Lessons to Be Learned From Industry/University Cooperation on Undergraduate Project Work

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Abstract: Experiments with cooperative learning started in 1976, and has since 1982 project work in groups has been the hallmark of the pedagogical approach at Hogskolen i Telemark. This paper examines some attributes of 18 senior semester projects to provide some feedback for future adjustments. By estimation, some projects have been labeled "successful", "ordinary" or "failure". This survey defines some common denominators to classify either of the three categories mentioned above. "Successful" projects tend to be well chosen, well defined, engineerable, and generally accepted by the partner's employees. "Failure" projects can be seen to crash because of too wide scope, too high ambitions, and to ill prepared partner company employees. However, it is claimed that no project result measured by this crude scale may be used to evaluate the value of the cooperative learning process as both a learning and personal development tool.

Keywords: collaboration, holism, interdisciplinarity, project-based learning, design

1. Introduction

After 24 years of undergraduate student project work experience, 18 successful, not-too-successful and some "failure" projects have been selected for evaluation.

Questions to be raised and - eventually answered - include: Were the reasons for success, mediocricy and failure caused by too little ambitious projects or, maybe, *too high* ambitions? Were the projects mainly designed to learn, or to solve problems? Did we get paid, or at least, make the industrial partners cover parts of the costs? What kind of feedback from the other part was given and received before, during and after the cooperative process?

2. Limitations

This paper is, above all, a teacher's attempt to halt for a moment to see if there is something to be learned from listing and evaluating some projects retrospectively. As the number of projects has had to be kept low at the same time as the selection contains projects under the author's supervision, the results may be of limited value to others. However, the author expects this work to revive former experiences from different angles and expectations and, maybe, find the effort worthwile with respect to future work with undergraduate student projects in groups.

The findings will finally be related to some general educational principles and goals. However, to provide some background for better interpretation of this survey, a short description of the "Telemark Model" of project work in groups will be given.

3. The Telemark Model

The Telemark Model is a slightly modified version of the pedagogic approach used at the Alborg University, Denmark. Engineering education at Hogskolen i Telemark lasts for 3 years, each year is divided into 2 semesters. The semesters are numbered from 1 to 6, where the 6th semester is the semester of graduation.

The Telemark Model is characterized by *the group, the project, the adviser, the documentation,* and *the evaluation*:

1. *The Group*. Consists normally of 3-7 students but special arrangements may be made on demand. The group is expected to constitute themselves, define standards for group behavior, exert self justice etc. The group is officially organized for the project oriented part of the studies. But many group members are cooperating also in courses taught in traditional ways
2. *The Project*. There are different types of projects:
   a) First Semester's Project should have a broad scope, dealing with general problems of interest to society at large - typically with an environmental emphasis. Ideally, this project is supposed to introduce the student to a

scientifical way of thinking, working and writing. The topics may be chosen by the group from a list set up by the teacher

b) The next semesters: Technical projects, often in cooperation with industry or public utility companies. The problem is usually assigned by the teacher

c) Sixth semester's project (main project, 60 % of the semester or more): A technical project given by the teacher or others

Common to all projects: The group members are required to present their report orally to an audience.

3. *The Advisers*. Each group is assigned one adviser and one censor. These are normally members of the ordinary staff. However, some external project partners have signalled their interest in closer cooperation. A handbook has been worked out to assist advisers and students during the process
4. *The Documentation*. The group's activities and progress should be documented by a "project file" containing notes etc., a "process description" where the group evaluate their progress, and the formal report
5. *Evaluation*. There is a pass/fail system. Only the final report is graded, with individual grades for each group member

4. Change of course content

The Telemark model is, depending on the engineering departmental needs, allocating 25-30 % of the total organized time for project work. The rest of the weekly schedule is filled with "traditional activities".

As the technical content of the project work can only partly be selected and controlled by the teacher, he will play a less active role to provide the "useful" material for his students. Instead: Cooperative partners outside the college will have the opportunity to influence the college directly through student work. Experience shows that teachers indeed learn from their students' reports and may include such material in their own classroom work.

An important aspect of the Telemark model is the opportunity of specialization - limited by the narrow frames given by the 3-year's program. Some graduates are reported to have been hired just because of the topic of the final semester's project. But this is not "the general rule".

5. Change of educational methods

Compared to "traditional activities", project oriented studies above all mean a change of methods.

The change is **fundamental** since the objectives of project oriented studies are something more than just a curriculum replacement: While a "traditional" program normally emphasises certain selected fields of specific knowledge, project oriented studies are trying to realize objectives like [1]

1. teach the fundamentals
2. help the students how to learn, and
3. give the students some training in solving problems

Done successfully, project oriented studies should have the ideal objective of helping the students learn to know themselves, making them fit for working in a constantly changing world.

6. Change of the teacher's rôle

The ideal rôle of the teacher serving as an adviser, may be fomulated like this:

The real challenge in college teaching is not covering the material for the students, it's uncovering the material with the students [2]

Consequently, the adviser needs neither be the expert of the topic chosen by the group nor in command of the group process. Instead, the teacher - often referred to as *facilitator* - should be the insightful indirect **leader** letting things happen.

7. Curriculum change

The partial shift of responsibility from the teacher to student groups will lead to the growth of "new" curricula containing several elements necessary to cope with the realities in the world of today.

The "new" curriculum may include *tangible* as well as *intangible* features [3]:

1. *Tangible* aspects are training in practical leadership, applied to handling and following up formal meetings, making oral presentations, basic technical writing including style, grammar, spelling etc. And - of course - training in finding and applying appropriate technical solutions in fields not even taught at the college

2. Some *intangible* parts include experience with group psychology processes and leadership training including social adjustment, responsibilty, flexibility, initiative, courage and perserverance

8. A holistic approach

Thus, it is believed and documented [4], [5] that there are indications that this way of conducting learning processes do respond to society' s demand for broadscoped engineering graduates, well fit for entering the workforce as well as well as prepared for advanced studies in a multitude of fields. [6]

9. Project selection

The selected 18 projects, *all* conducted by electrical power engineering students, are listed chronologically in Table 1. The samples are restricted to 18 to keep the table within one page. Crudely, the sampling may be sorted into three categories: 10 "successful" (**S**), 4 "ordinary" (**O**) and 4 "failure" (**F**) - see Part 10. However, it is important to stress that neither "successful" nor "failure" indicate any evaluation of these project 's value as learning and personal development tools. R & D denotes research and/or development type project.

Table 1: Some selected projects

Number/ theme	Year	Partner(s)	Project type	Result (**S**/**O**/**F**)	Economy
1. Automatic Control of a furnace	1978	Brick-producer Borgestad Fabrikker	Automating a manually controlled process, **Engineering**	Successful, the solution installed. **S**	Estim. yearly value: Ca. NOK 200.000
2. Upgrading a powerplant	1990	Vestfold Kraft, power company	Redesigning a hydroel. powerplant, **Engineer.**	A learning experience? **F**	None
3. Energy consumption at OVS school	1991	OVS vocational school/Telemark County	Energy cons. of 75 to 100 years old buildings **Engineering**	Successfully installed. **S**	Savings NOK 130.000/year, 6 years p.b.time
4. AC converter transient study	1993	Sintef Research/ Racom	Transient behavior of converter, **R & D**	Incompl.; partly a failure. **O**	Costs & equip. suppl. by cust.
5. Energy conservation at ANF	1994	A. N. Funnemark, Car dealer/SKK Power ut. company	Energy conservation at a local car dealer, **Engineering**	Mostly carried out. **S**	Investm. NOK 233.000; p.back time ca. 2 years
6. Upgrading offshore pump drives	1994	Statoil, plus ABB Energy & Offshore	Speed control replacing valve control for large motors, **Engineering**	Modified solution installed. **S**	Investm. NOK 4.7 mill.; pay b. time < 2 years
7. Remote control of a transformer station	1995	SKK Power utility company	Complete design incl. complete drawings for remote control. **Engr.**	Not implemented; considered student work. **F**	None
8. Upgrading of an industrial pump drive	1995	Borealis process plant	PMW variable speed control to replace valve control **- Engineering**	Not installed; too long payback time. **O**	Inv.ment NOK 250.000; p.b. time > 6 years
9. Upgrading of a model process plant (1)	1995	OVS vocational school/Telemark County	Enhancing the model plant to serve scientific purposes. **Engineering**	Operates successfully acc. to specifications. **S**	All costs covered by OVS and local industry
10. Model plant upgrading (2)	1996	OVS vocational school/Telemark C.	Adding multifunctional purposes, **Engineering**	Successful acc. to spec. **S**	Costs cov. by OVS/industry
11. Supermarket energy control	1996	PP shoppingcenter	Classical energy conservation, **Engineering**	Proposals carried out. **S**	P.b. time < 10 yrs. satisfactory
12. Industrial energy conserv.	1996	Teli metal workshop	Energy conservation - **Engineering**	Proposals not carried out. **O**	P.b.-time requirem. not defined
13. Industrial production hall heating	1997	Nobet, producer of prefabricated concrete elements	Keeping temperature at two levels without obstruction of traffic - **R & D + engineering**	Partly implemented. **O**	All costs, NOK 15.000 (~2.000 USD) covered by Nobet

14. Industrial motor control	1997	A manufacturer of steel chains	Checking motordrives and pow.factor, **Engrg.**	Interrupted. **F**	Costs covered by customer
15. Removal of power spikes	1997	PP, a porcelain manufacturer	Reduction of spikes and costs, **Engineering**	Carried out as proposed. **S**	Inv. ~ NOK 85k; savings ~ 1 mill. NOK/year
16. Heat distribution in a thin metal sheet	1997	Elva Induction, producer of induction heating equipment	Multivariable temperature distribution - **R & D**	Results acknowledged by Elva Induction. **S**	All costs covered by Elva Induction
17. Process furnace control	1998	Bjolvefossen/ Odda steel work	Furnace control system modification, **Engrg.**	Will partly be *the* solution. **S**	Economy not involved
18. Industrial energy conserv.	1999	ICOPAL, plastic tube division	Analysis of energy costs, **Engineering**	Interrupted. **F**	Costs covered by customer

10. Project assessment

First, it should be noted that all projects include interdisciplinary elements. By nature, energy conservation problems are broadscoped, and motor drive problems are applying elcectronic circuitry to control fluids through heavy current electric motor drives. However, even the R & D projects are integrating traditionally "independent" technologies. The extreme example is represented by project number 13, where the group had to research properties of concrete to convince the customer that their proposed solution for room heating was unlikely to harm the concrete hardening process.

Table 1 lists project results as "successful", "ordinary" and "failure". There are no sharp borders between the three. In general, "ordinary" may be sorted from "successful" because different evaluation from different platforms may vary significantly. "Failure" projects may not be completed, or may not have the expected effect on the external partner. Referring to this, the classification is:

"successful": 10 projects; number 1, 3, 5, 6, 9, 10, 11, 15, 16, 17
"ordinary": 4 projects; number 4, 8, 12, 13
"failure": 4 projects; number 2, 7, 14, 18

based on informations given in the "Result" column. In Table 2 (Project size), Table 3 (Feedback to groups) and Table 1 (Economy) some important premises for the grouping above are given

Table 2: Project size

	Successful projects	Ordinary projects	Failures
Well defined problems	1, 6, 9, 10, 11, 15, 16, 17	4, 8, 12, 13,	14, 18
Too large projects	3, 5, 7		2, 7

Table 2 indicates that well defined problems are important for success. However, this sampling has been chosen to illustrate that this is not the *only* decisive factor. Too large projects have been successful thanks to student group's will and ability to overload themselves, and several "well defined problems" have yielded "ordinary" and even "failure" results. Thus, even other criteria must be satisfied to ensure good results. It has been found, that environment feedback may be another factor important to success. Two major feedback sources are listed in Table 3:

Table 3: Feedback to groups

Description	Success	Failures
1. Teachers (facilitators) not sufficiently alert		2, 7
2. Feedback from outside partners	5	14, 18

Looking at 1. (teacher shortcomings), project 2 failure may have occured because the project was too large and the facilitators failed to help the students restrict the problems at an early stage. On the other side, project 7 failure represents a painful lesson that poor communication between teacher and student groups may yield surprising results: This group consisted of 5 students, all of them having at least one trade certificate as electricians. The problem was remote control of a transformer station; the report was filled with schematics and drawings to achieve such functions.

However, there was no *engineering* in the report. A record-long evaluation process following the project presentation revealed that the group's attitude to engineering could be described as "hostile". As trained electricians, they were still hooked up in traditional craftsman/engineer oppositions with, in this case, nearly destructive result.

"Feedback from outside partners" are important factors for success. Some companies cooperate because they (often reluctantly) believe they should help the college in providing projects. Others are all positive, even enthusiastic about the possibility of receiving help from the university. And - there are companies talking with a "split tounge" as the leaders welcome the project groups *without* having informed their staff in advance. As a result, the groups may meet resentment, indifference, and even hostility from their employees. One group, number 5, met hostilities between the staff and the young owner, who had recently succeeded his father, the founder of the company. This group of three students (all holding electrician's certificate(s) and with several years of working experience) discussed the situation with their professor and found a technical and socialpsychological solution as well. As demonstrated by groups 14 and 18, the technical success of this group was dependent on the sosialpsychological solution since these dropped out just because they were not ready to tackle indifferent and negative feedback from "the company floor". In these cases, the solutions for even attractive technical problems thus were out of reach.

With respect to economy, Table 1 shows that 6 projects (3, 5, 6, 8, 11, 15) include investment analysis and indicates that 4 projects (1, 5, 6, 15) as lucrative as seen from the industrial partners poin of view. As investment analysis is not taught at the college, the student groups, when needed, "pick" this knowledge from elsewhere. The lucrative projects tend to be well defined, even if project 5 excels in finding good technical solutions to a very large, complicated and emotionally affected project. Table 1 shows also that several external partners willingly cover project costs, which may include technical equipment (often donated to the college after project completion) and full travel expenses.

On the other side, and this is *not* in Table 1, the only undergraduate student project which has given the college a revenue, is project 15. No wonder, maybe, since an investment of a mere NOK 85.000 (about \$ 12.000) was calculated to produce a yearly electricity cost reduction of at least NOK 1 million (about \$ 125.000) from 4 to less than 3 millions.

11. Conclusions

From this small sampling of final semester student projects, it can hardly be found support for any conclusions but *cooperative learning organized as project groups* tend to facilitate good learning processes, personal development, interdisciplinary thinking, and introduce the students to the close interrelationship between human feelings/behavior and the key to technical success. At a lower level of certainty, it can be seen illustrated that well prepared projects with respect to limitations and human preparations tend to be successful.

However, there are indications that the reasons for "success" and "failure" are not well defined but rather a combination of several factors - often dependent on the teacher's long time experience with project work.

Maybe then, *the real conclusion*, is: The success of future integrating engineering education is the shift of focus ("paradigm shift") for the professor's work from "curriculum" knowledge to *learning processes* - implying a strong emphasis on the value of broadscoped interests and research.

12. References

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