# AC 2009-186: INDUSTRIAL INTERNSHIPS: THE FINAL PART OF A THREE-PHASE MULTISUBJECT EXPERIMENT IN PROJECT-BASED LEARNING IN VEHICLE TECHNOLOGY STUDIES

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# Industrial Internships: The Final Part of a 3-Phase Multi Subject Project Based Learning in Vehicle Technology Studies


## Abstract

The main goal of engineering education is praxis oriented learning. At previous ASEE conferences we presented the first and the second phase of our 3-phase multi subject didactical method as integrative parts of the degree program Vehicle Technology. The first part of the 3-phase method helps sophomores learn to work autonomously, but also to be able to work in teams, and to present engineering results clearly and impressively. The second phase starts in the third academic year and the students center on design, assembling and testing of a real racing car. They have to manage complex duties starting with engineering through to marketing the final product and participation in academic competitions like Formula Student.

The third and last phase encompasses the entire seventh semester in the last year of study (minimum duration: 450 hrs). The students have to apply to a company in the field of automotive or railway engineering and undertake an industrial internship in a specialized discipline such as design, technical computation, engine application, providing and evaluation of various tests, etc. On occasion, they have also worked as experts in insurance companies or in the marketing department of OEMs. The main challenge for the young engineers is to prove their knowledge and capabilities. However, unlike the previous two phases, this must be done in a professional and not in a student team. The colleagues from industry are experts and the projects are mostly real industrial tasks. The internship students have to work with highest responsibility, precision, innovation and reliability. Often they are instructed with investigations of new methods or even debugging of new software.

The main benefit for our students is that they can apply their special knowledge and the experiences in suitable projects. Here they collect valuable experience which helps them to choose their future professional field. The young engineers are also able in this way to select a diploma thesis topic, which is supported by the department.

The benefit for the department is that we receive a very broad response about the quality of our engineering education not only about the technical knowledge but also about our student's capability of integrating into professional teams and coping with completely new topics and tools that they have never worked before with. The main challenge is the harmonization of industrial and academic expectations and requirements that at times differ. We also have to cope with the extremely high degree of secrecy in the automotive and railway industry.


## Introduction

The third phase of our 3-Phase Multi Subject Project Based Learning[1,2,3,5] method is a part of the degree program curriculum, Figure 1. During the industrial internship the students leave the department for at least 3 months and work under real industrial conditions. The students' aims are to improve their technical knowledge and collect professional experience in the real world, as well as to develop specialized skills in team work, project management, communication, and customer care.
The number of students participating in the first, the second and third phases varies due to drop-outs. Usually, the in the first-phase 60-65 freshmen/sophomores take part. In the next two phases, we would expect to supervise 30-40 undergraduates.

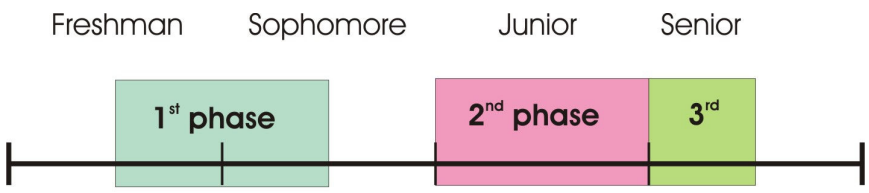


**Figure 1: Timeline**

The third and last phase is somewhat of a litmus test to check the quality of our engineering education. Here we can see if our students:

- have learned to use higher order thinking skills;
- can apply theoretical knowledge in practice;
- are able to work in teams with strangers;
- are able to be responsible for and to advance their work results;
- are motivated to develop methods and connect new learning to past performances (i.e. project work[1,2,3,5]);
- can think holistically;
- can cope positively with problems and act to find a solution.

As in the second phase, the students should transfer knowledge and experience during the internship but this time not in a familiar environment, under the professors' supervision in the department, acting without any real risk. They have to demonstrate their abilities in real customer projects in the departments of our partner companies.

The internship is also a very useful opportunity for both young engineers and employers to meet each other, and most seniors undertake their diploma thesis in the same company and department.

**Description of the industrial internship**

The industrial internship has four stages:

1. Planning the internship
2. Application to the host-company
3. Carrying out the internship
4. Final report and oral presentation

The internship starts with a kick-off lecture at the beginning of the junior year summer-semester (March/April). Here the students learn more about the content, formalities, terms, aims, assessment criteria, final report, etc.

The internship process is regulated by the department. The students apply to host-companies and report all applications, which must be approved by the head of department to avoid applications being made to improper entities (i.e. family establishments). The students also must provide the following information: start and end dates of the internship, company supervisor, projected main fields of work, etc. Supervisors from within the department of Vehicle Technology are selected according to the prospective subjects in an academic staff meeting. Hence, senior students have at least two supervisors: one in the company (external)

and one at the university (internal). The external tutor selects project work and is responsible for adequate, target-oriented tasks. The internal supervisor monitors the internship and receives monthly reports from the students. At the end of the internship, the students present their results orally as well as compile a final written report. The students are evaluated by the external as well as by the internal supervisor.

1. Planning the internship

Due to the internship's great importance, the host-companies are continuously checked by the head of department. The department holds a list of companies, and sections in companies, we already know and have had a co-operation with, although students are also free to build new contacts and be placed in new companies.

Each student sends a request for application approval (the so-called form 'A', from German word "**A**ntrag" meaning "application") to the head of department. The students mostly prefer to send more than one application and therefore, the request has multiple lines (items), Figure 2.

**Request for application for industrial internship**

Name: ……..
Student's ID-number: …….....

I hereby request internship-application approval in following companies:

| Company | Contact-person | Address | Country | Industrial sector | Approval (Date) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

**Figure 2: Form 'A', request for application for industrial internship**

The head of department then verifies each item according to the following criteria:

- The host-company is either in the automotive or in the railway industry.
- The host-company is not a family enterprise with a relationship to the applicant.
- If the company/section is already our partner the request-item will be approved; if not, the head of department gets in touch with the contact-person and checks on the working conditions as well as the adequacy of tasks and supervision. In the case of positive evaluation, the item will be approved.

2. Application to the host-company

The students receive the signed form 'A' and are asked to apply to the approved companies. They send a written application and a résumé and record responses in a second form (the so-

called form ‘B’, from German word “**B**ewerbungsübersicht” meaning “application summary”), Figure 3.

Using form ‘B’, we follow how the companies deal with the applications, how many acceptances respectively refusal letters our juniors receive, which industry areas have the most interest in internship students, and which are the preferred disciplines. Applying this system consistently we obtain an overview of our students areas of interest regarding subjects and host-companies as well as the existing demand in the vehicle industry.

This information is very important for us because the main goal of a university of applied sciences is tertiary education in relation to a professional field, i.e. automotive or railway engineering.

**Application Summary**

Name: ……..
Student’s ID-number: …….....

| Company | Company Supervisor | Address | Application date | Acceptance/ Refusal | Date | Approval for internship (date) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

**Figure 3: Form ‘B’, application summary**

The number of responses received varies enormously – some students receive answers to all applications, and some of them just one or two. Some juniors are very successful and can select between four or more internship offers, and some of them must follow up on their only acceptance letter. Of course, it is important is that all juniors (40-45) find an internship place – of these, approximately. 60 % are in Austria and 40 % in other countries (Germany, Italy, Sweden, GB, Mexico, Singapore, South Africa, etc.). Observing the applications and the company answers, we have realized that members of the Formula Student team[3] enjoy some advantages, especially when they apply to companies or departments which focus on motor sports. We can corroborate the statement that the 2nd phase of MS PBL[3] is of immense student benefit, in particular the Formula Student project. Otherwise, we can note that while we do not know either the content or the form of the student’s applications, we are convinced that the extremely positive image of a successful racing team is one of the best references possible for an employer.

As mentioned before, the senior students have two supervisors at least: one in the company (external) and one at the university (internal). The external tutor, selected by the company, chooses the project work and is responsible for adequate, target-oriented tasks. The internal supervisor monitors the internship and receives monthly reports and oversees the final seminar work. During a special faculty staff meeting the student’s internship list is discussed and according to the tasks, special areas, or working language the internal supervisors are nominated. They are finally designated by the head of department.

3. Carrying out the internship

At the beginning of the internship, the juniors move into the senior academic year. The junior year's summer-semester ends in June and the students can already start the internship (minimum 450 hours) in July, after their exams. Due to the Formula Student competitions (D, GB, I) in July, August and September the FS-team members usually begin their internship in either August or September. The host-companies are also very tolerant and allow the young engineers to interrupt the industrial placements for a few days during the competition periods. The employers know the importance of the project and support it.
For the period of the internship, the students sign a contract with the host-company that includes the placement's duration, and specifies the start and end, special conditions, compliance, and remuneration.

During the industrial internship the students are given precisely defined tasks. The task's main focus can be manifold even within one and the same department of a company. Some seniors concentrate on engineering fields like design, technical calculations, testing, etc. Others prefer fields of activity like project management or customer care.
Our students have to report on their tasks and the results at the end of each month. These reports should not exceed 3 pages. By writing short reports, the young engineers learn to concentrate substantial amounts of information and represent it in a clear and structured way. However, the reporting of project information in the automotive/railway industry is linked to a large problem – the extremely high degree of secrecy.
Employers are generally very happy to engage the near graduate engineers and they involve them in real industrial projects expecting high performance and professional work. The topics, as well as the results, are subject to a high degree of concealment. However, the seniors are obliged to report the results of their work monthly. The conflicts of interest can sometimes be very difficult to overcome but we have learned to cope with them. The answers to the problem depend on the company as well on the field of activity. We always contact the company supervisors personally and discuss the possible solutions with them.

4. Final report and oral-presentation

In the fourth stage, the students are required to write a final report of approximately 25 pages. The majority of topics focus on technical solutions such as engine application, driveline and chassis design, FE calculations, EFF drive-dynamics, fluid simulations, crash simulation, vehicle tests, design with fiber reinforced materials, etc. In some cases, seniors are required to prepare benchmark studies, as well as compare and evaluate project results, not only from the technical but also from the economical and customer point of view. Another area in which students may be active is in assisting insurance institutions in underwriting, statistical analysis and reporting.

The final report compliance is a major challenge for both students and supervisors for the reasons outlined in Figure 4. The work should be a structured seminar paper (not a project report), while at the same time acting as preparation for the diploma thesis.

| Problem | Statement | Solution |
|---|---|---|
| Currently there is no discipline in our curriculum that treats the subject of technical/scientific writing. | We recognize that this is a lack in our engineering education. Curricula re-design is unfortunately coupled with additional costs and very high formalism[1]. Even though we start teaching report preparation in the first and second phase of our Multi Subject PBL, we appreciate that this is not enough to enable students to compose a top quality seminar work of approx. 25 pages. | We have defined very clear instructions for the composition of the diploma thesis and also criteria for its evaluation. We communicate them to the seniors and apply them to the final internship report. The students are supervised by the professors at the department and they are requested to use recommended literature. |
| Students are not allowed by the companies to publish (even within the university department) important and representative data of their work. | We respect the high level of secrecy but we also require completeness and traceability of the final report. | All professors in our department are committed to absolute non-disclosure by contract. Sometimes it is necessary to sign an additional non-disclosure agreement. In special cases data is represented in a neutral form (i.e. normalized), product names are not used, etc. |

**Figure 4: Summary of the problems related to the final report**

The final report must be released by the company before the student sends it to the internal supervisor. Often the company's requirements differ from ours. The main reason for this is an alternative point of view: industry generally expects project reports, while a university expects a thesis-style seminar work. Therefore, it is very important to maintain active contact with the external supervisors during the internship. Of course, it is not possible to influence the expectations and requirements of the external tutors directly. Industry requires profits and maximum efficiency, and for this reason, we co-operate with our partners intensively.
In certain cases, the students make an internal PowerPoint presentation in the company. Here they can present all results and solutions regardless of any non-disclosure issues.

The common language is German. Those students who carry out they internship in non-German speaking countries (GB, Sweden, Mexico, etc.) are mostly supervised by our English professors. Some of the students may decide to compile their diploma thesis in same company. Therefore, we use the opportunity of the final seminar work to make the recommendation to them of whether to write the diploma thesis in English or not.

The students are required to deliver a PowerPoint presentation of their internship work and to show it to an audience of all their year-group peers and the internal supervisors. The content should not be chronologically structured but should focus on the main tasks, if there was more than one. Presenting the internship, the seniors came across as very poised, goal-oriented, and

[1] Our university currently is developing a new system for curricula re-design.

proud of their work and themselves. Sometimes we are given the impression that some of them have already forgotten they are still students.

In their presentations, the seniors also tell us about their personal impressions: on the one hand these touch on the working conditions, the quality of supervision, the infrastructure, the opportunities of learning more about other disciplines or departments, staff mobility, etc. On the other hand, they provide us with their reflections on our degree program, with regard to personal knowledge and skills. During these presentations we also learn more about the new engineering trends in the automotive/railway industry, new tools, etc.

**Evaluation of the industrial internship**

Evaluation is based on following assessment criteria:

- Monthly reports
- Final report
- Presentation at the university
- Assessment by the external supervisor

The external mentors should fill out an online assessment sheet and send it to the department[4]. They are asked to evaluate student's competence in the subject area, motivation, goal orientation, team capabilities, ability to think holistically, creativity, performance according to workload, and positive thinking.
Figure 5 shows the external evaluations of 40 randomly selected assessments of two consecutive internship years (IS 2007 and IS 2008). The best mark is 1 (excellent) and the poorest is 5. Here we can see that overall the seniors demonstrate high competence and professionalism, an aptitude to working under pressure and are highly motivated. During a personal exchange of viewpoints, the external supervisors have confirmed these positive impressions and suggested expanding holistic thinking during the students' studies.

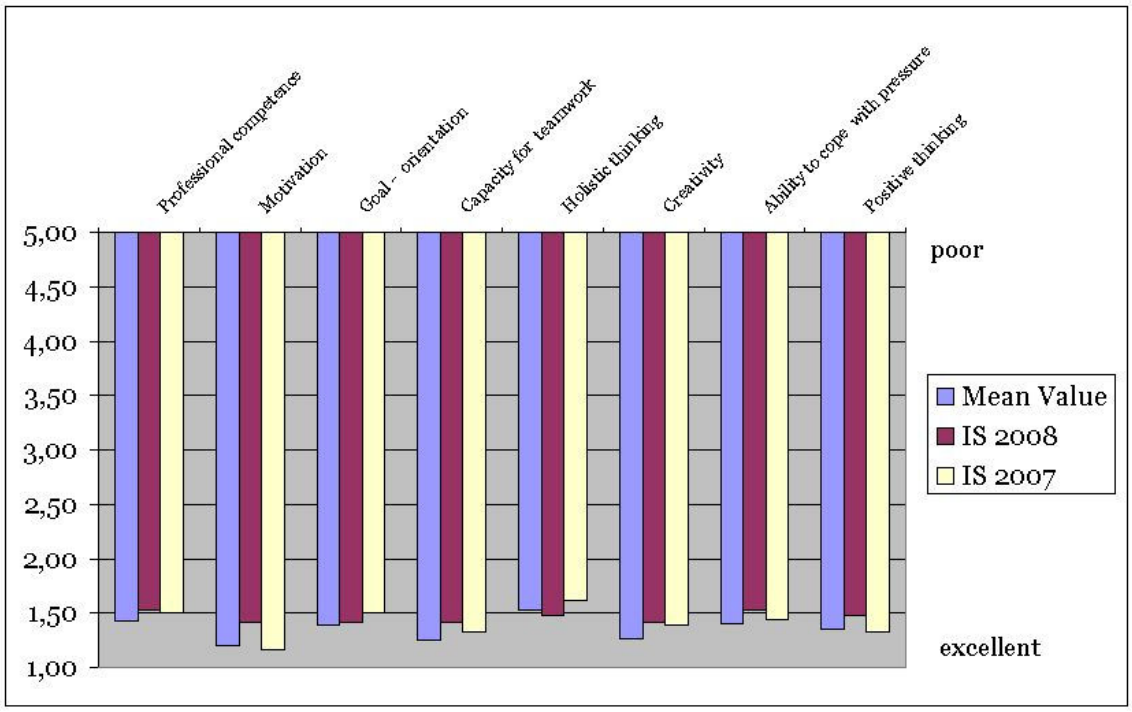


**Figure 5: External internship evaluations in 2007 and 2008**

In this sample, we have following distribution of marks across all criteria and both years.

1 – 61,4 %; 2 – 32,2 %; 3 – 6,1 %; 4 – 0 %; 5 – 0,4 %[2].

Internal and external supervisors evaluate independently and this is a good opportunity qualitatively to compare the final assessments from different points of view. We presently intend to harmonize the assessment with the objective of identifying the correlations and the incongruities respectively: i.e. in the appraisals of the two sides – industrial and academic.

## Conclusions

During the third phase of the 3-Phase Multi Subject Project Based Learning Method, the students work in an industrial field for 15 weeks at least. They are integrated into project teams and are supervised by company experts as well as by their professors at the university. Our experiences over the last 10 years show unambiguously that the project based learning phases in the first two years of study are extremely important for the development of personal skills and specialized knowledge. All of our senior students are welcomed warmly into the automotive/railway industry and are accepted as equal team members because they are familiar with the engineering requirements and project workflow. They are not only permitted to, but are generally required to deal with real project tasks comprising all the competences and responsibilities of a graduate. Furthermore, newly qualified engineers and employers meet under real conditions and they use the opportunity to plan bilateral co-operations (i.e. diploma thesis, employment).

Based on the evaluation – internal and external – and the responses given during students' presentations, we have gained and will continue to gain more information about the orientation, emphasis, quality and sustainability of our diploma degree program. In particular, the management of the contradiction between compact tertiary education and very high requirements of knowledge sustainability is one of the greatest challenges for us. We have been persuaded of the necessity of continuous, well structured, constitutive project based learning during engineering education and close collaboration with the relevant industries. The harmonious paradigm of lectures, seminars, laboratories, and project work is a guarantee of an optimal degree program in engineering education.

Naturally, we are constantly reflecting on the results of our 3-phase project based learning concept using various means: external evaluation, extended academic council meetings[3], alumni-survey, student mobility, etc. We would be also very thankful for any comments from the international academic community.

## Acknowledgments

Our special thanks go to all tutors and experts who supervise our students every year with high motivation and professionalism.

[2] One mark of (5) was given for not positive thinking.

[3] The extended academic council meetings comprise the academic staff in the department as well as the external lecturers, who are mostly internship supervisors.

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