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Wining Youth for Science and Technology – an Educational Challenge

Valentina M. Pomazan, Doina Mihalaşcu,
Lucian C. Petcu and Mihai A. Gîrțu
Ovidius University, Constanța
Romania

1. Introduction

The present study was triggered by the alarming decline in the number of students interested in scientific or engineering professions evidenced in the past years in Romania and throughout Europe. At a time when a technical background becomes very important for succeeding in the envisaged knowledge based society, the downward tendency in enrolments in Science, Engineering and Technology (SET) programs needs to be addressed by extensive studies (Lickl, E., 2007).

This chapter is an overview of the career choice motivations and of the factors that can be beneficial for increasing the future highly qualified and innovative personnel in a dynamic economic competition. After a brief overview of the Romanian National Curriculum that establishes the educational background, it reports correlation analyses performed on the results of a quantitative and qualitative study, aiming to determine the motivating and deterring factors for the young generation in choosing a career in science or technology, pointing out various factors affecting the decision making regarding professions. As school has the most significant influence in framing one's formation, the curriculum in secondary and high schools is linked and analyzed with respect to other important dimensions. This research was supported by the European Commission within the FP6 UPDATE project.

Previous studies have revealed the existence of a "glass ceiling" that prevents women from attaining further education and certain positions, even if they are qualified (Etzkowitz, Kemelgor and Uzzi, 2002; Götzfried A., 2004). European women researchers are underpinning the low-expenditure areas of R&D but are not exercising their fair share of control in the high-expenditure area. As a result, there are fewer female players in the fields of technology, mathematics, engineering and science (Smith-Doerr, L., 2004; McLoughlin, L. 2005). European Commission provides recommendations as to „how the talent pool of women could be employed more equitably and resourcefully" (EU Commission staff working document, 2005). These recommendations include attracting more girls to science and engineering to widen the recruitment base. Many reports (EU Commission staff working document, 2005; EU report, 2003) point out that SET becomes more and more a dedicated territory with sharp gender and age issues. Attracting and retaining qualified students is central, as SET provides essential expertise in the development of the European welfare and competitiveness.

A nowadays society paradox is the obvious fact that the increasing life dependence on technologies is followed by an obvious decreasing of young people's interest for SET. Moreover, the feminine component of the potential pool of students and future specialists does not match the population structure and society demands (Zoli C., Bhatia S., Davidson V.; Rusch K., 2008). Although girls outperform boys at school and more women enter the labour market with a university degree than men do, there is overwhelming evidence that the education process for girls and young women is a „leaking pipe" in almost each stage (EU Commission staff working document, 2005; Götzfried August, 2004). As a result, women graduates are significantly under-represented in scientific and engineering disciplines (EU report IP/03/110, 2003): although in EU25 half of the tertiary education graduates are women, there are more men graduating in S&E than women in every EU country. Women are significantly under-represented in scientific and engineering disciplines: in the EU-25, the percentage of female graduates is 28.4% for science and 30.8% for engineering; women accounted for 43.7% of overall growth in science and 35.6% in engineering graduates and parity cannot be envisaged in the short to medium-term (figure 1).

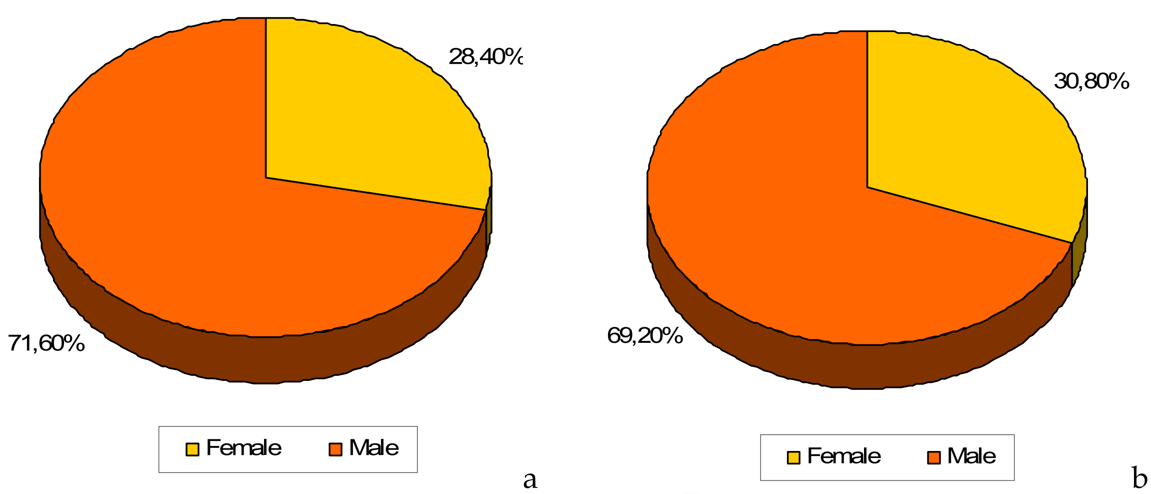

Fig. 1. Women graduates in science (a) and engineering (b) in EU-25 (EU report IP/03/110, 2003).

Not taking any action will continue to compound the chronic shortage of skilled scientists and engineers, and may deepen the gender gap, harming the perspectives for future social growth and welfare.

2. Science and Technology Education within the Romanian National Curriculum

The benchmarks for the education and training systems set up by the European Commission in 2002, at the European Council held in Barcelona, as well as the decisions made at the European level in the "Bologna process" triggered the reform of the education system in Romania (European Training Foundation, 2003).

The current structure of education and initial training system aims at ensuring flexibility and openness of individual educational routes (Ranga, L et. al., 2006). The current educational model provides for students the opportunity either to attend higher levels of education or to enter the labor market (after the 10th grade).

The Romanian National Curriculum contains (Romanian Ministry of Education and research, 2004) a core curriculum (the common set of concepts, principles, course of knowledge) comprising the compulsory courses (a 70% weight), and an elective curriculum (which differentiates one school from another, since they have complete autonomy in choosing classes - a 30% weight). Its courses (the compulsory ones and the elective ones) are grouped in 7 curriculum areas, which can be consistently found from the 1st grade until the 12th grade: Language and communication, Mathematics and natural sciences, Humanities and society, Arts, Sports, Technology, Counseling and guidance (Romanian Ministry of Education and Research, 2001).

In the National Curriculum, Technology Education has the following features:

- It is a part of the curricular area „Technology",
- It is a compulsory course,
- It can be an optional discipline in two cases: either as new curriculum themes from the Curriculum compulsory part, either when a new curriculum is developed,
- It has a multidisciplinary nature: technology education is designed as an integrated curriculum (it integrates various concepts from various disciplines, it involves various aspects of reality),
- Its objectives are accomplished primarily through the Technology Education course, as well as through other classes, such as physics, mathematics, chemistry, biology,
- It is structured in modules,
- It advocates a balanced relationship between theory and practice, science and technology
- It does not limit itself just to practical training or early professional choices.

At the secondary school level, there are 4 general objectives that must be accomplished throughout the gymnasium: 1. to understand the implications of technological progress for the people, the environment and the society, 2. to develop skills for the design, execution, evaluation, use and capitalization of products, 3. to exploit into communication the terms and symbols specific to technologies, 4. to develop entrepreneurship and the ability for professional orientation.

The passing from the 5 and 6th grades towards the 7th and 8th grades carries a growth in content complexity. New themes are introduced regarding the quality of products and services, the entrepreneurial behavior, the environmental and consumer protection. This way is supported the next step for the students heading for the technological high schools or the arts and crafts schools.

At the high school level, Technology Education is adapted to the mission and structure of the high school, allowing a diversification of the student evolution, in accordance with their interests and skills

The recent restructuring of the pre-university education system, namely the extension from 8 to 10 years of the compulsory education, includes within the last two years of the mandatory schooling one pathway dedicated to the achievement of vocational qualifications. These 9^{th} and 10^{th} grades of high school are part of a progressive professional

route, which allows students to continue their studies up to ISCED 3 (International Standard Classification of Education) – upper secondary education. The School of Arts and Crafts is an alternative to the first two years of high school recently introduced in the structure of the compulsory education, which is preparing students for jobs that are based on manual or practical activities.
A consequence of this diversified structure is the existence of a large number of Technology Education programs – 25 programs for the year 2007 (as part of the mandatory curriculum). If we also take into account the elective curriculum, the number of programs increases tremendously. We note the weight that the „Informatics" or „Information and Communication Technology" has in all types of high schools. The focus relies especially on computer proficiency, image processing techniques, computer assisted documentation, and database maintenance systems.
Analyzing the SET curriculum (Romanian Ministry of Education and research, 2003; 2004) and the methodology used in most of the schools, at every educational stage, we were able to draw the following conclusions regarding the Sciences and Technology education in Romania:

- The theoretical approach is still dominant despite the official emphasis on the practical training; achieving practical skills and building attitude for the technological domain are only weakly supported.
- Technology education contains modules with very heterogeneous themes. This can vouch for its advantage to correspond to everyday life's variety and to form practical life skills. The disadvantage of this heterogeneity would be that it can not fulfill its interdisciplinary approach, as it develops a kind of a hybrid feature.
- The specific objectives for these modules require a longer time for teaching/learning than the time set by the current curriculum; these modules seem to be designed for the stimulus-response learning approach. The quantity of knowledge is more important than the formative effects of learning.
- The psycho-pedagogical component and the technical or science content are not truly integrated and are not fully compatible. Regarding the psycho-pedagogical part we find a prolix language, with verbal structures that ignore the student age and learning features. Some teachers seem to believe that simply using this language guarantees the success of learning. Concerning the technical/science content, the curriculum proposes boring, obsolete or highly complex topics. It does not take advantage of the student experience, it fails to take into account their age and interests. The students notice a gap between what they learn and how they could actually apply that knowledge in everyday life (how does it help me and where can I use it?).
- The teaching strategies frequently pledge for a linear model of communicating the knowledge. These are „doping strategies," which deliver knowledge as a product, creating a passive attitude from the students and which require less effort from the trainer. The knowledge as a process approach is less often used. We believe that more skills and effort are required from the teachers to increase the student participation in the learning process
- Teachers with very different backgrounds teach technology education during gymnasium and high school. An improvement requires coherent training of the instructors and an integrated approach based on educational psychology concepts,

in accordance with stage theories of cognitive development and the modern methodologies of teaching technical and scientific topics.

3. Fact finding: what is keeping the enrolments in SET low?

The specific Romanian socioeconomic and cultural background requires a distinct, personalized approach, based on a rigorous fact finding strategy. A country with an interesting intellectual potential (4% of Romanian children are qualified as gifted, with respect to an European average of 2% - IRSCA Gifted Education, 2008), Romania still carries the historical burden of an excessive and invasive industrialization during the communist period, which induced a reticent, even aversive attitude towards „industry and engineers". Under these circumstances, attracting young people for SET studies is a challenge. In the same time, failing to recognize and remedy the severe under-representation of women in SET, in terms of both access and leadership, has limited the ability to advance of the Romanian society. Romania is still lagging, although it has been convincingly argued that the SET background allows women increased participation in political, social, and economic arenas and supports empowerment for themselves, their families, and their communities (Phipps Alison, 2002).

Supported within the FP6 UPDATE project frame, a complex study was set-up in order to point out the occurrence of gender stereotypes that might discourage girls from entering science and technology courses and careers. Starting at early stages, our study searched for the factors determining the career choice decision within the family, at school, in the media, and in society at large. Our three fold approach, aimed at finding the barriers that might prevent the girls from pursuing studies in SET and consisted of an on-line extensive questionnaire, semi structured interviews and mix team experimental activities.

3.1 Setting of the study and sampling

The study took place at the Ovidius University and the "Energetic" Technical High School in Constanta, Romania. The first research endeavor, aimed at finding the main factors that draw young people towards SET studies, was performed using as research instruments a 38 item online questionnaire and semi-structured interviews, enhanced with direct observations. The survey was addressed both to university students with their major in SET fields and to high school students. The two variants of the questionnaire were posted on the Ovidius University web site (http://www.dentomis.ro/update/update_eng.php). A sample of 257 university students was carefully selected with respect to age, gender, and field of study. They were offered laboratory conditions, a friendly web site form and a tutor able to offer explanations and help during the completion of the questionnaire. A number of 106 high school students completed the printed questionnaire under the supervision of a member of the UPDATE team together with their class tutor, the responses being subsequently entered into the data base for further analysis. In this manner, shallow or incorrect answers were reduced to minimum, with a response rate of 92.5 % and an estimated error of 5%.

The two variants of the questionnaire were built in order to fit both target groups in the sample: the freshman and sophomore students enrolled at Ovidius University of Constanta (in Biosciences, Engineering and Technology major studies) and the seniors enrolled in the technical high school. The descriptive parameters of the university students and the high school seniors are (figures 2- 5):

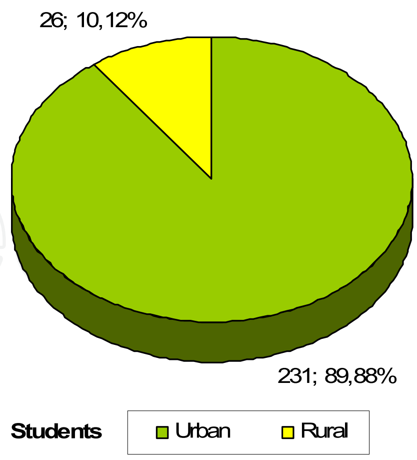

Fig. 2. Sampling: Provenience of the university students.

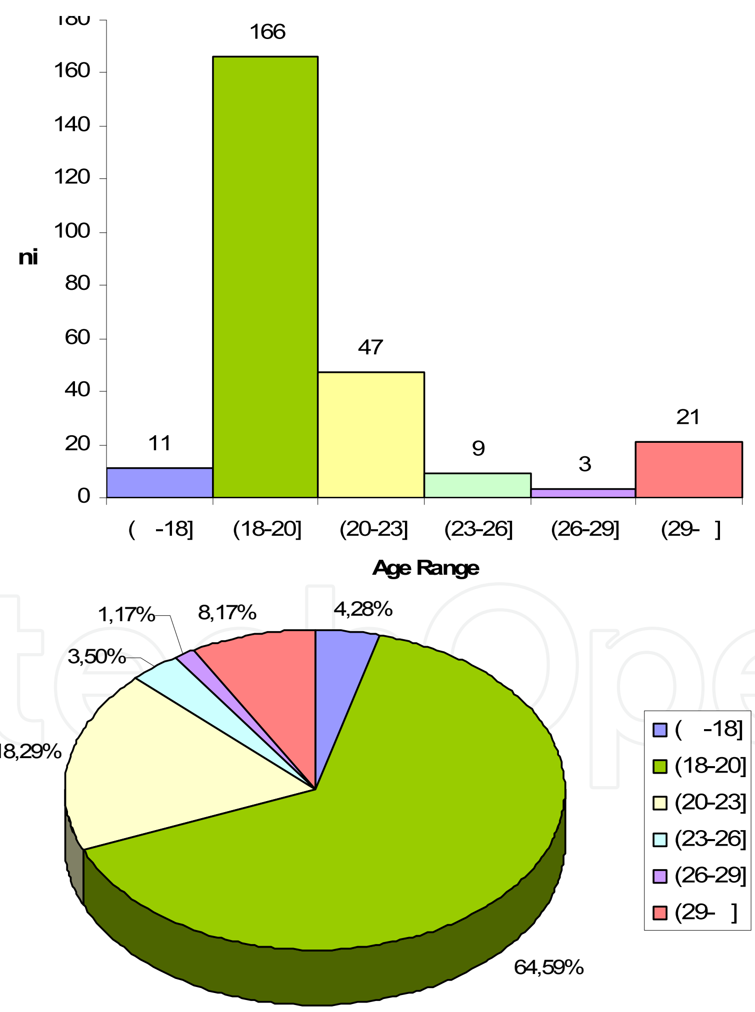

Fig. 3. Sampling - age groups of the university students

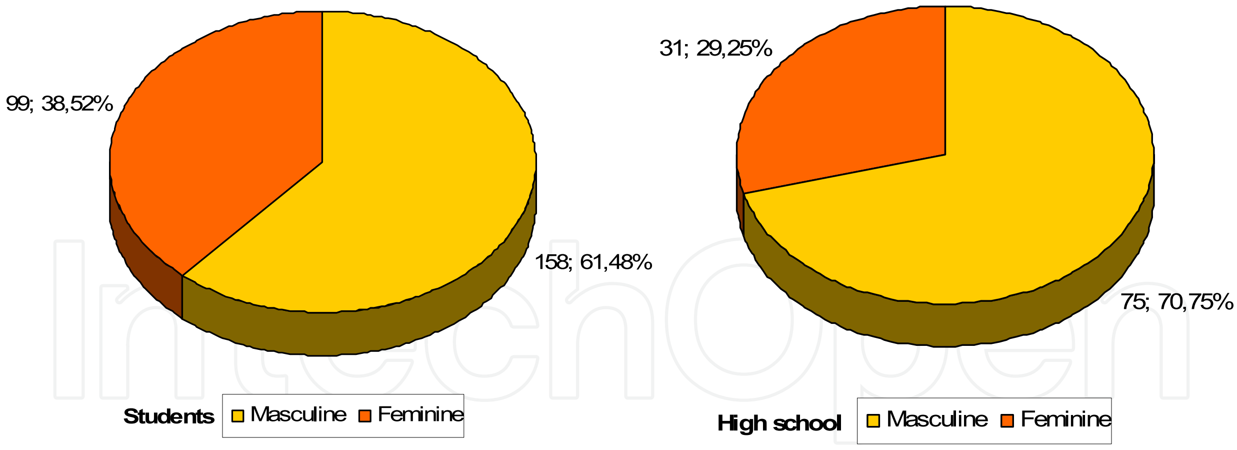

Fig. 4. Sampling - gender distribution of the samples of university and high-school students

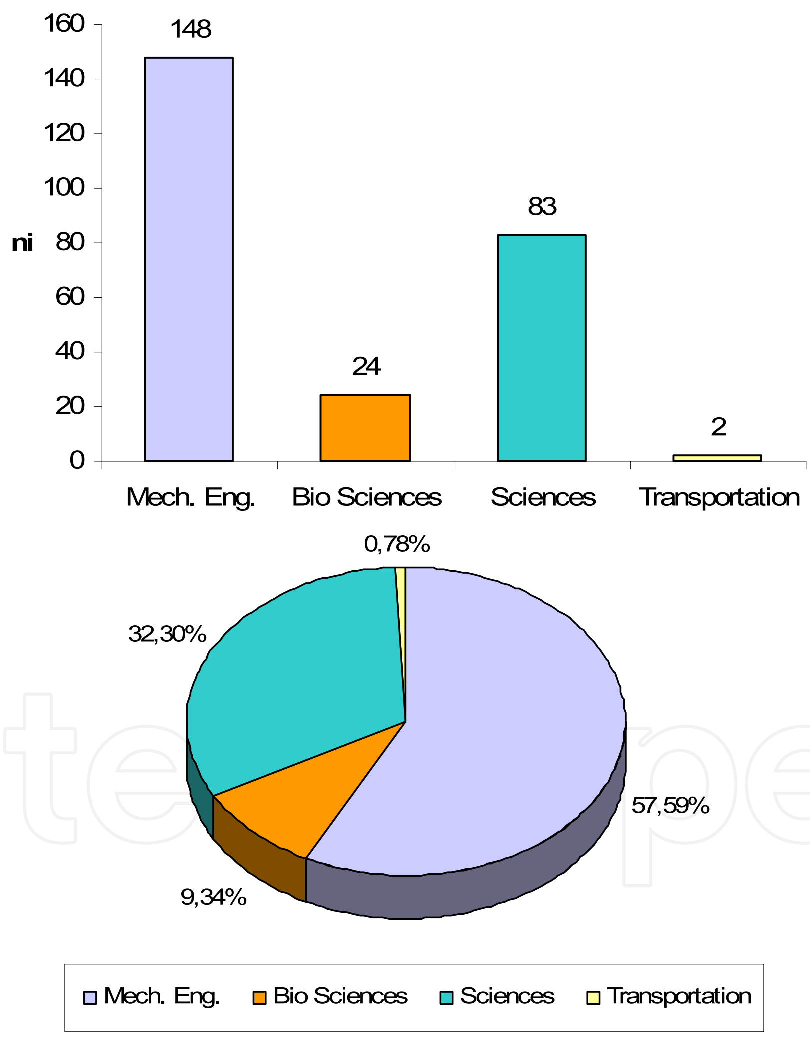

Fig. 5. Sampling - specialization chosen/targeted by the sample of university students

The questionnaire used mostly the Likert scale, the respondents being asked to indicate the amount of agreement or disagreement on a five-point scale. However, the rank-order scale was also used. The survey was built on the following psychological dimensions (table 1):

tradition in family	intelligence connected to the objects/ persons
early gender segregation	Primary education/ teacher's attitude
mentorship and role models	the manuals
self-efficacy	middle and secondary education
the support of significant others	time budget
cognitive styles	Changed hierarchies within the choice
images of science/ engineering	intergenerational differences

Table 1. Psychological dimensions of the quantitative questionnaire.
We focus here on the analysis of the „middle and secondary education" dimension.

3.2 Data analysis

With respect to the didactic methodology, the respondents obviously preferred the practical exercises. The registry of these methods underlines the students orientation towards the active-participative methods and the rejection of too much theory and theoretical exercises or passive methods ("preaching").
The responses regarding Technical Subjects in gymnasium and high school studied are, in general, similar to the previous item, but with lower means. Significant is the fact that, for the Technical Subjects, the respondents consider that they benefited from practical instruction and mixed team applications/ projects.
In Technical Subjects the active participative learning methods prevail and „learning by doing" is preferred to the passive and excessive theoretical methods. In other words, the procedural/ declarative knowledge is well balanced in the curriculum.
The respondents do not report gender discrimination regarding the didactic methodology during their own education (table 2). The issue that emerges and persists after other items analysis is the fact that the students are not/ less content with the visits at industrial sites. At high education level the subjects realize more and more that the link between the school, academic knowledge and „real life" environment is crucial for their professional performance.

Analyzed Items (ST)	T	p	Differences
Male - Male Items	1.447	0,149	No
Female - Female Items	-1,723	0,114	No

Table 2. T test applied for male/ female on the items referring to the evaluative attitude towards knowledge assimilation, problem solving, and interest for SET subjects.

The general curriculum evaluation received good marks, revealed by the close values for the means. The Technical Subjects area receives means rounded to/ over 3: IT (M=3, 59), technical/ technological (M=3, 44), math (M=3, 35), biology (M=3, 08) and physics (M=2, 98)/ chemistry (M=2, 95). For the social sciences and humanities the mean scores are lower: economy (M=2, 44), psychology (M=2, 60), history (M=2, 78), arts (M=2, 60). The responses respect the "real" versus "humanities" paradigm, an enriched paradigm since the subjects give better marks for foreign languages (M=3, 74) and physical condition/ sports (M=3, 48).

These seem to be appreciated for the abilities integrated in their future professions (communication and kinetic skills). When comes to appreciate the importance and the utility of the same disciplines for the formation in the Technical Subjects domains, the SET marks are upgraded, while the social sciences and humanities are downgraded. The curriculum components correlation in the SET choice for higher education studies are presented in table 3.

Analyzed Items		r	p	Correlated
the teaching methods used in high school and gymnasium	overall contribution of secondary education/ the gained abilities	0.5696	<0.0001	Yes
choosing SET for major at high education stage	overall contribution of secondary education/ the gained abilities	0.4503	<0.0001	Yes
choosing SET for major at high education stage	analytical thinking said to be gained in school	0.3903	<0.0001	Yes

Table 3. Correlation analysis between curriculum components

One of the items required a retrospective evaluation of the Technical Subjects regarding: the accessibility/ difficulty, utility, theory/ practice ratio, education facilities, didactic methodology, learning time and activity distribution, teaching styles. All the evaluations provided relative high means and revealed the importance and the synergy of these aspects with the learning environment and curriculum components. A certain discontent is related with the excessive theoretical content of the information and with the fact that the „teacher encourage mostly the reproductive thinking".

The opinions regarding the improvements that may help the Technical Subjects learning/apprenticing are conclusive: the students consider that up-to-day lab facilities are a must (M=4.26), and would appreciate more practicalities and applications (M=3.97) and changes in the teacher-student relationship (M=3.82).

The students seem to be more content with the scientific rather than pedagogical skills of their teachers. In addition, they consider that a broader range of activities (contacts with the local economical agents/specialists) would be wholesome (M=3.96 respectively M=3.83, which correlates with the 14th item evaluation). Thematic and fun science activities are high scored with means 3.76 and 3.60. Of special interest is that the students do not reclaim the information overload and consider that the restraint of the thematic is less or not necessary.

The retrospective evaluation of the learning cycles, with respect of personal formation, gives the following hierarchy: primary education (M=3.27), gymnasium (M=3.52), high school (M=3.95). The distribution of the answers has a certain gender component.

The students appreciate the high school studies with its significant subjects for their professional formation, while the primary education is the apprentship period, when the

basic instrumental skills are gained. The contribution of the gymnasium and high school disciplines is perceived with the following means, in terms of abilities gained:
Analytical thinking – M=2,98; Critical thinking – M=2,88; Creative thinking – M=3,33; Mathematical/ calculus abilities – M=3,21; Technical abilities – M =3,28; Communication abilities – M=3,42; Practical abilities – M=3,41; General knowledge – M=3, 49; Team working – M=3,46; Leading abilities – M=2,96; Planning, organizing abilities - M=3,18; The capacity to get a job/be employed – M=3,18.
Overall, there is a favorable perception towards the formative character of the education (figure 6). The perception of general knowledge synchronizes with the specialist's analysis of the National Curriculum. The critical thinking score reflects the novelty of this objective within the Romanian curriculum. No gender differences were revealed in the evaluative attitude, when they were asked to compare themselves with the same group, confirming other research results (Bain C. and Rice M., 2007). The motivation for choosing SET disciplines as major in high education is intrinsic. The students consider that SET will provide them employment.

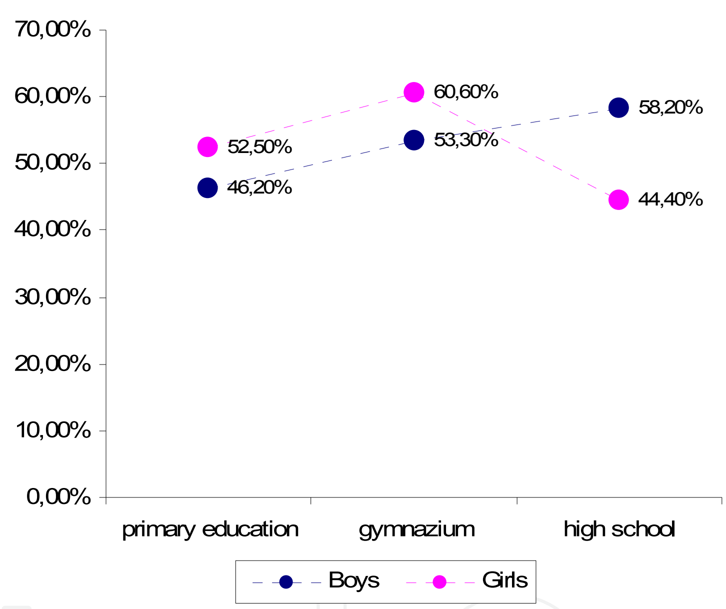

Fig. 6. Education cycles favorable perception within the sample

The overall contribution of secondary education, when comes to the gained abilities, is also related to the teaching methods used in high school and gymnasium ($r = 0.5696$, $P<0.0001$).
Comparing the means for male/female samples (t test), no gender differences were revealed in the evaluative attitude, when they were asked to compare themselves with the same group and the opposite group. The two items (22 and 23) point out the lack of significant gender differences regarding the knowledge assimilation and abilities formation for SET ($t = 1,447$; $p = 0,149 > \alpha = 0.01$). The motivation for choosing SET disciplines as major in high education is intrinsic - „passion for technique and technology" (M=3.42) and vocational - „I have aptitudes in the field" (M=3, 57). This item (choosing SET for major at high education stage) has significant correlation at the 0.01 level (2-tailed), with the abilities item ($r = 0.4503$, $P<0.0001$). The analytical thinking said to be gained in school is obvious correlated to this choice ($r = 0.3903$, $P<0.0001$).

The students also considered that SET will provide them employment. They seem to be well informed regarding SET careers (M=3.46), having the Internet as main information source (M=3, 47).

3.3 Case studies and interviews (enhanced with the direct observations)

Two extensive case studies were conducted in order to capture the motivation of the choice and deterring factors for choosing a carrier in Science, Engineering or Technology. One targeted a young female engineer, successfully integrated in her field of specialization, the other a young male accountant. The questions focused on the significant moments in the professional evolution, motifs for the career choice, the perception of choice by the close entourage and family, university life influence on one's choice, the studies, personal opinion on barriers and future career perception. The respondents were asked to emphasize if there were moments when they prioritized other aspects/options of their life against their formation as a specialist. In addition, they were required to consider if being a woman/man induces a certain behavior attitude towards them and if there are any differences between the ways their team mates are treated.

Four respondents (a female engineer, successful entrepreneur and … potential employer for future young specialists, two members of the university teaching staff and one young specialist) were interviewed regarding the motivating and discouraging factors influencing an SET carrier choice

The answers revealed that the strong will, hard work and positive attitude for study sciences, make a sure recipe for choosing SET as a way of living. The family support is very important but not decisive, while the teaching style and methods experienced during secondary school and college are crucial for establishing life long relationships with science or technology. The teacher's model is so important that, it can even detract and generate repulsive reactions in some students, who often report that they were tempted to quit the field due to the extreme preaching style and apparent incapacity of the teachers to sustain a vivid scientific debate or to present relevant case studies. Moreover, the lack of instrumentation in the labs and the poor correlation between the practical training and the skills needed for proper employment have also a strong negative impact on engineering career choices. This is why, the respondents who did not choose SET as their field associate these areas with a lack of creativity, comparing them with social sciences, which are seen as holding a more „tender," human load.

The lack of practical knowledge is one of the most important barriers that prevent a manager to employ young specialists, especially girls. Even though they do not make arbitrary assessments regarding the aptitudes of female engineers, they do express discontent with an observed reluctance towards practical, factory related problems.

3.4 Mix Team Project

The third research endeavor in the fact-finding quest has been an interactive hands-on laboratory activity with high-school students. A group of 10th grade high school students enrolled in the "Traian" Theoretical High School were invited to perform team project experiments in a Physics Lab of Ovidius University of Constanta, under the supervision of senior Ovidius University students in engineering and physics. They conducted attractive applicative experiments on alternative energy resources using special experimental kits offered by the UPDATE project. The aim of this activity was to detect the primary attitude versus since and technology in order to identify motivating and deterring factors for choosing further studies or careers in these fields.

The answers on short surveys offered by the high school students and by the university students acting as team leaders, offered a valuable feed back on the actual theoretical knowledge and interest towards SET of the participating teenagers.

The following aspects were thoroughly taken into account for the activity preparation:

- The high school staff: was approached 6 months prior, in order to build the fundamentals of the activity. The level and content of the activity were established, in line with the current pupil's knowledge on the subject.
- The materials: lab kits on energy and additional supplies, school supplies, were prepared for each team. Additionally, each pupil received a portfolio with the printed short presentation of the activity, description of the experiments and expected result, pretest and final test, basic school supplies.
- The 5 team leaders: were carefully chosen, out of a group of volunteers having some previous teaching experience, based on their pedagogical skills and their ability to detect and monitor the psychological responses of the students. They prepared the written material, tested the equipment, and structured the short presentations/sequence of tasks for each experiment. The student team benefited from a prior preparation of the activity, analyzing the learning sequences and their succession during the experiment. Their role was to guide the pupils in their group before and during the experimental work, providing explanations, answering questions, and offering various suggestions, while encouraging critical, imaginative thinking among the high school students.
- The theme: was selected from the physics curriculum at 10th grade „Energy sources and conversion". The topic was structured at a general level, using the basic knowledge of energy concepts, energy resources, and conversion principles between mechanical, electromagnetic, and electrochemical forms of energy. Static, kinetic, transformation representations were expected to be built and used during the experiment. Pupils were asked to build wind miniturbines, solar energy conversion systems with electrical circuits able to light a bulb.

The operational objectives were set according to the fact that physics concepts stay at different abstractedness level. The generalization process is applied not to singular cases but to structures with gradually increasing abstractive level (Piaget, J., 2001 defined it with the classic term of reflecting abstractedness).

One of the main objective was to keep the knowledge and the promotion of cooperative at the applicative, experimental level, as the tasks needed the positive interdependency between the group member (Pavel Andres et. al., 2007; Melezinek Adolf, 2001). The operational objectives in the frame of the theme were set in order to permit connections between concepts and representations:

1. Build a small turbine, turn the palettes with the hair dryer and light a light emitting diode (LED), measure the currents.
2. Turn a small turbine using a small motor and some batteries.
3. Build a small circuit with a photocell and a LED. Light the LED using an external source of light (sun or lamp). Measure the dependence of the current on the distance between the light source and the solar cell, light a LED using some Zn, Cu

bars, wires and lemons. Answer what happens in case of serial connections between the lemons?

The experimental data were recorded by the UPDATE team through direct observations and by means of four questionnaires as additional instruments collected from the participants:

- Two questionnaires were applied to the high school students: Q1 - prior to the activity (to collect information on their representation of the profession of scientist/engineer and on their prior knowledge in the area). It included 10 items distributed in 3 psychological dimensions: the perception of and attitude towards the theoretical knowledge gained in school in the SET area (items 1-4), pre-existing representations of some scientific concepts (energy forms and energy conversion) (items 5-6), and the representation of the SET professions (items 7-10). Q2, taken after the activity, collected data on the general information gained, on the opinion regarding experimental activities in general as well as this activity in particular.
- One questionnaire (Q3) was applied to the university students (the team leaders), in order to determine their view of the experiment, of the high school student preparation, attitude, involvement and response.
- One questionnaire (Q4) was given to the SET academic staff and high ranking faculty management.

The analysis of the Q1 data revealed that 82% of the subjects benefited from encouragement and positive attitude in the family (through simple practical activities such as toy repair-88%, bicycle repair -82%, domestic appliances repair -11%). We observed that the chance for the teenagers to display their abilities to perform practical tasks increases with their integration at the appropriate age specific interest zone. It is surprising that only 42% of the subjects admit that, when they are involved in repairing or other practical activities, they actually apply some of the theoretical knowledge acquired in school. This low degree of consciousness of the interconnection between practical activities and theoretical concepts illustrates the insular character of representations for different knowledge categories in the SET curricular area, the gap between notional and procedural knowledge.

Often, the students limit the causalities to a unidirectional scheme, operate with sequential thinking patterns; they don't manage to take into account several elements and, mostly, neglect the interaction effects. All these must be considered as learning obstacles and must be addressed with suitable didactically approaches. The learning process in sciences cannot be limited to simply providing information and even less to merely transmitting savant notions. The issue is to transform the spontaneous connections in a scientifically validated direction. In this context it is no surprise that all the teenagers expressed their will to be involved in practical activities and applications.

Prior to any formal education in science, the pupils gain an important amount of representations and notions from the direct contact with the environment. Consequently, concepts such as force, mass, velocity, energy appear as intrinsic qualities of the objects, generating serious distortions in the formation of a correct and coherent system of scientific concepts. Therefore, the sources currently easier to be identified in the environment received higher frequencies.

Understanding some of the energy transfer and the energy consumption activities was surprisingly difficult for the pupils. Their answers reflect the presence of thinking stereotypes. Understanding these notions entails the plan of transformative representations, i.e. the specific coordination of images and operations which mutually support. The answers proved that the pupil's thinking stays within the frame of images, which are unable to express the continuity of the transformation. Although images are indispensable, the meaning of the transformations and their effects cannot be expressed solely with their help, but mostly by using verbal operators.

The answers to the question „what does, in your opinion, the work of an engineer consist of?" reflect that the teenager thinking stays attached to the concrete dimension of living, and seldom, to the specific engineering field (IT, chemical, mechanical, electrical, or civil engineering, etc.). Engineering is perceived as a wide opening to various other domains, viewed mostly as a „verbal tag": 52% of the pupils consider that an engineer can substitute an economist or legal expert but 88% consider that the reverse is not possible. The popular belief is that the engineer and the economist hold more chances to accede to key managerial positions (52% and 47% respectively).

Q2 included 5 items and returned larger scores for the attractiveness of the activity, but lower for the attitude and professional orientation. This kind of exploration needs more time, and is more complex as the attitude change is a slow process, in numerous stages during which many factors need to crystallize.

Q2 also asked the respondent to formulate a question regarding the theme of the activity performed. A rather shy attitude towards inducing/challenging knowledge was revealed by the 76% of non-answers and the poor quality of the other 24%. As the comprehension validation comes mostly from formulating questions based on the newly acquired knowledge, these results may indicate some communication difficulties and understanding gaps.

The question regarding the subjects that might be of interest to the high school students for future activities in their school or various other locations, brought a sad truth: the pupils are eager to perform practical experiments, they are aware of their value for learning and apprehension but this type of activity has almost vanished from the actual syllabus of their classes. The young people are aware of some of the current challenges for science and engineering and want to know more about them but lack adequate opportunities and support to find the answers.

The question regarding the practical home applications of the phenomena observed during the activity revealed the lack of confidence in using acquired knowledge and even the gaps in mastering basic science principles.

Based on the student overall response to the experimental activity we can summarize the following positive effects:

- Positive effects in socio-affective plane: *i*) the creation of a relaxed learning environment, where inhibitions and emotivity can be over passed, the anxiety diminished, the fear to fail lowered, *ii*) the acceptance of other opinions, even if they disagree with one's own, *iii*) the stimulation of communication and interactions, of socialization, *iv*) the developement of solidarity and team spirit as well as of a feeling of emotional security, *v*) the encouraging of negotiating and decision making abilities, *vi*) the development of positive personality attributes, motivation and emulation.
- Positive effects in the cognitive plane: *i*) the activation of cognitive and thinking capacities, *ii*) the multiplication of knowledge, *iii*) the familiarization with various thinking patterns, *iv*) the enhancement of learning abilities due to the

argumentations and „pleading" situations which occurred, *v*) the raising awareness regarding one's level of understanding with respect to others.

Q3 was conceived for the team leaders and addressed the evaluation of the high school students (in terms of knowledge, abilities, qualities and attitudes) as well as their own personal experience.

The novelty of the experimental activity and the relaxed and friendly working environment surprised the high school students, who were initially impressed by the university ambience. The good chemistry of the groups, which were allowed to form voluntarily, the statements of the students who suggested that the activity would be retained as a positive event in their affective memory generated the high scores given by the team leaders when judging team-working abilities.

The team leaders found difficult to capture and keep awake the attention of the students. They considered challenging to determine the real level of knowledge in physics of their group members and to deal with the knowledge disparities among the teenage participants. It was demanding to adapt themselves to the age characteristics and to formulate explanations in accessible terms.

The team leaders complained that the background in applied science of the students is vague and imprecise, but reported that the experiments were far more attractive for the pupils than abstract theoretical lectures. The interest of the students in the experiments was reported to increase during the activity, as they gradually discovered the fun in making new things and finding answers to new, puzzling questions. The initial reluctance of the teenagers was attributed to the insufficient experience in performing practical activities during the regular school classes.

Regarding their personal experience the team leaders mentioned that they had the sentiment of responsibility as guides, when interacting with the younger generation, and trying to share their knowledge in an appropriate way.

Q4 aimed to grasp the opinion of university teaching staff regarding the motivating as well as deterring factors in choosing SET education paths and careers. Members of the academic staff, of the University Senate and of the managerial boards of various colleges were approached and asked the following questions:

1. What trend do you see in the young generation with respect to choosing a career in science, engineering and technology? 2. What do you think are the causes of this trend? 3. At what level of the education one must act to stimulate the interest of young people for an education or a career in SET? 4. Do you think that there are differences in the way girls and boys could be approached when one wants to offer or describe the alternative to study in SET? If yes, how can be these differences surpassed? 5. What are, in your opinion, the barriers and motivations which make the young people hesitate about choosing to pursue an education/a career in SET? 6. What can be done, in your opinion, to stimulate the young people to consider further education/ careers in SET?

Most of the professors considered that the 7th and 8th grades are a good start to promote science, but the time for more concentrated efforts is around 10th and 11th grade. All noticed the difficult recruiting of SET students and specialists and most attributed the trend to the sensitivity of the teenagers to the artificial success models promoted by the Romanian media and to the amount of hard work required by such studies. The respondents seemed to agree that the society does not encourage enough the SET studies, which continue to bear a poor "return to investment" ratio as the rewards in terms of salary and social position hardly match the time and effort consumed. They proposed that a new curricular approach, more adapted to the continuous evolution of the society, with more attractive syllabi, designed together with potential employers are crucial for improving SET perception. The respondents were in agreement that very few young students are aware of the real content of the scientific work, and that inappropriate teaching style during the early secondary school and throughout high school and even college discourage teenagers from embracing scientific or technical careers. A major responsibility lies not just with academia but also with the industrial players, who can be more efficient in communicating to the public the strong need for well trained specialists in SET. The partnerships between universities and employers and between universities and secondary schools are the key for a long needed change in the way society perceives scientists and engineers.

4. Conclusions

The extensive study performed in the frame of UPDATE FP6 project permitted to set statistic correlations between the dominant factors identified within dimensions. It was emphasized that there are important gender differences in the curriculum perception but not in to the self perception and attitudes versus SET in secondary education. This reveals that the so called gender stereotypes are rather induced and cultivated from outside the SET domain, which confirms other research findings (Jenkins Maura; Keim, G., 2004; Sevgi L. 2006). “Protection wall” mechanisms and a tendency to “demote” the SET field occur after, in order to justify one’s non-SET choices (Maccoby, E., Jacklin, C., 1974). Students that report lower impressions of engineering, despite a certain enjoyment of math and science courses, and confidence in basic engineering knowledge and skills, usually do not choose SET for further studies and carriers. Dropout is induced by a loss of interest in science, feel overloaded by curriculum, and perceive the teaching quality as low (confirmed also by OECD workshop summary, 2006 findings). Students most likely to choose and complete SET degree requirements have success in high school math and science, a persistent interest in science, and positive perceptions of SET and of the curriculum components, despite the researchers expectation for some strong criticism towards the education route (Pavel Andres et. Al. 2007).

The correlations revealed a strong liaison between the SET methodology and technical abilities formation. The results presented pleads that there are still SET clichés induced by the curriculum, that must change, in order to fulfill the different gender expectations, leading to a benefic perception of a career in SET arias. Significant is the favorable perception towards the curriculum in primary and secondary education stages correlated with the intrinsic motivation for the careers in SET. This brings into attention the need to encourage for SET children and young people beginning from early stages of their education.

Overall, the respondents do not report gender discrimination regarding the didactic methodology during their own education. They consider that they benefited from practical instruction and mix team applications/ projects and that up-to-day lab facilities are a must. More practicalities and applications and a broader range of activities (contacts with the local economical agents/specialists), attractive thematic and fun science activities are considered beneficial, while the pupils would prefer changes in the teacher-student relationship. It is of crucial importance to foster inquiry-based science teaching and learning strategies and increase science interest and learning.

The mix team projects activity had three folded remarkable effect: (1) Scholar performances: all the pupils were interested to succeed; their implication, constant working rhythm, general satisfaction concurred for gaining a superior level of work results. (2) The interpersonal relationships: profound and more sincere relation among the mates due to the team spirit, more flexible communication, acceptance of team leader role in learning process, development of more tolerant attitude versus other person's ideas and behavior. (3) Personal identity plan: strengthening the self and self identity, social competences development, efficient communication and improving the self image.

The answers at the questionnaires given suggested that pupils know very few things about what science and technology mean, have a distorted idea about some basic knowledge on energy but were eager to learn and even proved themselves quick learners when faced with the practicalities of their assignments. They declared that they understood better the concepts and the content of a scientific experiment and were willing to give more chances to SET domain among their further studies choices.

The conclusions to be drawn are not new (Terry, R. E. and Harb, J. N., 1993): make the science classes more attractive, with more illustrative applications! This will bring the science closer to the pupil. He/ she will become familiar with the application of "a hard to understand theory" and will bring his/her own creativity in practical applications.

The scientific theories are not built by successive addition of new facts but rather by focusing the instructor's activity on cognitive obstacles that must be overcome. This can be achieved during the continuous restructuring of the assimilative schemes and their integration in more and more advanced cognitive structures. Too often the students are regarded as "knowledge consumers", and their knowledge are inert, since it is used only to obtain a passing grade, not for problem solving. This is to be achieved by recognizing the students "knowledge builder" status. The mix team activity engaged a cognitive effort in a stimulating relational, cooperative climate.

It appears that changing the one's aptitudes, the attitude towards science and technology will be as well changed. This will be in the benefit of Science, Engineering or Technology enrolled students number.

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InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821