courses.

Furthermore we intend to promote these smaller sustainable projects to students as well as companies, to show the potential of interdisciplinary projects. Examples that are being considered at the moment in consultation with companies and municipalities:

- energy economy homes / estates in multidisciplinary projects (CE, E, ME, POM/BM)
- low-energy and environmentally friendly tools (E [et], Chemical Engineering, ME [construction], POM)
- sustainable faculty (FTN)-building (CE, E, ME, M2, POM/BM)

Students would be able to experience the advantages of multidisciplinary projects by these small projects (the cultural differences and the differences in approach) that might increase the motivation for a multidisciplinary final year project.

The programming of the studies has to be brought in line with this and this ‘opportunity’ for interdisciplinary learning must be taken into account during the current educational reform.

6 Summary most important findings.

With regard to the surplus value and the appreciation by the students and companies, in our view the following can be said.

Pro:

- Such a project enriches the student's learning process enormously. Collaborating in a multidisciplinary team calls for the ability to learn and appreciate each other's language and way of thinking. Subsequently (very) good results can be achieved in the border areas of each other's specialisms.
- Companies, such as ECN and Xerox were quite taken with such projects.
- Students must be better or become better in their own fields to be able to work in a multidisciplinary project.

Neutral:

- The teambuilding process can better take place within the Faculty.

Con:

- Students are tired of being levelled down due to group assessments; therefore recruitment of good students in particular is very difficult.
- The programming of the studies, especially the start of the final year project and the positioning in the curriculum, differs greatly within the Faculty of Technology and Science.
- The acquisition of external multidisciplinary assignments is hard; companies feel the supervision of a group of students with such a broad assignment to be problematic.

Literature cited

[1] Tuckman B.W. & M.A. Jensen, Stages of small-group development, in Group and Organisation Studies, 2 (4) 1977, 419-427

[2] Belbin, R.M., Management team: why they succeed or fail, Heineman, London (1987) 1981