

## RESEARCH AND DEVELOPMENT WORK FROM THE PERSPECTIVE OF COMPILING BALANCED CURRICULA FOR SCIENCE EDUCATION

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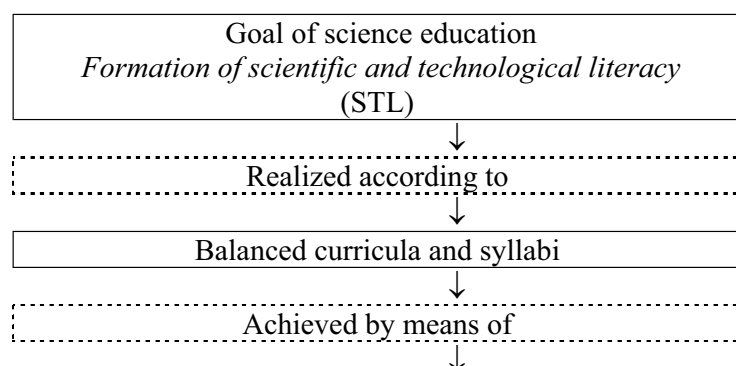
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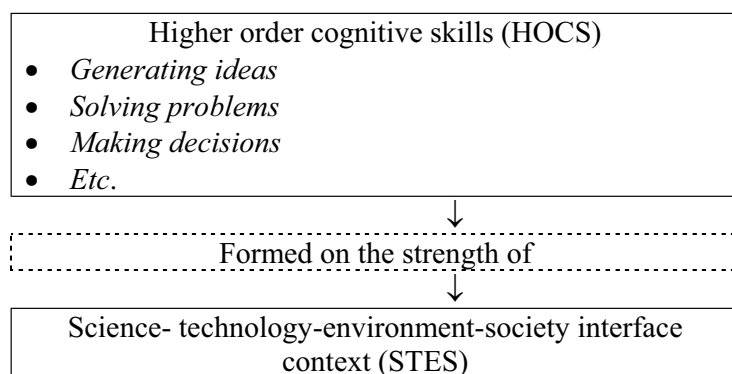
**Abstract.** In this paper, research and development (R&D) work in the context of the current reforms in science education is analyzed from the perspective of compiling balanced curricula and syllabi for teaching science. We argue that science as a subject taught is not a rigid body of knowledge, rather than a style of life in rapidly evolving society. We consider the ideal paradigm of science education today as well as in the future as teaching balanced science according to balanced curricula in strongly social context based on psychological and didactical treatment. The main aim of science education is to achieve scientific and technological literacy (STL) among the students, to improve public understanding of science, and currently, to prepare future citizens. Compiling of the balanced curricula for science education should begin from establishing balance between educational goals aimed by the formation of STL. Implementing the balanced curricula demands the compiling of the balanced instructional system including balanced strategies and methodology for teaching science.

**Key words:** balanced curriculum, scientific and technological literacy (STL), educational goals, educational components.

The purposes of science education, as a component of young people's whole education experience, means to prepare them for a full and satisfying life in the world of the 21<sup>st</sup> century. Implementing the main aim of science education in the new millenium is to prepare future citizens' demands by compiling the new strategies as well as the new methodology of teaching and learning including the new curricula and syllabi.

As the formation of STL is one of the main goals of science education, it might usefully be taken to the means of developing the ability to creatively utilize science knowledge in everyday life, or in a career, to solve problems, to make decisions and hence to improve the quality of life. This is based on acquiring educational skills at the intellectual, attitudinal, societal and interdisciplinary levels (Holbrook, 1999). Science taught in schools today as well as in future is to enable the students to operate within a scientific and technological society. U.Zoller envisions the science education as an interdisciplinary critical thinking-, problem solving- and decision making-oriented and, consequently, higher order cognitive skills learning in the science-technology-environment-society interface context, leading to the capacity of transfer beyond the subjects(s) or discipline(s) (Zoller, 1999, p. 19). On the ground of the above mentioned theoretical items it is possible to scheme the paradigm of future oriented science education (Tõldsepp, 2000).





**Figure 1. Future oriented paradigm of science education**

We consider the ideal paradigm of science education today as well as in future the teaching balanced science according to balanced curricula and syllabi in strongly social context based on psychological and didactical treatment. There should be balance between

- governmental and non-governmental education;
- formal and informal education;
- subject oriented and student oriented teaching;
- algorithmic and non-algorithmic activities;
- objectivity and attractivity.

Balance should decisively be established between formal and informal issues in any science course. The majority of the post-socialist countries are still oriented on formal issues, taking into account only the requirements settled by governmental curricula and syllabi. However, the formation of STL has got to help young people to acquire a broad general understanding of surrounding world, ability to observe, describe and explain the substances, materials, processes etc. around us in terms of science. STL will be formed only in case that two important considerations – relevance and motivation are governed. How to make science teaching relevant? J.Holbrook suggests that relevant education is related to issues or concerns within society. This could relate to environment, health, energy needs, population control, industry, and communication or to more global concerns geared global warming (Holbrook, 1999).

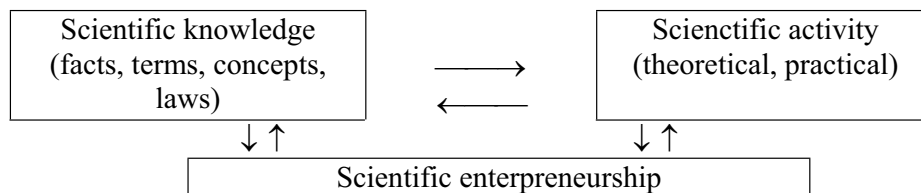
According to the requirement of relevance we see a number of advantages of informal science teaching and learning aimed by the formation of STL. Common everyday observations, conversations, and discussions with parents, friends, teachers, coaches, etc. in school, at home, in living area, supermarket, sporthall etc. provide the students with the facts and experiences needed to be generalized in terms of science. In any case, science teachers choose additional content from very different sources that help students learn intended outcomes. For example, teachers use local data and everyday information to change teaching and learning more relevant and motivated. The science teachers should find the optimal strategy how to relate everyday knowledge and experience to formal curriculum requirements. Among the different possibilities we see the simplest way of compiling written reports, essays, diagrams, tables and other written tabular or graphical forms. As our empirical studies have shown, the students compiled their written reports very objectively, honestly and emotionally. Therefore we can consider the students' written reports as an evidence of their everyday experience, family habits, traditions, etc. (Toots, Töldsepp, 2000). It is obviously inevitable to establish two major types of science education and two different curricula as was suggested by J. Holbrook (Holbrook, 1999):

- which provides a background for further study, especially when specializing;
- which enables a person to operate within a scientific and technological society.

Such curricula are deemed relevant when they meet the needs of students who are striving for multidimensional STL. While such curricula need to incorporate the cognitive, attitudinal,

societal and communication components, the needs of students are culturally bound and hence context will differ in substance from one location to another (Holbrook, 2000).

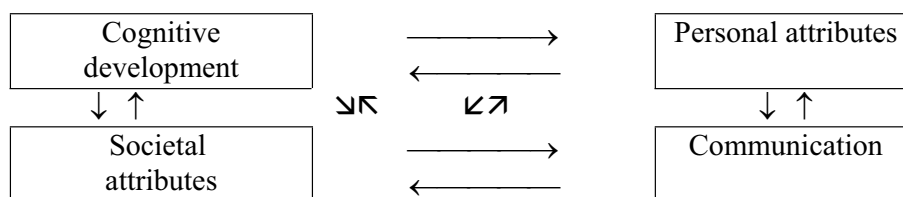
Our school needs today as well as in future the balanced science curricula. Any curriculum of science education should consist of three components including relationships between these components (see figure 2).



**Figure 2. The model of balanced science (Benchmarks for Science Literacy, 1993)**

Nobody can understand science without understanding the history of science, psychology of scientific discoveries, language of science, methods of scientific research and social aspects including entrepreneurship.

In addition to the above mentioned balances, we see the balance between all educational goals (cognitive development, personal attributes, societal attributes and communication) signifying the curriculum intention in the framework of the formation of STL and between educational components (creativity, analytical and critical skills, evaluative skills, social skills, communicative skills, mathematical skills, learning skills). Compiling the balanced curricula for science education should begin from establishing the balance between educational goals aimed by the formation of STL. Science education is achieving educational goals through a context of science. This is put forward as a very important deviation from goals of science education that are seen as putting forward science education as simply a body of knowledge (Holbrook, 1999).



**Figure 3. The model of balanced goals for the formation of STL**

In different national standards of compulsory education we can see very different approaches to weighing the importance of education goals. J. Holbrook and M. Rannikmäe, summarizing the experts opinions on the importance of the objective areas, bring out the following numbers (Holbrook, Rannikmäe, 2000) :

Intellectual (cognitive)	–	45 %
Communicative	–	20 %
Social and Moral	–	10 %
Personal and Physical	–	15 %
Aesthetic	–	10 %

From the national standard for compulsory education of Latvia we find that communicative, social and evaluative (moral and aesthetic) skills have in science education, especially in teaching physics and chemistry only a little value (National Standards of Compulsory Education, 1998). These are such general abilities and skills the development of

which should be paid attention to, but which is not the main task of the given subject. Opposite to these objective areas the experts evaluate highly analytical and critical skills in teaching science. The last point of view agrees entirely with the above mentioned experts opinions referred by J. Holbrook and M. Rannikmäe. It is obvious that most post-socialist countries should raise the role of communicative, social and evaluative areas in science curricula and syllabi.

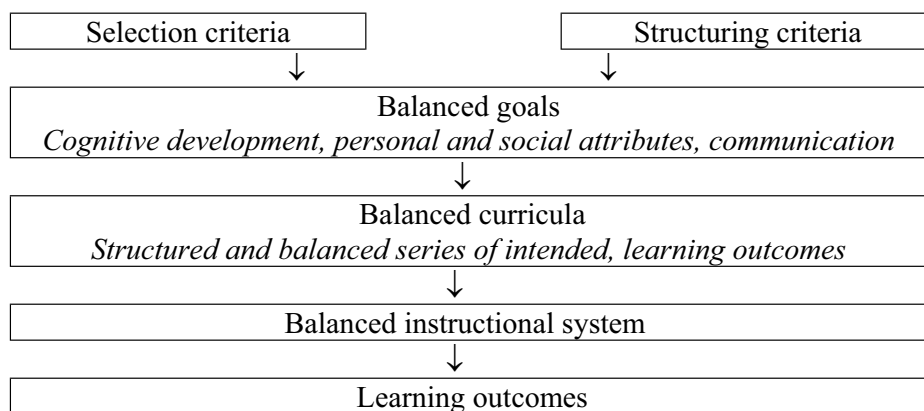
Acquiring communicative skills means the ability to communicate using verbal, written, tabular, symbolic or graphical forms. The formation of communicative skills is usually considered as a problem of teaching languages. However, chemistry has its own special language of symbols, formulae and chemical equations, the role of the communicative skills among the goals and content of chemistry teaching is much more important than is described in science curricula. The language of chemistry has its own syntax, semantics and pragmatics, too. In addition to acquiring the symbols, formulae and chemical equations (to read, write and understand) every student should be able to use the periodic table of elements, the table of solubility, activity series of metals; every student should be able to describe graphically experimental data about solubility, energy changes, etc.

Cognitive development is the ability to think conceptually, plan study and the ability to make rational and independent decisions. Every 8<sup>th</sup> grade student should understand and explain the difference between atoms and ions, pure substances and mixtures, physical and chemical changes, oxidation and reduction, oxides, acids, bases, salts, etc. Every 9<sup>th</sup> grade student should understand and explain the nature of energy changes occurring concurrently in different chemical processes including burning, dissolving, breathing, decaying, fermentation, corrosion, etc.

Personal attributes are creativity, ingenuity, perseverance as well as initiative, reliability and positive attitudes. To the personal attributes belongs the ability to take into account the properties of the substances as well as the peculiarities of chemical processes in everyday life for improving dietary, leisure, etc.

To social attributes belong abilities to identify and cultivate ethical values, a concern for the community, to develop general social skills. From point of view of chemistry teaching acquiring the societal attributes shows that the students understand the role of producing and practical applications of different natural resources such as air, water, metals, fuels, for sustainable development of society.

Implementing the balanced curricula and syllabi demands the compiling of the balanced instructional system including balanced strategies and methodology for teaching science. Restructuring a model of the relationship between curriculum and instruction in a technical approach (Sowell, 1996) we offer the following model (see figure 4) for compiling the balanced instructional system.



**Figure 4. A logic of constructing the balanced instructional system of science education**

The main thesis of balanced instructional system should include (Zoller, 2000):

- interdisciplinarity as a core element in teaching science;
- formation of higher order cognitive skills;
- alternative assessment methodology.

## Summary

We consider the ideal paradigm of science education today as well as in future the teaching balanced science according to balanced curricula in strongly social context based on psychological and didactical treatment. There should be a balance between governmental and non-governmental, formal and informal education, between subject oriented and student oriented teaching, algorithmic and non-algorithmic activities. In addition to these balances we see the balance between all educational goals (cognitive development, personal and societal attributes and communication) signifying the curriculum intention in the framework of the formation of STL and between educational components (creativity, analytical and critical skills, evaluative skills, social skills, communicative skills, mathematical and learning skills). Compiling of the balanced curricula for science education should begin from establishing balance between educational goals aimed by the formation of STL.

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## Резюме

### **НАУЧНО-ИССЛЕДОВАТЕЛЬСКАЯ РАБОТА, НАПРАВЛЕННАЯ НА СОЗДАНИЕ СБАЛАНСИРОВАННЫХ УЧЕБНЫХ ПЛАНОВ ДЛЯ ЕСТЕСТВЕННОНАУЧНОГО ОБРАЗОВАНИЯ**

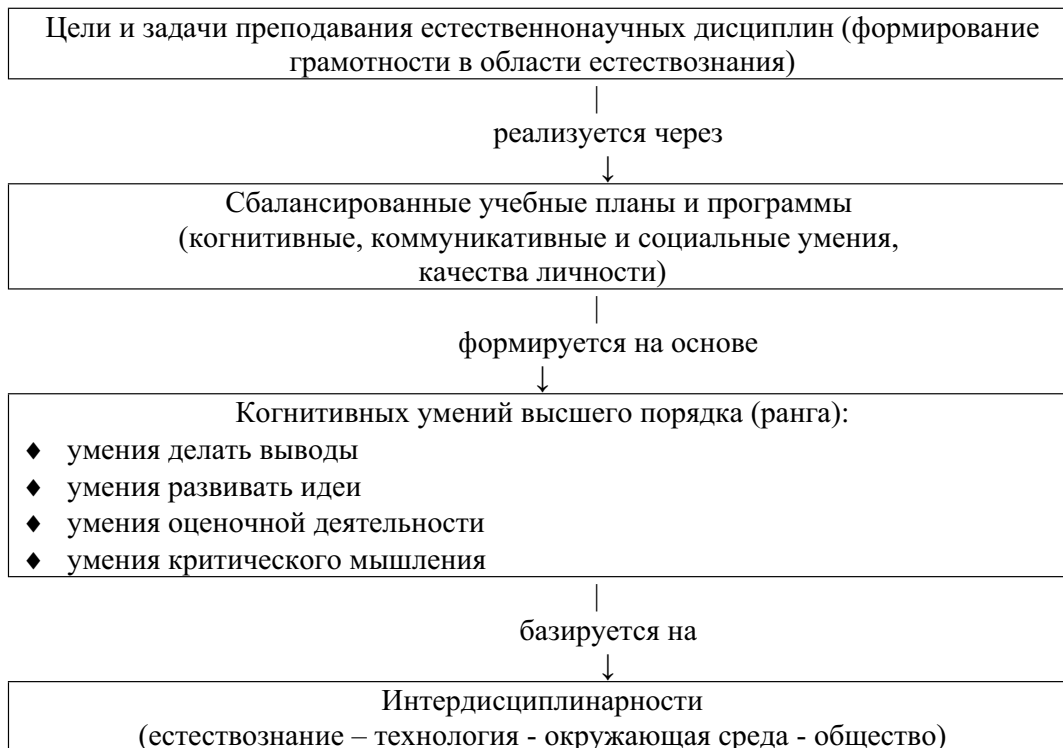
**Аарне Тыльдсепп, Вилья Тоотс**

Решение всех проблем, связанных с преподаванием естественнонаучных дисциплин в новом столетии требует, в первую очередь, серьёзных научных исследований в двух направлениях:

- ◆ как развивается общество и требования, предъявляемые им к молодому поколению, и,
- ◆ как развивается педагогическая наука.

Естественнонаучное образование должно быть организовано так, чтобы учащиеся после окончания школы нашли себя во всех областях личной и общественной жизни, также, чтобы они получили полное удовлетворение от пройденных дисциплин, также, чтобы содержание и методы обучения естественнонаучным дисциплинам соответствовали их ожиданиям и требованиям общества.

Идеальная модель (парадигма) процесса преподавания естественнонаучных дисциплин, по нашему мнению, выглядит так:



**Ключевые слова:** сбалансированный учебный план, естественнонаучная и технологическая грамотность, цели образования, компоненты образования.

*Received 6 December 2002; accepted 15 January 2003*

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