

FUTURE FOR SCIENCE AND ENGINEERING EDUCATION

Boris Aberšek

University of Maribor, Slovenia
E-mail: boris.abersek@uni-mb.si

Abstract

School educational systems on the threshold of millennium all over the Europe are experiencing radical changes. Deliberation, which generates this changes, is mostly oriented into balancing which competences (capabilities) should educational system develop with the students, so they can successfully perform roles, that can be expected during their life, and therefore to create their own prosperity.

- *In this context it is exceedingly important to see curriculum aims*
- *as global (and not as it happened at previous renovation; subjects dispersion). We have to think about a correlation of knowledge between the humanities, social sciences, natural sciences and technical fields and also their role (dimension) at forming entire personality for future grown. It is not possible to deny, that humanities, social sciences, natural sciences and their application: techniques are inseparable connected, because things are getting their practicability value (become logical) only in the field of application. (Foreign language, when or if we meet foreigner; mathematics, when we want to calculate something...). Natural science knowledge gets its meaning in application (techniques), and therefore gets its market value – that can led up to rise social welfare (prosperity). That however reflexively generates new impetus of society: art, culture, humanism...The circle is joined or even better, a vertical spiral is released (Picture 1).*
- *it is highly important to use in this process methods, that's support such curriculum aims. In our research we proposed Problem-Based Learning (PBS). PBS was first established as part of the education of physicians in medical school over 40 years ago. Developed by Howard Barrows, this strategy has grown into an instructional approach which is finding success in elementary through high school. PBL is now a prominent strategy in many elementary schools through high schools.*

Key words: *curriculum design, science and engineering, problem base learning, constructivism, educational research.*

Introduction

If we take into consideration that our thinking is correct and think of actual school system, we will find out that we made several mistakes in the last decade (The Education system 2000, White Paper 1996).

- First of all, in desire to teach the children as much as we can, and in search of the right solutions how to reach that aim, we at the same time also tried to relieved the children. The usage of knowledge, technics in the primary school curriculum was completely ousted on the edge. So derogated, simple can not fulfill none of its own tasks: it can not form

the interest that is interesting to make something, and the cognition that if we want to do something, to solve the problem, we also have to know something (See Appendix).

- Even greater mistake was tearing apart above described circle and the elimination of technical knowledge out of educational system half of the population. When we have allowed to crossed the technics out of high school curriculum, half of the population does no know what is the use of knowledge, why do they have to learn and what do they learn. In their horizon the circle from knowledge to its application is not connected, an essential element is missing. The most critical point is, that precisely that half of the population is the one that carries out the responsibilities for creating social welfare (prosperity). The consequences can already be seen and are creating new social problems: not only that there is only a small part of young people who decide for natural science and technical studies, even the ones who except this decision and conguer natural science and technical knowledge on the highest possible school level (degree, doctorate), can not find the way how to use this knowledge on the application level, to make it reasonable for solving problems (e.g. in economy), for developing new products...

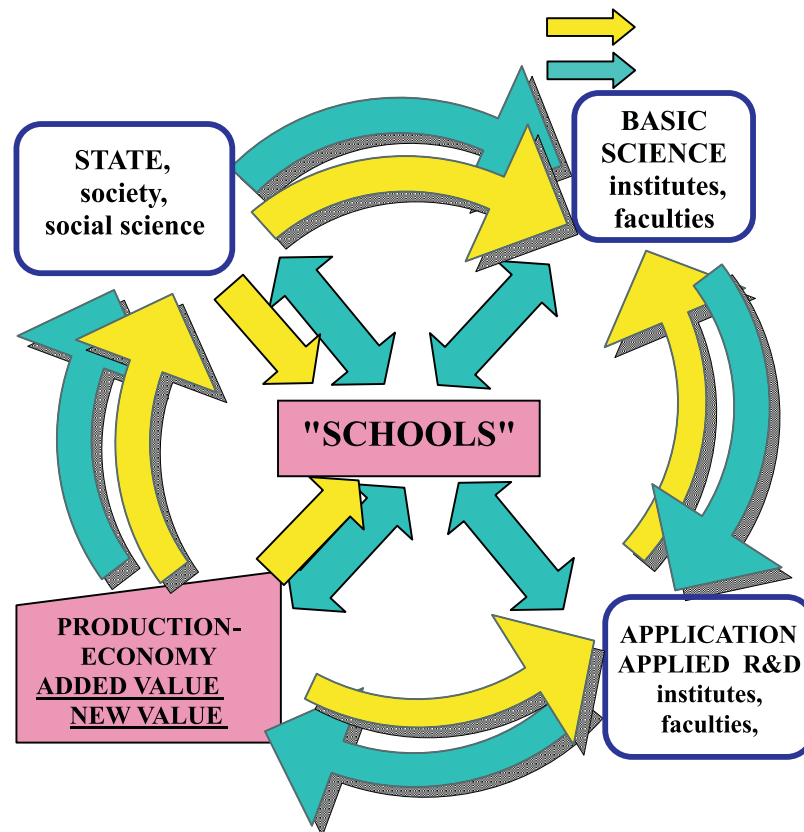


Figure 1. Social developmental circle.

In this context is more than calmly to observe the activities of Ministry of Higher Education in connection with the strategy of development in Slovenia (Strategy of development in Slovenia, 2005), which are connected with the guidance of interest with future students of nature science and technical studies. All that indicates that deliberation has been already performed where to is development in Slovenia directed and what is necessary education for young people so they can lead and accomplish such development in the right direction.

At this point we have to emphasize, that the excessive interest which youth has for humanities and social study programmes, it is not something that could be solved permanently with the actions of vocational counseling and other activities at the end of secondary school. We need to solve this problem long before that – on the level of primary and secondary school education.

Similar or even more urgent situation is on the secondary school level. We have reduced the

role and the meaning of secondary school and vocational education on minimum, but we have introduced vocational high schools and even there is not enough hours of technics. The interest for technical high schools is relatively small, from year to year smaller. As already told, more than half of the generation continues their education at classical (general) high school programmes, where they do not hear anything about technics, the result is, that a part of the population which carries out the responsibilities for creating social welfare (prosperity) after the last year at primary school does not have any technical education – and there is no possibility to be interested in such education.

Proposed changes

First proposal

How to solve the educational problems of young generations with technical and nature science knowledge. In this article we will hand out the concrete activities, that will indicate solutions above for mentioned problems, namely: the ones based on existent situation in Slovenia in the field of technics and natural science and also comparison of international successful systems and economics. We are prepared:

1. Suggestions for completions and changes for primary school curriculum with knowledges methodology and contents, which are necessary for economic successful society in the near future and
2. Suggestion for completions and changes for secondary school population with emphasis on general high school programmes, which are and have to be the foundation for Bologna renovations of higher educational studies.

We have to take into consideration two key principles:

- With developing technical capability (competence) we will have to connect (become more logical) with natural science knowledge, which at the same time (or before that) is intervened by primary school curriculum or high school curriculum.
- At the same time we will have to define aims, contents and activities in curriculum in the way, so that would be possible in didactic process of developing technical competence, to develop key european competences: information competence, communication competence and above all, “how to learn” competence.

Second proposal

We must use methods which enable students to actively participate in educational process while acquiring skills necessary to function in tomorrow’s world, especially tomorrow technological society. It will be mentioned only two the most important methods used in science and engineering studies, namely Problem based learning and Constructivism.

Problem-based learning

Problem-based learning and engaged learning enable students to actively participate in their learning while acquiring skills necessary to function in tomorrow’s technological society. The teacher provides importance guidance throughout the study. Problem-based learning requires an artful combination of a skilled teacher/facilitator who recognizes the value of each step and who takes the time for proper preparation, assimilation, development and involvement. As a result students will:

- **Engage** - Define and investigate a research question or problem.
- **Inquire and Investigate** - Access, process, and apply information through a variety of resources including the use of current technology, i.e., Internet.
- **Evaluate and Justify** - Interpret results; develop solutions for real-world application.
- **Communicate** - Information, conclusions and personal responses.

Myers (1995) state that “problem-based learning is a curriculum development and instructional system that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured problem that mirrors real-world problems”.

Goals of Problem-Based Learning

PBL is used to engage students in learning. This is based on several theories in cognitive theory. Two prominent ones are that students work on problems perceived as meaningful or relevant and that people try to fill in the gaps when presented with a situation they do not readily understand. Teachers present students with a problem set, then student work-groups analyze the problem, research, discuss, analyze, and produce tentative explanations, solutions, or recommendations. It is essential to PBL that students do not possess sufficient prior knowledge to address the problem. In the initial discussion, students develop a set of questions that need to be addressed.

Norman and Schmidt (1992) state there are three roles for PBL. The first is the acquisition of factual knowledge, the second is the mastery of general principles or concepts that can be transferred to solve similar problems, and third, the acquisition of prior examples that can be used in future problem solving situations of a similar nature.

Problem-Based Learning - What Are the Benefits?

Using PBL as a strategic tool in the classroom entails the development of the teacher as facilitator of learning, the class as strategic learners and problem solvers, and the district as an innovator and embracer of productive, progressive education. Effective PBL strategies will result in the following benefits for the teacher, the classroom, and the society:

- Problems encountered resemble the nature of problems encountered in the real world. Problems provide clues, context, and motivation; they are the maps which guide learners to useful facts and concepts.
- Since the problem cannot be clearly approached on the first encounter, it becomes a challenge, promoting creative thinking and developing organizational skills.
- Prior knowledge provides a foundation for establishing a framework for extending learning opportunities for all parties involved in the process.
- Misconceptions about teaching and learning, curriculum, math and science instruction, and learner content level understandings are revealed.
- The legitimacy of the group's as well as the individual's learning goals are established.
- The process empowers the group (student and educator alike at their own level) to assume responsibility for directing learning, defining and analyzing problems, and constructing solutions.
- Transfer of knowledge and skills is enhanced through the use of multiple tasks and problem concepts to help form functional abstractions.
- Participants are instructed in becoming responsible members of a learning community by active participation in the PBL process.
- The PBL process models a strategy that can become a foundation for a life skill- vocational training for future problem solvers.
- Common understandings and unexamined assumptions are articulated district-wide as the PBL process is employed - providing direction and opportunities for staff development activities for the future.

Constructivism

Constructivism is basically a theory, based on observation and scientific study about how people learn. It says that people construct their own understanding and knowledge of the world, through

experiencing things and reflecting on those experiences. When we encounter something new, we have to reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. To do this, we must ask questions, explore, and assess what we know (Brooks, 1999).

In the classroom, the constructivist view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure she understands the students' preexisting conceptions, and guides the activity to address them and then build on them. You might look at it as a spiral. When they continuously reflect on their experiences, students find their ideas gaining in complexity and power, and they develop increasingly strong abilities to integrate new information. One of the teacher's main roles becomes to encourage this learning and reflection process.

The differences between Traditional and Constructivist class room are indicated in the Table 1.

Results of Research

And now, back to our main problem in Slovenia (and EU too):

1. We must realize analysis of existant situation in Slovenia and abroad. We must also realize international comparison of primary and secondary school curriculums, along that we will not just realize a paper comparison, but with help of our partners we can also evaluate their experiences and practise and compare their visions, guidelines of development in researching field (study cases of good comparable practise (in our region) (See Appendix).

Let us brighten actual situation of technics, technical education in primary school and secondary school education.

- While there was only 3.2% hours of technical education meant in eight year primary school, there are only 1.7% hours remained in nine year primary school.
- It is possible to compare that in the international context: a share of technical education in Austrian primary school curriculum is 4%+2%, in France 6%, in Finland 6% and in Italy 10%, e.g. (Source: Comparative analysis of curriculums in the field of technics and tehnology, 1997). This source was a part of renovated documentation.

Table 1. Traditional education versus Constructivist education.

Traditional education	Constructivist education
Curriculum begins with the parts of the whole. Emphasizes basic skills.	Curriculum emphasizes big concepts, beginning with the whole and expanding to include the parts.
Strict adherence to fixed curriculum is highly valued.	Pursuit of student questions and interests is valued.
Materials are primarily textbooks and workbooks.	Materials include primary sources of material and manipulative materials.
Learning is based on repetition.	Learning is interactive, building on what the student already knows.
Teachers disseminate information to students; students are recipients of knowledge.	Teachers have a dialogue with students, helping students construct their own knowledge.
Teacher's role is directive, rooted in authority.	Teacher's role is interactive, rooted in negotiation.
Assessment is through testing, correct answers.	Assessment includes student works, observations, and points of view, as well as tests. Process is as important as product.
Knowledge is seen as inert.	Knowledge is seen as dynamic, ever changing with our experiences.
Students work primarily alone.	Students work primarily in groups.

2. We will realize evaluation of existant curriculom for technics and tecnology in connection with natural science in primary school and we will also suggest changes and completions of entire curriculum for primary school – content, aim and methodical renovation.
3. We will aslo develop the proposal of curriculum for general (high school) education. We will try to introduce modern approches to secondary school students, technical vocationals as visions and guidelines of development in this field in the future (Computer based construction and modelling, computer based and integrate productions, automation and robotization, virtual simulation, bionika, nano technology, e.g.) We will include experienced experts, high shcool teachers and we will aslo closely collaborate with them. Their willingness to collaborate can be seen from the enclosure, where we have collected their statements about collaboration.

Methodology

We have to analyse and search for causally consequent connections of knowledge in natural science and technical field in entire life vertical from basic education to secondary school education, faculty (collage) education to final, lifetime education, informal adult education, with emphasis on economy education for people. Based on that we can organize and develop suitable curriculums and study technologies which can be comparable with different methods and forms of work, that are already realized all over the world, but with that we must also emphasize our experiences and needs.

With an analysis of trends and needs of economy development in Slovenia, we can get necessary input informations. We must concentrate on human resources and necessary knowledge of this cadres in the field of natural science and technical branches. We will have to include these cognitions into developmpment of curriculums and study enviroment, that will enable and encourage selfstudying, reduce educational time and work absence and will also increase quality. These instruments will enable transition from passive to active forms of teaching, educating and qualifying.

Based on this analysis and suggested innovatory process we can increase quality and quantity of informations, along that we will effectively modify vocational profiles and competences, and with this we will also contribute towards solving problems in fast changing working situations, and enviromentals nature science and technical profiles, that are extra subjected to these changes.

On the bases of knowledge and cognitions of previous researches we have collected more for our research: Germany, France, Great Britain, Greece and Czech. All these countries reflect almost entire range of differences in systems within EU. Worldwide researces in the field of vocational education and qualification are reflecting necesesity to project curriculum, that enables vocational flexibility and conformism of needs in the market of manpower.

Reforms, in the field of technical and nature science education, are because of pressures from the market of manpower reflecting with time and content frames, study enviroment, and specially with the usage of new informational technologies. With the help of those we can really represent complex authentic situations. We can brighten them up from different sights of angles, what even more magnifisize the quality of education and with that also reduces necessary time for that. Let us explain all together clearly on the scheme on Picture 2. We have planed this activities in three parts, three phases. We will have to focus mostly on technics and nature science and their connection with society (social competences).

1. PHASE: Analysis of home situation -in Slovenia. We will perform

- literature anaysis and or acts, as e.g. Strategy of development in Slovenia... (Strategy of development in Slovenia, 2005)
- analysis with the help of standard and nonstandard questionnaires,
- recording situation– conversation, interview...
- analysis of local guidelines of development.

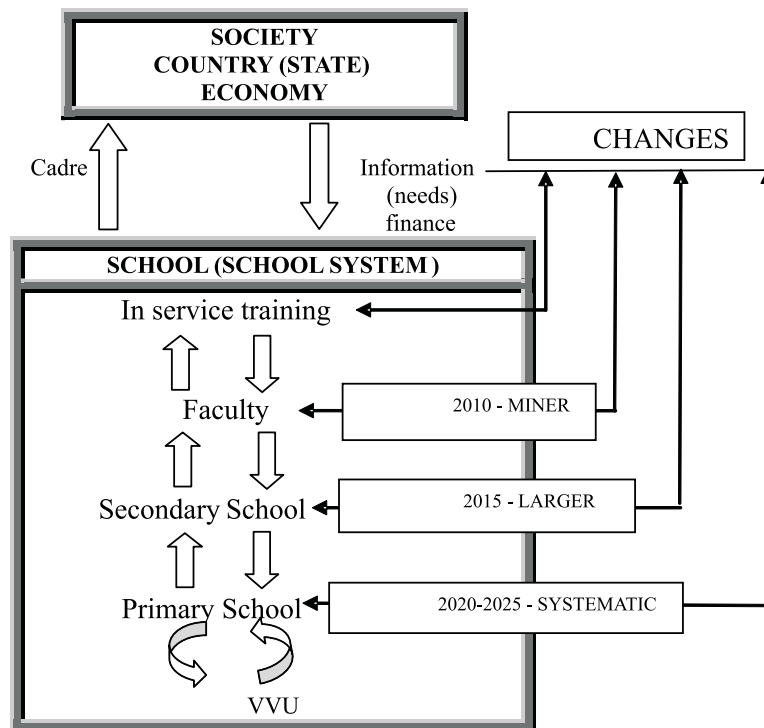


Figure 2. Strategic development of human resources.

2. **PHASE:** An international researches oriented mainly within EU and the ones that at least partly consider global area – USA, and also fast developing countries in Asia. With this will perform:

- analysis of existant situation in the field of economy and schooling.
- analysis of trends, guidelines of economy developmpnt and responses of school systems on changes in economy.

3. **PHASE:** Elaboration of changes and completions of curriculum for technics and nature science in a primary school and aslo suggestion for curriculum in general high school programm. We will proceed from some general knowledges and general valid principles:

- a. the cadre, which is produced by our school system, is not any more the cadre, that our economy needs (for encouragement of naturale science and technical studies from the side of Ministry of Higher Education, Science and Technology).
- b. If we want to tackle the problem entirely, we have to be aware that the school system is inseparable integrity, which connects kindergartens, primary school, secondary school and univerities in the lifetime learning system. Every change of individual segment directly influences to all other segments.
- c. With the changes of the individual segment we achieve time connected changes and different intensity of changes. So we find out that:
 - primary school changes generate long - term, entire, larger changes, results of those will be shown in our economy in the year 2020 – 2025,
 - secondary school changes generate medium – term, larger changes and will be shown in our economy after 2015,
 - Bologne changes are short – term, not systematic, for those we can not be certain if they will fulfil local demends and also hardly likely global demands. Results of those will be shown after the year 2010, 2015
 - lifetime learning, - in service training – satisfys current, short – term needs, and it is already by its definition not systematic and designed for the particular user »in present« moment.

- d. More than half of secondary school students do not hear anything about technics (and comparison between technics and natural science) after they turn twelve. That means, that everyone who attends high school programmes, the ones that are responsible for creating social welfare (prosperity), do not hear anything about technics or about connection between technics, natural science and social science. They do not know why do they have to learn. And they also do not know why a person should choose nature science study programme or technics. But the fact is that society needs them; **we need technical and science educated people.**

On the base of Phase 1 and Phase 2 we will therefore prepare optimal model of completions and changes of the curriculum for primary school and also proposal model of curriculum for general high schools.

THE MAIN AIM OF THIS ACTIVITIES IS: IN ONE SIDE SYSTEMATIC PLANNING OF REQUIRED HUMAN RESOURCES FOR ECONOMY IN LONG – TERM PERIOD AFTER THE YEAR 2025 AND AT OTHER SIDE INCORPORATION IN SCIENCE AND ENGINEERING STUDIES METHODS OF EDUCATION THAT PRODUCE HIGH LEVEL LONG TERM KNOWLEDGE.

Conclusion and Discussion

If we want to change the school system (universities, secondary schools, primary schools, educational and protectional institutions) to be proceed systematically – entirely, because only that kind of approach will gives us complete solutions (Strategy of develop. in Slovenia, 2005), but we have to take into consideration following:

- **demands of final user** – economy, that considers local demands, local trends of development that is based on history facts and actual possibilities (financial, employmental, developmental...). These demands are usually short - term, and with these they mostly do not consider Slovenian trends of development, not even global trends of development: Europe and the rest of the World, therefore we have to take into consideration also;
- **trends of development in the World**, that are presenting long - term visions of development. With that we should not neglect the danger of only exclusively observation of this problem from global perspective, such kind of outlook does not consider local speciality.

THE ADVANTAGE OF SUGGESTED SOLUTIONS IS MAINLY IN ITS WIDENESS; AND IN CONSIDERATION OF BOTH ABOVE MENTIONED IMPORTANT VIEWPOINTS!

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APPENDIX

A share of technological education in compulsory subjects, as it is shown on the table below, it presents for most part around 6% of all time. We collected informations that were available.

AUSTRIA	4 % + 2 %	manual work + textile / technology
FRANCE	6 %	technology
FINLAND	6 %	manual work
ITALY (11 - 14 years)	10 %	technical education
ISRAEL	6 %	manual skills
HUNGARY	6 %	technology
HOLLAND	3 %	manual work, technological education
NORWAY	9 %	art, manual work
SWEDEN	12 %	natural science and technology
SLOVENIA (before reform)	3,2 %	technical education
SLOVENIA (after reform)	1,3 %	technics and technology

Country	age in years	6	7	8	9	10	11	12	13	14	15
Austria	manual work		1	1	2	2	2	2			
	textile or technology								2	2	
France, general	technology						2	2	2	2	
	technological						2	2	7	7	
Croatia	technical culture						1	2	1	1	
Germany, Hauptschule	work and technics					1	1	4	4	4	
	Realschule					1	1	4	-	-	-
Holland	manual work	1	1	1	1	1	1				
	technological education									180 hours	
Slovenia before reform	technical education						1	2	1	2	
Slovenia after reform 2000	nature science and technics				1	1					
	technics and technology						2	1	1	-	

*Advised by Laima Railienė,
Siauliai University, Lithuania*

Boris Aberšek

Professor at Faculty of Mechanical Engineering and Faculty of Education,
University of Maribor, Koroška 160, 2000 Maribor, Slovenia.
E-mail: boris.abersek@uni-mb.si
Website: <http://fs-server.uni-mb.si/si/inst/iko/larkon/Abersek/>