TekNO: Employing low-tech activities for the hi-tech employees of tomorrow

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Abstract

Technology is a core subject at compulsory (K-9) schools in Sweden but the outcome until now has been very dependent on each teacher's interest and priorities, especially at primary school levels. Few of the teachers at this level have had any significant amount of science or technology included in their teacher training. There is also a lack of guidance and teaching material in the K-6 schools.

With the aid of the project described in this paper the participating schools and municipalities can get access to thematic visits, ideas, hands-on experiments, pedagogical support and networking. The overall objective is to secure the future supply of skilled manpower in technical and engineering positions in the region. We aim to go beyond the traditional external contacts with science and technology at primary school level such as visiting science centers and presentations by researchers. The project prioritizes:

- spending more time in the classroom with the pupils – at least one week per class,
- adapting activities to each individual class; its curriculum, prerequisites and previous knowledge,
- visiting local industries/businesses that makes practical use of the particular area of technology studied in the individual class,
- having project managers who are themselves primary school teachers but with special interest in technology and engineering (no academics please!),
- using IT as an aid in teaching; as a tool for communication, programming of gadgets, problem solving etc.,
- gender and equality issues e.g. by working, in most cases, with separate groups for girls and boys and let them try to solve problems with different angles of approach,
- building networks among the teachers locally and regionally, and
- conducting seminars and workshops with the teachers to increase confidence and knowledge (academics invited).

During the first two years we have cooperated with some 70 classes and roughly 1,900 pupils in East-Central Sweden. The evaluations show that more than 95% of the teachers and pupils are very satisfied with this cooperation and would like to extend it further.

Introduction

This paper describes a project aiming at connecting Engineering with Education at the first levels of formal education, K-6. In short it is employing low-tech activities for the hi-tech employees of tomorrow. Consequently this project was named TekNO, which is a Swedish abbreviation for engineering technology ("teknik") and natural sciences ("naturorientering").

The initial idea and needs had been discussed in different regional forums since the middle of the 1990s. It was forecasted in our region that the level of education (mostly in science and technology) would not be in balance with the regional structure of the industry and the employment market. Different actors such as industries, compulsory schools, upper secondary schools and universities all foresaw problems connected to technology education.
Some specific facts and point of views were:

- Very variable demographic situation in decades to come; large fluctuations in number of pupils and students, retirement boom among teacher cadres etc. – see figure 1.
- Many teachers in primary school felt uncomfortable when it came to teaching technology and other subjects related to engineering.
- Declining relative numbers of applicants to vocational and technical education in upper secondary schools.
- Declining relative numbers of applicants to education in science and technology at the colleges and universities.
- A tendency in media at presenting technology and technological 'faults' in negative connections (e.g. accidents, natural disasters, pollution, unemployment or conflicts).

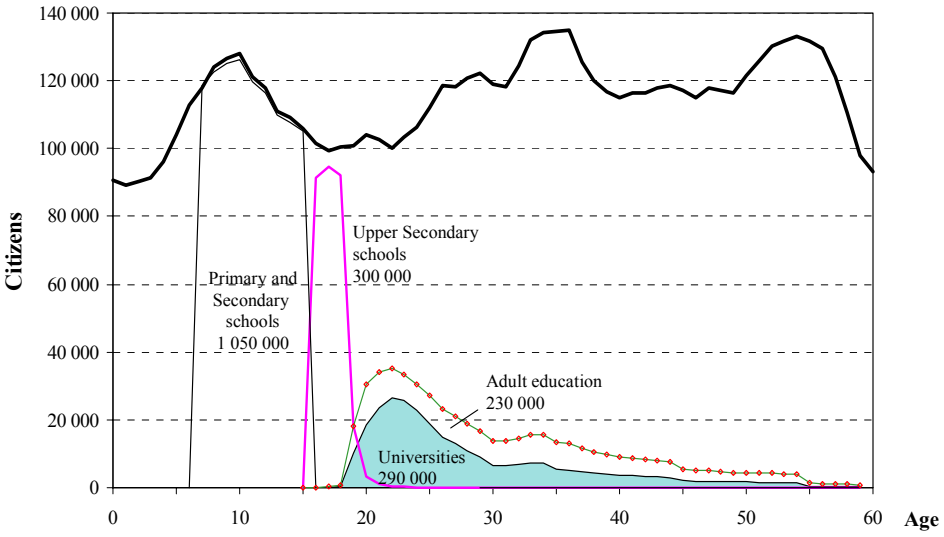

Figure 1. Structure of population: age and involvement in education, Sweden 2001 (Source: Statistics Sweden)

Facing this common anticipation of future problems a project was outlined. Interestingly enough it was the regional and local industries that were the heaviest supporters in initializing the project as they foresaw future problems with lack of skilled manpower in technical and engineering positions.

Project TekNO

Background

Our region in East-Central Sweden has several different faces and traditions. In the west are traditional agricultural landscapes, and in the east the harsh archipelago on the Baltic coast. In the northern woodlands are the "Wallonian" areas (cradle of Swedish industry) and to the south the regions main city of Uppsala with Scandinavia's oldest university - founded in 1477. With the exception of Uppsala city itself this is a region with limited academic traditions and a relatively small number of employees with higher education exams, see table 1. The structure of the industry is also quite varied in different areas of the region.

Table 1. Some basic facts about parts of our region – the County of Uppsala (Source: Statistics Sweden)

Municipality	Tierp	Uppsala	Östhammar	National average
Population (Nov. 1, 2003)	20,139	180,656	21,737	
Part of pop. with university exam	16%	46%	18%	30%
Part of pop. in university studies	2.3 %	13.4%	2.2%	5.2%
Number of employees in some technical/engineering/scientific professions (2001)				
Physicists, chemists	1	865	20	
Computer specialists/technicians	21	2,312	91	
M.Sc. or architects	24	1,277	112	
Engineers/technicians	146	2,696	440	
Technical craftsmen	767	5,539	843	
Factory laborers/specialists	1,261	1,965	1,505	

Partners in the project

As described earlier there were quite a few numbers of actors in the project. Three of the six municipalities in the county were interested to participate in and finance the project so the cooperating parties (planning and conducting the project) were finally:

- The regional body of Confederation of Swedish Enterprise (which on the national level organizes some 57,000 member companies with more than 1.5 million employees),
- Representatives from local industries, corporations and factories,
- Cities/municipalities of Tierp, Uppsala and Östhammar with primary schools, and
- Uppsala University.

Focus of the project

The overall objective was to secure the future supply of skilled manpower in technical and engineering positions in the region, see table 1. This is closely connected to the number of graduating students from vocational and technical education in upper secondary school and university. It was also a common belief that long-term actions to influence this situation were best aimed at pupils (and teachers) in compulsory schools. To get a focus for the project it was soon decided to concentrate on pupils in young ages. Due to the regional structure of the schools and the teacher's needs it was unanimously decided to concentrate on K-6 classes.

- Primary target group: primary school pupils, aged between 6 and 12.
- Secondary target groups: their teachers, parents and local industries.

Limitations

The budget for 2002-2004 allowed initially hiring two persons full-time to run the project. Most administrative duties were relieved from them as Uppsala University housed personnel and "infrastructure" for the project. Since the project should pinpoint individual classes (some 800 K-6 classes in the region) there was a natural limit on the number of classes it could reach during the project period, 2002-2004.

The size of the primary target group was found to be roughly 20,000 pupils distributed among 100+ schools, see table 2.

Table 2. Some facts about K-6 (9) schools in the participating municipalities (Source: Statistics Sweden)

Municipality (school data from 2002)	Tierp	Uppsala	Östhammar	(Total)
Population (Nov. 1, 2003)	20,139	180,656	21,737	222,532
Number of schools; grade 1-3 or 1-6	8	63	15	86
Number of schools; grade 1-9 or 4-9	4	23	4	31
Total number, prim. + sec. schools	**12**	**86**	**19**	**117**
Number of pupils, grade 1-3	790	7,281	1,141	9,212
Number of pupils, grade 4-6	886	7,939	1,026	9,851
Total number of pupils, grade 1-6	**1,676**	**15,220**	**2,167**	**19,063**

We found few limitations when it came to the interaction with K-6 classes and schools. Of course our activities had to comply with requirements in the national Swedish curriculum for (K-9) Technology Education. According to this there are certain goals that pupils should have attained by the end of the fifth and ninth year in compulsory school. After the final year pupils should be able to:

- describe important factors in technological development, both in the past and present, and give some of the possible driving forces behind this,
- analyze the advantages and disadvantages of the impact of technology on nature, society and the living conditions of individuals,
- build a technical construction using their own sketches, drawings or similar support, and describe how the construction is built up and operates, and
- identify, investigate and in their own words explain some technical systems by describing the functions of the components forming it and their relationships.

The last three of these goals served as a guideline when possible and suitable activities started to take form.

Possible methods and activities – in theory

" Today's kids do not show interest in crafts and vocational training and technology teaching in early years may counteract this tendency"[1]

According to Mantler[2] the concept that one should stay in the same profession all life is outmoded in today's changing society. Researchers predicts that the primary school pupils of today on average will have seven different professions during their lifetime, and that at least half of these professions don't even exist today.[3] This is also an angle of approach to consider when discussing possible activities for the hi-tech employees of tomorrow.

What are the possible methods and activities at hand when it comes to bringing Engineering and Technology into the K-6 classrooms? The activities should give the pupils an understanding that reflects what it means to work in engineering and with technology. From the industries point of view it is important to present opportunities for the pupils to discover their latent abilities in this line of work, and experiences that may be eye openers into engineering as a future profession. Equally important would be to reveal to the pupils that engineering and technology might in fact be "fun" and consequently increase their motivation towards technology.

The problems concerning understanding technology as a school subject on its own appear to be due to two main characteristics. First, "technology" captures a large range of fields of activities where knowledge and practice in each field are highly contextualized and related to specific purposes.

Secondly, the circumstance that technological knowledge is always related to human activities and involves a significant tacit component[4] makes it problematic to categorize it intellectually.[5] One could argue that it is through activity in specific practical areas that technological knowledge finds its meaning, therefore being interdisciplinary in its selective use of formal knowledge for practical purpose.

Technological problems and solutions can be categorized in different ways. How this is done depends on what one wants to accomplish. The following fundamental functions can be identified: transforming, storing, transporting and controlling. By clarifying such fundamentals pupils can acquire their own tools enabling them to analyze the role and function of technology.[6]

TIMSS[7] (Trends in International Mathematics and Science Study) give some indication concerning difference in attitude towards science subjects. For the Scandinavian countries you find an insignificant difference between girls and boys; they are both middlingly positive towards science subjects. This is when the children are nine years old. During secondary school the TIMSS-report indicate a decrease, and the girls show a higher rate of decrease in interest and attitude.

Another ongoing cross-cultural project, SAS[8] (Science and Scientists), deals with 7th graders experiences, attitudes, interests and priorities. The most systematic discrepancy in this study showed differences between girls and boys. Sweden and Norway were the countries with most differences when it came to interest in different suggested themes in science and technology, see table 3.

Table 3. Most favored themes to study in science and technology, 7th graders in Sweden and Norway

Boys most favored themes were:	**Girls most favored themes were:**
The latest technological development	HIV – what it is and how it is spread
Satellites and modern communication technology	What we should eat to stay healthy
Rockets and space travels	Rainbow- what it is and why we can see it

When it comes to age differences in our primary target group we have to cope with children in rapid development both as individuals and in their learning stadiums. The younger pupils would typically be in their preoperational/intuitive (self-centered logic) stage and the older pupils in a more concrete-operational stage.[9] Since our project managers were advocates for many of the thoughts expressed by Célestin Freinet[10], it was natural to try to implement his "constants" concerning methods of education whenever they were applicable.

Most forms of knowledge seem to be parts of a structure where concepts are correlated and dependant upon each other. Concepts are like parts of a large web. Learning technology can perhaps be compared to the process when a child learns a language. Each word gets its meaning through the other words – the child does not learn new words through precise definitions but rather in its connections to other appropriate words. The web gets more intricate and dense as the child grows older.

Maybe there will also be a problem in transferring information to individual knowledge in a new subject like technology if the teacher starts with definitions and exact concepts and then try to build from there. The alternative can be to introduce new concepts and terms rather loose but that the connections to other subjects are pointed out and that its relevance gradually gets clear with examples from real life.[11]

Methods and activities in the project

When the project was financed and initiated the actual planning phase was short, a few weeks. Objectives were identified, contacts made with the individual schools and teachers and school visits started within a month from the start of the project. During the first term, autumn 2002, we aimed at working at two levels in parallel, development of themes and visits to the classrooms. It worked quite well, mainly because the project managers were very familiar with the working conditions, opportunities and problems at primary school level. For the year 2003 we could start with very positive evaluations to back us up. The interest from new classes to cooperate with the project was also soaring – almost 100 classes had signed up on the waiting list.

One important objective of the project is to adapt the teaching process to the different prerequisites among the pupils in this age group. We have seen it useful to try to work around themes that could have a common core of hardware but can be adapted to interest a pupil at 6 years of age as well as one at the age of 13.

Every visit to a class is prepared well in advance. During meetings with the teacher a schedule is laid out for the visit. It is agreed upon what field of technology (or science) to work with. One of six ready-made themes is common to use but tailor-made themes can also be created if none of the ready-made ones fits the need of the class. The teacher will also meet the project team in advance to try out and evaluate the hands-on experiments and discuss practical issues concerning the individual class. The project team will also engage a local industry/workplace that makes use of the chosen field of technology, and prepare a study visit there.

Carrying out the visits can be quite different dependent e.g. on the age of the pupils. As a start, and working in smaller groups, a common overview is sought; why is this technology used, who needs it and use it?

Gradually hands-on experiments and activities are introduced and tried out. After a few days there will be a visit to a local industry or workplace to see the practical use or need of this technology, meeting people working with it and having further discussions and insights. For older pupils this can be combined with a "real" task or mission from the industry to solve. We make as much use as possible of IT as a tool for developing methods and conducting teaching. When visiting industries or businesses we will particularly point out innovative ways of using and exploiting IT assets.

The visit to industries and corporations are aimed at letting the pupils see the many facets of technology when in comes to a future employment. In these visits we aim to make connections between the experiments the pupils do in the classroom and real applications found at work in the industry. Since visits from young children are quite rare to most industries, these must also strive to present and explain what they do in a simple and interesting way.

Everything during this week is noted in individual logbooks and often other subjects such as math, history or social sciences are connected to the work. During the final day there is usually a competition of some kind and an exhibition for parents, other classes and industry representatives where the chosen field of technology is displayed and explained. All pupils and teachers evaluate the activities in writing.

After the visit there is a follow-up with teachers. These are invited to workshops and meetings together with other teachers in the region, where we try to make sure that the teachers maintain their self-confidence in teaching technology. We also initiate and support networks between teachers locally and regionally, to ensure support between interested teachers and to encourage new teachers to take a more active part in bringing technology to the primary school. The project team will also volunteer to walk through the "science cabinets" found in many schools together with the teachers, to discuss further and better use of the material the school already have at hand.

Results and recognitions

After 1½ year six different technological themes are developed. These themes are tested, evaluated and revised continuously in different classes and grades. The project has cooperated with 1,900 pupils in some 70 different classes in all parts of our region.

All evaluations (industry, schools, teachers, pupils) indicate a very positive attitude towards the activities as such, there is a clear "pressure from below" that the work should continue after the project is finished.

A network and system for study visits and industry cooperation has been developed. The project has also been invited to different line of trades (confederation of specialized industries) to present the concept and have more opportunities for cooperation with local industries. Some of the industries and corporations in the region have started to build up special visiting programs to cater for visits from primary schools. They see this as a very good opportunity to interest potential future employees for their companies or line of business.

For Uppsala University this is a long-term commitment and there is no immediate increase in recruitment. An increase in number of university engineering students from the areas with low academic traditions, and as a result of this project, would not show itself for many years. In the short-term the advantage for the university is to be an active part in a regional network with the municipalities, industries and compulsory schools.

As recognition our project managers are nominated as "technology teachers of the year" in a national competition announced by the Association of Swedish Engineering Industries (total prize sum equals USD 600,000/year). Project "TekNO" has also won second prize in the European Regional Innovation Award after competing with almost 100 other innovative projects from the whole of Europe.

The future

We are currently in the planning process for the period from 2005 and all involved parties have contributed with funding and support to continue the activities in the future. The cooperation's and activities we have started 2002-2004 are successful and will most certainly continue; thematic visits to the classroom, study visits to local industries and teacher support/networks.

A second branch of activities that is taken into consideration is supplying material from industries that could be used in technology education at primary schools. This type of mediation of simple but cheap and useful materials for classroom activities has been in demand from some teachers (the concept is in use in other regions, e.g. in the United States)[12]. This branch also includes lending of materials to teachers and an on-line forum and "help-desk" for teachers for giving advice on short notice and spreading information about ongoing activities in the region.

A third branch of activities could be to supplement the mobile activities with some stationary assets. This would not be in the form of a traditional science center, but could e.g. be integrated with the University faculty of education and thus be a bridge between active teachers, pupils and future teachers in training. Stationary assets could also be developed in cooperation with, and located at, some of the major industries in the region.

Summary

The project is a success because it was initiated through a broad partnership between industry, businesses, municipalities, primary schools and university. Each one of these can see clear benefits from participating in and contributing to the project, and the extra cost for each one is limited.

Our project makes younger children (aged between 6 and 12) and their teachers more interested in engineering and technology and create networks between these and the local workplaces, industries and businesses in East-Central Sweden. The project focuses on establishing a more continuous contact between primary school pupils and the area of engineering and technology, both the basic fundamentals and its application in industry or research. Local industries initiated the project by identifying future problems with lack of skilled manpower. They are now, in collaboration with the municipalities and university of the region, developing methods to increase interest in technology.

One main objective of the project is to develop methods to increase the interest for, and understanding of, engineering and technology among pupils aged between 6 and 12. This is achieved by creating a durable system of cooperation between the actors in order to give the schools new possibilities in teaching technology. The project develops themes in technology-related applications for primary school level, which can be included in a subject-integrated way of teaching with problem solving as an important aspect.

Through this collaboration a cornerstone has been set to satisfy the future competence needs for the local and regional industry and higher education institutions. This will help improving conditions to attract and keep well-educated employees and contribute to a durable growth of the region, as well as a growth in entrepreneurial spirit.

Conclusions

This project is a supplement in technology teaching, supporting schools and teachers who welcome a helping hand in this rather "loosely defined" school subject. There are no underlying agenda to take over teaching in the region – this is still the responsibility of the schools.

Our vision is to carry on with the activities on a limited scale until technology teaching in the K-6 classes in our region will be handled with the same naturalness and independence as the classical subjects, e.g. languages, math and social sciences.

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Bibliography

[1] Statement from a teacher in a Norwegian curriculum project ('Technology in the School', TiS) run by the Norwegian Society of Engineers (NITO) in the period 1997 – 2002.
[2] Mantler, O. (1999). Internet in der Schule [online]. http://www.lernspiele.at/internet.html.
[3] Morris, J. (1996). The technology revolution [online]. http://www.uvm.edu/~jmorris/comps2.html.
[4] Polanyi, M. (1967). The tacit dimension. Routledge&Kegan, London.
[5] Herschbach, D. (1995). Technology as knowledge: Implications for instruction. Journal of Tech. Ed., 17.
[6] CETIS-Center for School Technology Education. http://www.liu.se/org/cetis/english/index_eng.shtml
[7] Trends in International Mathematics and Science Study (Boston). http://timss.bc.edu.
[8] http://folk.uio.no/sveinsj/SASweb.htm
[9] Piaget, J. (1977). The Child's Conception of the World. Granada, London.
[10] Freinet, Célestin (1988). För folkets skola. C&L Förlag, Göteborg.
[11] Sjøberg, S. (2002). Naturvetenskap som allmänbildning. Studentlitteratur, Lund.
[12] See for instance "Resource Area for Teachers – R.A.F.T. http://www.raft.net.

Biography

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Per E. Andersson is liaison officer at Uppsala University, Sweden. He is coordinating the TekNO-project as well as several other projects related to recruitment and Continuing Engineering Education. During 1981-2001 he worked with The Swedish Armed Forces. He received a M.Sc. in Engineering Physics from Uppsala University in 1987, and in Electronic Warfare from the Swedish National Defense College in 1994.

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