# EKOTEKNIK (ECOTECHNICS/ECOTECHNOLOGY) – 30 YEARS OF EXPERIENCE IN INTERDISCIPLINARY EDUCATION

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**ABSTRACT (250 WORDS MAX)**
An important part of a society's resilience is how prepared it is to cope with the changing conditions during the alpha and omega phases according to resilience theory. Lars Thofelt, an academic from the mid Sweden region, early recognized this need for students to develop skills needed for a societal change, and devoted his life to pedagogy suitable for this. The main outcome of his achievement was the interdisciplinary university program in Ecotechnics/Ecotechnology (Ekoteknik in Swedish), at Mid Sweden University. Ecology, economy and technology in cooperation for sustainable development were the original approach, and still are.

Thofelt's ideas had a main focus of helping students develop their inherent capabilities of solving problems and overcome obstacles. After Thofelt's 12 years at the program his ideas were carried on by former colleagues and students, and the teaching further developed with a mix of the Thofelt tradition and other experiences brought in by new employees. This paper describes this interdisciplinary teaching approach with special focus on development of resilience capacity in students.

It was concluded that 1) a key element to develop resilience skills in students is to push them to a self-propelled learning behavior rather than traditional teaching, 2) not too easily provide the students with answers will develop their problem solving skills, 3) doing-before-reading teaching is more time consuming but seem to give deeper knowledge, 4) interdisciplinary teaching will in the long run benefit from having the interdisciplinary team within the department, rather than as a conglomerate of several departments.

*Keywords: Resilience, social change, problem solving, self-propelled*

## 1 INTRODUCTION

Resilience theory includes the important phases of change in the development of systems, and even labels them "creative destruction" [1]. These are the added alfa and omega phases to the traditional r and K phases, see for example figure 2-1 in Holling and Gunderson [2]. For systems including humans these phases of change are of course connected to ethical dilemmas as resource division and sharing, poverty and even questions of life and death. An important part of the resilience of a society is how prepared it is to cope with the changing conditions during the alpha and omega phases. Lars Thofelt, an academic from the mid Sweden region, early recognized this need for students to develop skills needed for a societal change, and devoted his life to pedagogy suitable for this [3-6]. The main outcome of his achievement was the university program in Ecotechnics/Ecotechnology (Ekoteknik in Swedish), which started in 1983 at the University college in Östersund, later merged into Mid Sweden University.

Thofelt's ideas had a main focus of helping the student develop the student's inherent capabilities of problem solving and to overcome obstacles. In his memoirs about a life with teaching, Thofelt [5] describe how he struggled with this since the mid-70s at different levels in the Swedish school system.

Thofelt left Ecotechnics in 1995 but his tradition was carried on by former colleagues and students. The teaching was further developed with a mix of the Thofelt tradition and other experiences brought in by new employees.

### 1.1 Purpose

Sustainability science is difficult to achieve since it demands an interdisciplinary approach over the traditional faculty division of natural, social, and engineering sciences. At Mid Sweden University all these three have been integrated in education for 30 years. The purpose of this paper is to describe the interdisciplinary teaching with special focus on development of resilience capacity in students.

### 1.2 Method

The paper has a phenomenological approach in its aim to describe the experiences from the 30 years of interdisciplinary teaching.

## 2 EXPERIENCES OF INTERDICIPLINARY TEACHING

### 2.1 The creation of independent, problem solving students.

It is a common feedback from both former students and employers that compared to competing groups, which has mainly been biologist, "biogeo"-ists, environmental health inspectors, etc., the Ecotechnics/Ecotechnology students had a higher degree of problem solving capacity. During the period when the Ecotechnics/Ecotechnology was a 2-year education program one employer even said: "These Ecotechnics students, they don't know much, but they always solve the problem you give them!". The students they were compared with most of the time had a 3-year education with focus on detailed knowledge instead of problem solving. After 10 years the Ecotechnics education was upgraded to also include 3 years. Today it is also complemented with an International Master's program in Ecotechnology and Sustainable Development.

It is interesting to see that Lars Thofelt was successful with his ideas of producing adaptive problem solving students. And that the focus on this skill had a trade-off regarding the amount of facts the students were able to gather. During the early years this "fact underdog" situation of course was explained partly by the 2-year length of the education. But this is the experience also from later teachers that 'skill learning' takes more time than 'fact learning'. The skill focus is of course not unique in education; it is the focus of the engineering tradition. But since the Ecotechnics/Ecotechnology students competed mainly with natural science students the engineering approach showed results. Another saying of Ecotechnics/Ecotechnology is that it is a natural science based education with engineering attitude. This makes sense in that ecology was not at that time (and still is not to any recognizable extent) part of any engineering education, but was part of the natural science tradition. The experience from today is that this tradition has been possible to preserve to some extent. The opinion is that Ecotechnics/Ecotechnology students still have an advantage compared to competing groups regarding projects work and problem solving capacity. However, other educations have reduced the gap, probably partly because of the increased popularity of problem based education, and partly because lower education in Sweden in general seems to have taken a large step toward project based education, especially in the upper comprehensive school.

### 2.2 "Don't answer questions"

Probably most striking for new teachers coming into Thofelt's teaching group was to absorb the habit of not answering questions. Thofelt [3] writes:

> "The teacher is to be a guide in the project, never to have any answers but to help the students find their own answers and thus their true capacity. The teacher has to, by listening and discussing, clarify the student's mind and thus deepen a holistic understanding…".

This can be illustrated by the exercise "The green square meter" which students met as their first exercises at the Ecotechnics/Ecotechnology program the first 15 years. It was a very simple exercise but "…a shock to the students" [5]. Immediately after the roll call the very first day of the course the students were taken to a grass lawn or similar place with low vegetation, at a first glance appearing to be homogenous. The students worked in pair of two, and had the assignment to find "What, and how

much? (meaning what plants and how big biomass)" [5]. At first the students could not find anywhere to start. But when the teacher gave no further instructions the student started to find some structure in the square meter. Some blades were sharp, some were round. Small parts were bare ground. The square meter started to get some character. The next step was for the student to find tools to analyze the square meter. Either a new method was developed or a standard was used. Now the teacher had a clear role as a guide. However, it was important that the student himself/herself made the choice of method. Now it was possible to work the way through the square meter. The student had now had the first lesson in being the driver of the project, finding a method that can solve the problem, and structure the result in a way that can be presented. From the teachers perspective it is important not to lead the student, but rather "mirror" their questions and help them reformulate questions. Thofelt [5] writes: "For example you could ask the question back with a little addition of a different angle." This will help the student through the challenge. A problem can be that the teacher feels that he/she has to teach the student for reasons like: "I get paid for this. I must perform to live up to my salary". Or, that the teacher has a need to show to the student that he/she knows more than the student, and can transfer knowledge to the student. This is not what the student needs according to Thofelt, and several times he had to take new teachers away from the student group, hissing in their ear "Come here, you destroy the whole teaching!". Rather the student benefits most from learning how to be self-propelled.

## 2.3 Doing before reading

The example above of the green square meter shows also another feature in Ecotechnics/Ecotechnology teaching: the doing before reading. The principle is to let students try to solve a problem without any prior teaching. After a period of trial some lectures are introduced. This is more time consuming than teaching the theory first, and then let the students test the theory in some experiment. The experience is that the knowledge goes deeper and will last better with the doing before reading. It is like the minds of the students are prepared by the trial and the motivation to learn when the theory comes is much higher. Another explanation may be that the student put up many more hypotheses, conscious or unconscious, if they have fewer instructions what to expect from the exercise. They practice the skill of finding patterns in the unknown. Another example is the approach in the chemistry lab. Very rarely the teacher has prepared the equipment needed for the experiment. Rather the students have to find the equipment in the chemistry lab. In their search they add a lot of "grey zone" information what other stuff is available in the chemistry lab, which gives them means to later set up experiments created in their own mind, or when facing another problem in a totally different context.

## 2.4 Group dynamics

Over the years we have observed a lot of group dynamics in the Ecotechnics/Ecotechnology classes. Here we will present some patterns that have repeated themselves, even if we don't have a clear explanation of the pattern.

During a period we had what was called the October or November revolution. First year students were really angry with the teaching and complained more and more. This was the perfect time to talk to them about what the program was about, why this setup of courses were chosen, why we used the pedagogies we did, and more. Coming with the right speech at this time really flipped the class from anger and disappointment to strong motivation. We have no clear explanation for this behavior but probably important factors were (the phenomenon was discussed to a large extent among teachers during the coffee breaks and staff meetings):

- the students realized that this was a reality situation. Many of them being young and so far just have followed the "flow" of life; they realized that it was up to them if the education would be successful. The degree of taking responsibility in the class rose from low to very high before and after the motivation speech.
- the students realized that the teachers really cared for the class and the teaching. That we actually had a plan for them and were discussing the pedagogic aspects of teaching very much outside class. A large part of their displeasure was based on that bureaucratic things didn't work as well as they expected. They did not get the service level they expected from the teachers. They didn't learn as much as they expected, and this was the teachers fault. The teaching had low quality in the eyes of the students. However, realizing that they themselves were the key element to their learning changed

everything. Motivation was suddenly there, to a much higher degree than before. We experimented a little with this and tried to give the students this information earlier during the semester, but that had very little impact on the class level. The storm had to build up before teacher speeches could make any difference. October or November revolutions gave those classes a strong motivation boost, and many of us teachers had the experience that those classes with October or November revolutions in general produced better thesis' at the end of the program, than classes that did not go through this revolutionary behavior.

## 2.5 Working in teams

At Ecotechnics/Ecotechnology there have always been a lot of group works. During the period when the teacher resources were more abundant the normal situation was that the students group work reports were returned multiple times. Every time problematic parts were pointed out but no solutions were given. This was probably the most fruitful part of the group work, since it forced the students to have a discussion how to act on (or handle) the criticism. In the first report many groups divided the work and wrote different parts. No group process developed during this phase. Later with cut down teaching resources there is still a lot of group works, however, not so many returned reports. We are currently struggling with new solutions for this, where student peer review is one path tested.

## 2.6 Synthesis courses

The last year of the program has always consisted of different types of synthesis courses. During ten or 15 weeks the students work with for example business ideas in the course Environmental Driven Innovation, creating a brand new environmentally friendly city on the same spot as Trondheim in the Visionary course, or make a development plan for the bioresources in a Swedish or European municipality. The full course will focus on the same project. The students take most of the contacts needed themselves, which strengthens their feeling of sitting in the driver's seat of the project. If not before this is also the time when the students see that their previous gained knowledge and skills can be put into action in a realistic and holistic context. Our latest experiment here is to create three different tracks of students, all of them interdisciplinary but with a little different focus in their courses. The first year they study most of the courses together and learn to know each other, the second year they are more separated, and the third year they come together again in the synthesis courses. The Ecoengineers have the traditional engineering math in their courses, and more environmental engineering courses; the Ecoentrepreneurs have less chemistry and math, but more social entrepreneur and green procurement courses, and the Ecotechnology students are standing in between as the most interdisciplinary students. In addition a group of international students are accepted to the Ecotechnology program every year to increase the "melting pot" of different backgrounds and experiences in the synthesis courses.

## 2.7 Being in the context of engineering or natural science

Interdisciplinary teaching and research always have problems to fit into the traditional faculty division of social, natural and engineering sciences. During the 30 years Ecotechnics/Ecotechnology have been placed both in natural science and engineering departments (so far never in a social science department). The experience is that in engineering departments there has been an understanding that we need to bring in interdisciplinary competence to the group to fulfill our mission. There is a respect for the integrity of the group. In natural science departments on the contrary, during the periods we have been placed within them, there seemed to be a prevailing view that the subjects of chemistry and biology should be the pillars of the program and that these departments should take responsibility for these parts of the education program. We have seen this pattern also from other universities in Sweden. The benefit of having an interdisciplinary team on its own is that the members are then given the chance to transcend from their old subjects to become more interdisciplinary oriented teachers and researchers. Belonging to the biology or chemistry group seems to keep you tied to that subject for good and bad. The experience from earlier periods was also that the natural science department sooner or later will try to cut up the program into more traditional pieces of biology and chemistry, and a pedagogic idea of the Thofelt type will be very difficult to maintain. It is our belief that interdisciplinary teaching will in the long run benefit from having the interdisciplinary team within the department, rather than as a conglomerate of several departments. However, this should of course not be an excluding approach. Cooperation is always potentially good.

### 2.8 Teachers are individuals

Using the ideas of Lars Thofelt highlights that teachers are individuals, although Thofelt's aim was to make the teacher obsolete. For example Thofelt's habit of pushing the student to the limit of their capacity, can be a dangerous road to walk if the teacher doesn't have the skill to do it properly. Pushing the student over the limit can be long term harmful for the student. Thofelt himself was highly skilled in knowing how far it was possible to push a student, and still see the recovery occurring within the course. However, most of us followers don't have that skill to the extent Thofelt had (hopefully we have other skills though!). Nowadays there are also larger classes with more students to handle. Obviously, it is important to know your capacity regarding this as a teacher. Many of the examples Thofelt gives in his books, and the stories told about his teaching from former students, seems a little bit extreme to many of us. It must be remembered that Thofelt could teach far out on the edge, since he had that skill, but you should not follow that far if you don't have the same experience and skill.

## 3 CONCLUSIONS

A key element in resilience theory is the ability of systems to cope with the change that occurs between the four phases r, K, alfa, and omega. The conclusions of this paper from this perspective – although not based on a systematic evaluation but rather on accumulated phenomenological observations during the 30-year period–are the following:

1) a key element to develop resilience skills in students is to push them to a self-propelled learning behavior rather than traditional teaching.

2) to not too easily provide the students with answers will develop the problem solving skills,

3) doing-before-reading teaching is more time consuming but give a deeper knowledge, since it stimulates students motivation.

4) interdisciplinary teaching will in the long run benefit from having the interdisciplinary team within the department, rather than as a conglomerate of several departments.

5) when performing problem based teaching where an important part is challenging the students inherent capabilities, it is important to also focus on the teachers inherent capabilities. It is important to realize that teachers too are individuals.

## ACKNOWLEDGEMENTS

We thank the Faculty of Science, Technology, and Media at Mid Sweden University and the European Regional Development Fund for funding this research.

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