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demands on engineering education

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EDUCATING ENTREPRENEURS FOR HANDLING THE INNOVATION PROCESS WITH NEW PRODUCT DEVELOPMENT IN INDUSTRY OR IN OWN FORMED COMPANY.

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ABSTRACT

At small Halmstad University College on the west coast of Sweden, we have a unique education in INNOVATION and ENTREPRENEURIAL ENGINEERING. The three year program provides the candidates with a broad technical economical education with special emphasize on handling the innovation process and running new product development projects.

This is the summing up of 10 years experience during which 140 INNOVATION ENGINEERS have been graduated.

SWEDEN UNIVERSITY COLLEGES

In the year of 1977 a vast revision of the academic education in Sweden took place. The higher education were then organized to be analogous for all different academic studies. Also the purpose was to guide the student more directly out into society and work. The so called free academic studies were limited by restrictions.

Some of this revision showed to be of great significance to "the small and regional university colleges" as they were to be called. Not less than 14 new university colleges were decided upon in Sweden. Compare with the figure of 12 so called "full universities" besides this, of which only five have technical faculties.

The above is of interest, as it has been said that the guiding principle in some of our educational programs, could not be introduced in an established university system. As a matter of fact the INNOVATION ENGINEER education was first developed at the Technical University of Lund in cooperation with industry representatives. However they failed in starting it up in Lund, because of the demands of this special concept on high integration between faculties. On the other hand this was in 1979, and 10 years of new thoughts have passed.

HALMSTAD UNIVERSITY COLLEGE

The Halmstad University College is the second smallest and one of the two youngest of the university colleges and did actually not reach full status as independent university unit until 1983. Previously it was functioning under provisional forms.

The total amount of students is 1300, also counting short time courses, or equivalent to 780 full time annual places. Of these 370 are technical or economical students.

The college is rapidly growing with 22% this year and 17% next year, up to 890 full time equivalent places.

UNIQUE PROGRAMS IN HALMSTAD

The following of our educational programs are mentioned:

- MECHATRONICAL ENGINEERING is a 2 year technical education integrating computer engineering and electronics for use in mechanical structures.
- ADP ECONOMICS is a 2 year economical education integrating business administrations and automatic data processing.
- INNOVATION ENGINEERING is a 3 year technical and economical education integrating several disciplines, which will be further presented below.

The following special guiding principles are to be seen in the technical courses:

- * Integration between several disciplines.
- * Working closely together with (mostly) local industry.
- * Integrating studies with comprehensive projects also including producing of hardware prototype with own budget responsibility.

INNOVATION ENGINEERING

The aim of this program is to provide the candidate with a broad technical-economical education with the emphasis on innovation.

Two technical areas are integrated: mechanical engineering and electronics. Furthermore, there is an integration between engineering and economics with marketing. Business and technical English are also studied.

The special emphasis in the program is on handling the innovation process and running product development projects, which entails a study of patent law and project leadership among other things. For instance lectures are also given in human resource development.

After the first year of studying basic engineering, the training is mainly carried out in the form of industry related projects, where the technologists make business contacts, are responsible for a budget and do their own negotiations with workshops they choose, in order to develop a prototype. During the passed 10 years we have built up a good relation to local industry, and all the INNOVATION ENGINEERS, who are out working mostly in the industry is a great contact source.

This education also intends to give the engineer competence to start and run a company of his own.

PROJECTS

One forth of the studied subjects concerns product developing with projects tied on to the courses. These projects are:

- "Product Improvement":

This is part of the subject "Mechanical engineering", studied during the third semester. An existing product is picked out in cooperation with an industrial company. The product is to be improved regarding manufacturing economy or functioning.

- "Product Planning":

This is part of the subject "Innovation Technique" during the fourth semester. In this project the students work in groups of four and start with an analysis of a local company. Each group works with different companies. The company's profile regarding technical competence, marketing channels, production possibilities, and so on, is first analyzed.

When different tools for stimulating creativity is lectured, the student groups work out ideas for new possible products for the company. Now the students often work two groups together, as eight people is an amount that according to research, is recommended in different brain storming techniques.

Further the ideas are valued also by different calculation regarding project economy and future production economy for each interesting idea. The calculations are to be made according to company normal procedure and if possible with some new thinking.

A few of the best ideas with a short evaluation is then presented to the company representatives. Effective speaking is one subject which now is trained. Also a written report is presented.

Finally an attempt to estimate the "innovation climate" at the studied company is made.

- "Product Development":

This is part of the one year course with the full name "Integrated Product Development with Entrepreneurship". It runs semester no 5 and 6 and is the final thesis work.

There are two different ways of carrying this project through. One is to get allied with a company, who expresses interest in a certain well specified market, or a certain type of products. The other way is that the student himself has an idea of his own. This final year the students work two and two together.

The product developing process is carried through according to what is adequate regarding to the specific project. Every aspect is tried to be covered and the idea is to work simultaneously with all problems: Information searching, market, competitors, calculations, generating of ideas, sketching, patents of invention, design, buying of technique and machine details, electronics for control, production demands, buying of workshop job, tests, redesigning and modifying, prototype building, and finally exposing the project with a prototype at an exhibition during four days.

This is not to be a description of the simultaneous product developing process, which we try to execute very systematically. I only like to point out that the students are to meet reality on their own responsibility. And thus meeting all kind of people, all according to what will be the case when they eventually have reached a position as product developer in a company or alternatively working on their own. Also the financing problems are to be dealt with. Written agreements on confidentiality, financing consequences and other legal papers also demand engagement.

One year is very short time for this kind of job. The students all the time keep contact with their teachers to report and to consult. One important thing for the teacher is to stop the student from spending too much time on one problem leading to shortness of time considering other problems. You can say that this is an education in handling stress, which is true for the teacher as well.

- "Marketing":

Also in the subject "Economics with Marketing" is a project carried out. Normally this is integrated with the project "Product Planning" as the analyzing of the industry is a common part of both projects. A market investigation with inquiries is then carried out and a marketing plan is outlined. Finally the result is presented to the company both at a briefing and with a written report.

SOME PEDAGOGICAL REMARKS

A closer discussion on last year's final thesis work will be done. An innovation we define as an invention with economical potential. Handling the innovation process is the only thing our INNOVATION ENGINEERS are supposed to be specialists in. Otherwise they are expected to consider and handle all other technical, economical, administrative, financial, legal, etc. problems.

The student's self-confidence is built up. The role as a project leader is emphasized. The student must be willing and have the ambition to deal with all sorts of problems. He must identify himself with his project, which he must choose out of own free will and carry the responsibility himself. Therefore he must be the owner of the project or, if the owner is a company, the student must be the one who gets all the credit or is the only one to be blamed if anything is not going the most adequate way. This is achieved by letting the teacher be almost invisible in the relations built up around the project. Many such relations are built up in order to find financing, getting a reference group representing the market or future selling partner, finding different specialists to achieve various information and so on.

Each week the teacher demands an oral report from each student group and offers advice. This is done in discussion with two groups at the same time for mutual benefit between the groups. The student shall be given very large freedom in setting the goals and deciding upon what is to be done. The teacher's role is to demand that the student actually structures the work, produces reports and shows some advancement every week. Experience shows that it hardly ever happens that the student has too low ambition. On the contrary, the teacher must often warn him that he has too high ambition. It is always a battle against time.

We try to avoid high technology, which demands the need for research and laboratory work demanding more money and time. Even the development of a simple product is very time consuming. Normally there will not be time to fully complete the drawings adapted to a real manufacturing workshop considering a larger series of products and handling other manufacturing conditions such as inquires for purchase of details and so on. The simpler the product is, the further the process can be driven.

It is essential that the student has got good working conditions. He needs a writing-desk, copy machine, telephone, fax, drawing-table, computer with wordprocessing program and CAD, printer, plotter, quick reference library, bigger library with data base information searching possibilities and so on. In short he needs an engineer's place of work or office very much like what is needed at his future position in industry. Of course reality at college is, that too many students get squeezed up into one room, that too many have to share the same telephone etc. Some difficulty arise from lack of money due to this unconventional need, not foreseen by those who set the economical frames for the college. Envy from students in more conventional courses and lack of understanding from their teachers, sometimes causes problems. The growing of our university college with more conventional courses coming in, might become a threat to this unconventional program with its special needs. The growing is however a ben fit as we need more and different competence to be attached to the college. Another problem yet, with this special educational approach is, that a suitable teacher must have long industry experience, wich however the academic system is not encouraging.

SPECIAL RESOURCES

Last semester before graduation the student can apply for economical assistance for covering costs for application of patents of invention and even for consultant assistance if the matter seems too complicated to be handled by the inventors themselves. These funding come from The Swedish National Board for Technical Development and The Regional Development Fund. Some of the projects can also find full financing from the same sources already during college time. Otherwise this is where companies and private inventors can apply for support, but we have built up a direct channel into these organization. Actually, one of our INNOVATION ENGINEERS is in charge of these matters at The Regional Development Fund in Halmstad.

Even if it is not the purpose with the education, it is of course of great interest that some projects, find a future after the students' graduation. A local board for supporting industrial development in the area called Nfo (Stiftelsen för Teknisk Utveckling i Hallands Län) is closely connected to our university college. This is where spin-off companies can, for some limited time, be supported after the students finished their studies. Here the students can apply for assistance regarding how to handle the tax situation for their new company, and also get negotiation assistance for some purpose or other. The normal support is a desk with telephone and part of two or three months living expenses and covering some costs according to a budget.

EVALUATION

Many students fight to enter this education. We always had more than 10 applicants per vacancy each year. For coming year, 626 students apply for the 48 places. 142 apply for this education as their first alternative. (In table below called "First choice")

Totally 140 INNOVATION ENGINEERS or 8 groups have been graduated since first group 1982, of which 88% passed. Figures have reduced by the years. (See table "Graduation percentage") Figures are misleading as the very first months many (5 or 10 out of 50 or 60 registered) students leave of reasons which might be irrelevant to consider in this statistic. Also many last year students find attractive jobs last semester and do not fully complete their examinations, although they go out and work with same salary and same job as if they would have had their formal graduation. They normally complete their final year thesis, and as we have restrictions for allowing students to start his final year, it is adequate to account for "Students passing thesis" in table below with the total 208.

I apologize for referring to our students as "him". 11 girls have passed. 3 girls per group is a normal figure last years.

The salary offered to the INNOVATION ENGINEER is slightly less (estimation 9%), than that offered to a conventional engineer with 4.5 years education (MSc) from a technical university.

The students find easily jobs and almost to 100% in line with their education, according to their own judgement. With this broad education most jobs can be considered to be adequate.

THESIS PROJECTS AND SPIN-OFF COMPANIES

From the last years thesis projects, a yearly pattern can be seen: Half of the projects are industry owned from the start. 80% of these projects find a future in that industry. The other half of the projects are owned by the students most of the last year. 20% of these survive (=time and money is put in) at least half a

year. Half of these, find a steady future in a "Spin-off company" as I call it below, or alternatively one or both of the students form a company with other base.

Following are estimations of the level we are now working:

- Say 44 students are likely to fulfill 23 projects, if 2 work alone.
- Of these 11 projects would already from the beginning be close to an industry company and mostly not owned by the technologists. 9 of these projects are to find a future at the company owning the project. Normally further work remains before the project is completed. In a couple of cases the new INNOVATION ENGINEER finds a job at the very same company and some continue actually with their project.
- 9 projects are in this example owned by the students themselves. 2 or 3 of these find buyers or financial means for continuing the project in a so called spin-off company. 6 or 7 projects are thus closed after graduation, the college carries a cost around SEK 15000 (1425 pound sterling) for each, which could be said to be the minimum possible for making the work meaningful. A normal budget for externally financed projects is e.g. SEK 50000 (or e.g. 5000 pound sterling)
- 3 projects are planned to be of the type of transferring technique to a developing country, as we have built up a cooperation with The Swedish International Development Authority. The receiving country is Sri Lanka. The budget covers 8 travels to Sri Lanka plus maximum cost SEK 45000 (4275 pounds) for each of these three projects.
- 5 patent applications (involving 10 students) are likely to be sent in (much thank to the fact that we can cover the costs).
- Between 5 and 10 students will register a company, much because of Swedish tax regulations.

TABLE

TABLE	Examination month & year								Total
	January				June				
	-82	-83	-84	-85	-86	-87	-88	-89	
Applicants 3 years ago			226	372	406	397	437	520	
First choice applicants			53	75	68	79	85	110	
Registered 3 years ago	18	18	19	32	33	33	50	49	252
Students passing thesis	14	17	14	22	23	25	37	48	208
Do. percentage of registered	78%	94%	74%	69%	70%	76%	74%	98%	
Graduated students	14	13	13	21	21	16	18	24	140
Do. percentage of registered	78%	72%	68%	66%	64%	48%	36%	49%	
Graduated female students	0	0	0	1	3	0	4	3	11
Approved thesis projects	12	15	11	14	13	14	20	25	124
Surviving projects 28/6-89	2	2	6	3	4	4	11	16	48?
Registered companies	2	4	3	4	2	2	8	6	31
Active spin-off companies	1	2	2	2	2	0	2	2	13

Comments:

- 1989 only counted spin-off companies already marketing product.
- First 3 years students mostly working alone on project.
- Before -86 education 2 1/2 years with graduation January.
- From -86 education 3 years with graduations in July.
- Definition of surviving project a little uncertain.

Presentation of author:

JAN EINAR BLOMQUIST

Born in 1936, holds a M.Sc. in Mechanical Eng. and a Ph.D. in Mechanics, both from Chalmers Institute of Technology, where he was assistant lecturer between 1962-68. He then passed pedagogical education at Gothenburg University, School of Education during 1968/69. He has 12 years experience from product development and business in private industry: In the years 1969-72 he worked with developing cellulose machinery at Sunds AB and between 1973-75 he was responsible for the machinery development at the SCA Development AB, both subsidiaries to the Swedish Cellulose Company AB. In 1976-80 he was head of technical development at the Orrefors Glasbruk AB, undertaking mechanizing at the six factories in this company in the so called manual glass industry. In 1978-79 he was also lecturing part time at Kalmar University College. In 1979-80 he was manager of a department at Kalmar Verkstad AB, responsible for both engineering and business concerning railway wagons.

From 1981 he has been senior lecturer at Halmstad University College, thus graduating the INNOVATION ENGINEERS from the first group, and also head of department during first three years.

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89 år
mån 44 stud gör 23 projekt
11 projekt industrimärka
av dessa 9 överleva i industrin
9 projekt studentägda
av dessa 2-3 säljs
eller lever vidare
3 projekt u-landprojekt
8 resor + max 45' x 3
5 patent (10 studenter) ansökningar
5-10 reg firma

Av alla projekt 124 8 år 82-89
Hälften industriförda projekt
80% överleva i industrin
av dessa flera anställer

Hälften elevägda
20% överleva = 4d ut
av dessa pengar sålats $\geq \frac{1}{2}$ år
efter skol projekt slut
varan hälften \rightarrow spin-off company
ca 5% av alla 124

8 år 82 \rightarrow 89 totalt 208 år
124 projekt
Överleva ca 48
reg firma 31
Spin off 12