Socrates - Comenius 2-1-2006-1
Improving Quality of Science Teacher Training
in European Cooperation - constructivist approach (IQST)

EUROPEAN DIMENSION IN INTEGRATED SCIENCE EDUCATION

Training material for students

Olomouc 2008

UDK

Authors

Vincentas Lamanauskas
Margarita Vilkonienė

The contents of units, summaries, FAQ, next readings, lists of references are prepared by Vincentas Lamanauskas
The objectives of units, tasks, case studies and questions to the case studies are prepared by Margarita Vilkonienė

Reviewers

Prof. RNDr. Danuše Nezvalová, CSc., Palacky University in Olomouc, Czech Republic
Dr. Laima Railienė, Siauliai University, Lithuania

This material was printed with the support of the European Community in the framework of the Socrates – Comenius 2.1 scheme under the project No. 128747-CP-1-2006-1-CZ-Comenius-C21.

First Edition

ISBN 978-80-244-???

CONTENTS

Unit 1

A Conception of Integrated Science Education

Objectives:

- To have a look at the evolution of the integrated teaching idea;
- To define the essential elements of integrated science education.

Depending on the adopted criteria, integration has never remained to be identical. The process itself was known in didactics long time ago and was used for training by the famous classics of pedagogy such as Komenský, F. A. Dysterveg, J. Lock, etc. B. Kedrov maintains in his description of the evolution of natural sciences that since the outset of the 20th century, "… two converse tendencies of natural sciences evolution appeared: one was famous for its resolution, embranchment and differentiation of sciences, the other– on the contrary, was seeking to combine the isolated sciences into a single system of knowledge, i.e. integration…" (Kedrov, 1967).

The various ideas of integration spread out in Europe and North America pretty late after the World War II. The very first educational projects of integrated natural sciences were conceived in Great Britain. Later, teaching integrated natural sciences was distributed into the schools of the Netherlands and other continents including Australia, Asia, etc. New projects were developed: Biological Sciences Curriculum Project, Elementary Science Study, etc. (Charles B. Klasek, 1972).

The integration issues of natural sciences have been a field of interest for many scientists from various countries. Thomas R. Koballa, Lowell J. Bethel (1985) paid close attention towards the integration of natural sciences into the other educational subjects. H. Cohen and F. Staley (1982), R. Francis (1996) and other scientists were trying to prove the meaning of natural sciences and mathematics integration. Judah L. Schwartz and Jerrold R. Zacharis (1977) additionally supplied the integration method with the science of technology. They supposed there would not be possible without the formation of the con-

cept of modern technologies. A. Glatthorn and A. Foshay (1981) were interested in the issues of launching integrated teaching programs. Arthur A. Carin and Robert B. Sund (1989) paid much attention to contemporary teaching of natural sciences. They tried to define contemporary natural science as a subject as well as considered the question how to integrate the subjects of natural sciences into the other subjects, how to individuate the educational process, how to apply the latest technologies (for instance, micro computers, etc.). Other researchers focused on the problems of the integrated curricula/syllabuses. The following main points can be underlined:

- the integrated curriculum must strengthen and reinforce existing student knowledge in a given area (Gunston, 1985; Jacobs, 1989);
- the integrated curriculum must extend student understanding into new areas, student need to participate in activities which allow them to grow and to learn (Underhill, 1994; Abraham, 1989; Francis, 2001; Šapokienė, 2001). Teaching on the integrative base is one of the tendencies of modern primary school (Korozhneva, Melnik, 2003);
- the curriculum must make the connection to the real world. It directly influences the child's motivation to learn. (Fogerty, 1991; Lamanauskas, 2001);
- thinking in terms of integration is generally difficult for teachers (Lang, 2001, p.132), at the same time they don't fully understand the process of integration and this limits their opportunities in realizing the integrative way of teaching in primary schools (Lamanauskas, 2001; Korozhneva, Melnik, 2003). Nevertheless, primary natural science education has to be purposefully implemented on the basis of integration (Akvileva, Klepinina, 2001).

In addition, integrated natural science education is examined in the context of the ideas of constructivism. A basic premise of constructivism is that knowledge is not passively received but developed as students construct their own meanings (Treagust, 1996). Teachers who valued their students existing ideas` and attempted to link learning to them (i.e., using a constructivist premise about learning) were more able to make relevant links and transfer of skills across curriculum areas. They were more likely to involve integration as a framework in their teaching (Waldrip, 2001). According to Bentley and Watts, learning is always an interpretative process involving individuals` constructions of meaning. New constructions are based upon previous experience and prior knowledge (Bentley, Watts, 1994, p. 24).

Tasks (assignments)

1. Draw a chart showing the evolution of the idea of integrated science education (chronologically indicate the evolution of the idea of integrated science education).
2. Enumerate the essential elements of integrated science education.
3. Outline the objectives of Integrated Science.

Case study

A teacher *N* of a school *XXX* teaches physics, always searches for different forms of work and frequently makes original decisions. Sometimes, the classes given by the teacher involves more than the taught subject, for instance physics/chemistry, physics/biology or physics/physical education and physics/music. The students enjoy such lessons as they find them easier, funnier etc.

Questions to Case Study

1. What is your opinion on the possible problems that can be encountered by the above mentioned teacher who prepares for non-traditional lessons?
2. Why are the above mentioned lessons favourably evaluated by the students? What are the ways of having benefit from the situation?

Summary

The experience of teaching integrated natural sciences is enormous. The ideas of integrated education spread out over the schools of Europe and the North America in 1960 – 1970. The first projects of the similar method of teaching were set up in Great Britain: Nuffield Secondary Science, Scottish Integrated Science, etc. Later, such projects as "Improvement of the Curriculum of Natural Science Subjects" and "Natural Sciences – Society – Technologies", etc. were established in the U.S.A. The models of integrated natural sciences teaching carried a character of the experiment the results of which were thoroughly assessed.

A primary purpose of integrated natural science education is the construction of the whole world picture, the development of the child's world outlook and intense correlation with an environment, the fosterage of affective experience. In this case, integration helps to avoid resolving educational content into related /or loosely related fields that expand the child's world picture.

The integration of natural science education with other educational subjects should present pupils the knowledge of natural sciences as well as the material produced in the textbooks and workbooks that are linked with the current affairs of school, with the customs and traditions of the schoolchildren and their relatives of the inhabited locality. The closest natural objects such as the park, forest, lake, mound, etc. are not out of the way. Hereby, the learners are encouraged to show interest in an environment of their inhabited locality, are stimulated to know more and more, their thoughtful evaluation of nature is developed, etc. Integral natural science education requires a different approach to the educational process itself.

Frequently Asked Questions

What is the main point of integrated science education?

Science education is an integral phenomenon that can be grasped as a whole science. It is disintegrated in the substantial parts such as ecology, envi-

ronment education, etc. The parts of any of the units advance and finally settle in the complete wholeness. In order to understand the problems of science education, they have to be investigated complexly embracing different fields and levels.

What will you consider as a classical definition of Integrated Science?

There are many classical definitions of Integrated Science which you may find in many advanced books.

Next Reading

Adeniyi, E. Ola (1987). Curriculum Development and the Concept of "Integration" in Science - Some Implications for General Education. *Science Education*, Vol. 71, No. 4, p. 523-533.

Duit R. (2007). Science Education Research Internationally: Conceptions, Research Methods, Domains of Research. *Eurasia Journal of Mathematics, Science & Technology Education,* 3(1), p. 3-15. Available via Internet: http://www.ejmste.com/v3n1/EJMSTEv3n1_Duit.pdf

Gedrovics J. (2000). Subject integration – goal or tool? In.: *Today`s Reforms for Tomorrow`s School`s* (ATEE Spring University). Klaipėda, p.76-80.

Hodson D. (1992). In search of a meaningful relationship: an exploration of some issues relating to integration in science and science education. *International Journal of Science Education*, Volume 14, Issue 5, pages 541 – 562.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Lamanauskas V. (2007). Science Education as a Core Component of Educatedness. *Problems of Education in the 21st Century (Science Education in a Changing Society)*, Vol. 1, p. 5-6.

Lamanauskas V. (2007). Modern science education as investment to the future. *Journal of Baltic Science Education*, Vol. 6, No., 1, p. 4.

Riquarts, K. Hansen, K. Henning. (1998). Collaboration among teachers, researchers and in-service trainers to develop an integrated science curriculum. *Journal of Curriculum Studies*, Volume 30, Number 6, 1 November, pp. 661-676.

Wellington, J. (1996). *Secondary Science. Contemporary issues and practical approaches*. London and New York.

References

Abraham Shumsky. (1965). *Creative Teaching in the Elementary School*. New York.

Arthur A. Carin, Robert B.Sund. (1989). *Teaching Modern Science*. Merrill Publishing Company.

Charles B. Klasek. (1972). *Instructional Media in the Modern School*. Professional Educators Publications.

Cohen H., Staley F. (1982). Integrating with Science: One Way to Bring Science Back into the Elementary School Day. *School Science and Mathematics*, Vol.82, P. 560-570.

Bentley D., Watts M. (1994). *Primary science and technology. Practical alternatives*. Buckingham*Philadelphia: Open University Press.

Glatthorn A., Foshay A. (1991). Integrated Curriculum. In.: *The International Encyclopedia of Curriculum*, P. 160-161.

Fogerty R. (1991). Ten ways to integrate the curriculum. *Educational Leadership*, 49(2).

Francis R. A Procedure for Integrating Math and Science Units. *School Science and Mathematics*, Vol.96(3), p. 114-119.

Jacobs H.H. (1989). The interdisciplinary concept model: theory and practice. *Gifted Student Quarterly*, Fall.

Koballa T.R., Bethel L.J. (1985). Integration of Science and Other Subjects. Research Within Reach. *Science Education*.

Korozhneva L., Melnik E. (2003). The integrative approach to studying of natural sciences in primary school. In.: *Importance of Science Education in the Light of Social and Economic Changes in the Central and East European Countries* (The materials of the IV IOSTE symposium for Central and East European Countries). Kursk, p. 118-119.

Lang M. (2001). Teacher professionalism and change: developing a professional self through reflective assessment. In. H. Behrendt, H. Dahncke, R. Duit et al. (eds). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers, p.131-136.

Lamanauskas, V. (2001a). Gamtamokslinis ugdymas pradinėje mokykloje /Pasaulio pažinimo didaktikos pagrindai/. Šiauliai.

Schwartz J. L., Zacharis J. R. (1977). *Science, Mathematics and Technology: Recognizing the Quantitative Arts*. National Elementary Principal, p.87.

Šapokienė E. (2001). *Mokykla+aplinkotyra=VIOLA*. Utena: "Utenos Indra".

Treagust D., Gräber W. (2001). Teaching chemical equilibrium in Australian and German senior high schools. In. H. Behrendt, H. Dahncke, R. Duit et al.

(eds). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers, p.143-148.
Waldrip B. (2001). Primary Teachers` Views About Integrating Science and Literacy. *Australian Primary and Junior Science Journal*, Vol.17, Issue 1.
Underhill R. G. (1994). Editorial: What is integrated mathematics and science? *School Science and Mathematics*, 94, 1.
Аквилева Г. Н., Клепинина З.А. (2001). *Методика преподования естество-знания в начальной школе*. Москва: Владос.
Кедров Б. М. (1967). *Предмет и взаимосвязь естественных наук*. Москва, С. 302.

Unit 2

Some Philosophic, Didactic and Social Aspects of Integrated Science Education

Objectives:

- To find out the impact of the well-known philosophical trends on education of the 20th century and to discover how those promoted the ideas of integrated science education.
- To learn how integrated science education affects the processes of students' socialization;
- To analyze and understand the main problems of natural science education in terms of pedagogy;
- To motivate the qualities of natural science education in terms of the constructive aspect of teaching/learning.

Philosophic aspects

One of the most important fields of training is natural science education, the models of which differ in practice and theory of pedagogy. The most relevant problems are integrated natural science education, the development of children's spirituality in nature, individual education, group work in the classes of science subjects, the possibilities of implementation the reformation ideas of sciences teaching, their search and conditions, etc.

A fundamental attribute of antiquity is the perception of the wholeness of the world. Education looses its versatility in the Middle Ages when dualism takes a prevailing position. Dissolution starts in the 15th – 16th centuries. The epoch of renaissance obtains predominating comprehension of the antique world the basis of which is the experiment (F.Bacon). The settled objective understanding of the Age of Enlightenment (middle of the 18th century – end of the 19th century) looses its previous significance today. We again are back to the whole cognition. According to Z.Gelman, the purpose can be achieved only

through the prism of science of culture. The basic task is to raise the awareness of the harmony of the world, and therefore the role of integral processes at school is extremely important as holistic essential visuals are embodied here (Gelman, 1991). Gelman supposes that the end of the 20th century – the beginning of the 21st century is an epoch of integration.

Different trends have formed considering a question of integrated teaching in foreign pedagogy: technocratic, pragmatic, cognitive, humanistic, etc.

W.Gräber and other scientists (2001) maintain that science teaching can be described in three dimensions:

Teacher centred – student centred
Teaching facts – teaching processes
Discipline oriented – daily-life oriented

Therefore, the education of the 20th century has mainly be influenced by neotomism, pragmatism, existentialism and other philosophic trends.

Social aspects

The reconstruction of the content of sciences teaching reveals the relevancy of pupils'cognitive activities organization. One of the suitable forms of teaching is group work that is useful for bright and weak pupils and pedagogically important when combining learners'teaching and upbringing into a single process. Facilities for group work must be provided during practice, laboratory work and other kinds of practical activities.

Considering the specificities of pupils'age and the peculiarities of cognitive material, it is necessary to heighten the sense of individual responsibility for learning, to help with practise of the skills of personal work, to fulfil a responsibility for the knowledge and actions of yourself and other members of the group (for example, group work).

The socialization of the personality is also notable in the process of natural science education. Some authors maintain that integrated natural sciences teaching is obligatory when we discuss the socialization of personality. According to J.Gedrovics and I.Wäreborn (1999), integration in science teaching may be necessary, if we want to reach some other goals, such as the socialisation of a student to promote his/her incorporation in the society.

Didactic aspects

In terms of philosophy, integration is the intensification of the correlation, the combining of separate elements into the wholeness. However integration at school level is differently understood.

Three burning issues of didactics become pronounced along the integration of natural sciences:

- integrated subjects change (structure, tasks, the logics of a subject, the complex of concepts, etc.);
- methodological means reach a higher level;
- the format of teachers and pupils' activities and that of teaching-learning alterates. How can it influence the process of teaching/learning?

Only having solved the mentioned problems, a certain level of the completeness (knowledge, information, etc.) will be achieved. For example, if the knowledge of physics is demonstrated at molecular level and that of chemistry – at atomic or ionic levels, an integral correlation between these subjects will be weak. From a didactic point of view, the most important ideas are as follows: what are the possibilities to apply the model of integrated natural sciences teaching in school practice; how it can be achieved under the circumstances of the present situation; what is the level of the integration of natural sciences, etc.; what are the main differences between integrated and linear teaching/learning of natural sciences; does integrated natural sciences' teaching help the pupil to perceive the outward things. The move to integrated teaching abundantly changes the process itself. Will integrated natural sciences teaching really develop and strengthen children's intelligence and abilities to realize and accept the changed content of teaching? Won't the process disorganize their normal development (for example, along with integration a degree of abstraction increases) and help to stay efficient? Such questions are raised bearing in mind that ***formal*** and ***informal*** integration of natural sciences is noticed. Trying to implement informal integration, primarily the affinity of all science subjects (physics, chemistry, biology) need to be distinguished, i.e. goals, teaching/learning conditions, the opportunities of practical work, concepts, etc. have to be classified. In other words, integrated natural sciences teaching is possible up to the degree and volume which leave the learner's system of natural science knowledge undisturbed.

Table 1. The key issues of integrated natural science education

General didactic and methodic integration of teaching	The system of the categories (concepts) of the integrated educational course	The essence, forms, principles and functions of integrated teaching	The consistent patterns of integration processes
The forms, stages and trends of teaching and educational process integration	Theoretic reasoning of the significance and opportunities of integrated teaching	The consistent patterns and models of applying integrated teaching in school practice	The integral results of teaching/learning and their evaluation

Pedagogy literature stresses that the integration of natural sciences needs all possible preconditions such as:

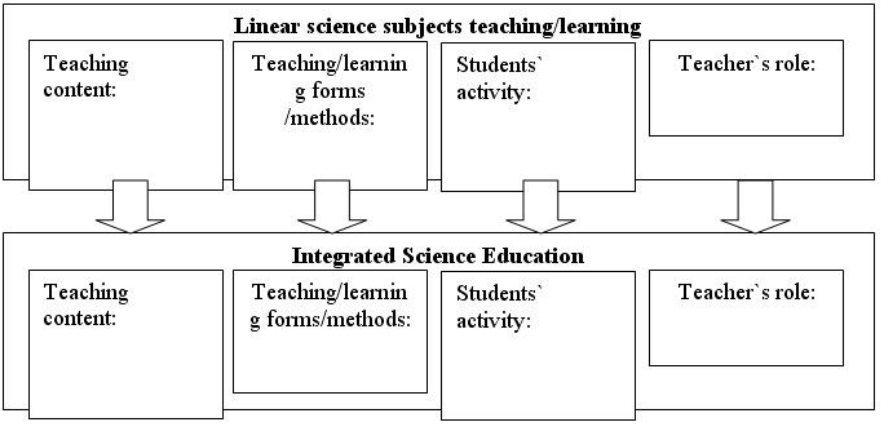
- the general principles of the structure of subjects (for example, chemistry, physics, biology);
- general laws and consistent patterns;
- general concepts, definitions etc.;
- the general didactic conditions etc. of integration;
- similar methods and forms of teaching, etc.

Tasks (assignments)

1. Fill in the table:

	10-14 years	15-16 years	18-19 years	20-21 years
Peculiarities of the world study characteristic of the period				
Peculiarities of the world study under the influence of trends				

2. Use the provided sources of information to describe philosophical trends presented in the table. Emphasize the impact of the above introduced philosophical trends on promoting the idea of integrated science education.
3. Explain the impact of integrated science education on the processes of students' socialization.
4. Define the main didactic problems of integrated science education.
5. Complete the scheme indicating how the content of science education changes in the process of replacing the linear educational strategy with the integrated one.



Case study

An integrated lesson of science introduces the students an everyday phenomenon – a car suddenly stops on the roadway. The learners work in groups, every group examines the situation from a different angle (physics, chemistry, environment protection) and the end of the lesson, presents its work

results and arrives at conclusions. The students ask questions about the topic they deal with. Discussions between the groups are sometimes possible.

Questions to Case Study

1. Do you think this case of integrated science education corresponds to the essential elements of constructive teaching/learning? Use 3-5 propositions to motivate your position.
2. What is the role of teacher in this particular lesson?

Summary

The issues of integrated natural sciences teaching should be complexly discussed. ***The system of personal values – theoretic and practic knowledge of the personality – practic skills of the personality*** is an undivided system closely interrelated and functioning only through specific, intensive, practical activities of a personality.

Evidently, the integrated natural science course helps pupils to convey the whole (***holistic***) world picture that encourages to easier realize the issues of ecology, nature (environment) protection, the implementation of modern technologies, etc., to link outcomes with reasons, obtained knowledge with sociocultural life.

Integration should not be only formal (mechanic) combination of a few related natural science topics. A nominal coherence of knowledge does not allow to reach the level of the wholeness, i.e. the synthesis of knowledge.

An important point is that integrated/integral teaching should be optimal as schoolchildren most frequently arrive at a single-sided understanding of the basic laws of nature, the structure and qualities of substances, etc. and answer the questions in different ways (agreeably to the subject).

Frequently Asked Questions

Why the teaching and learning of natural sciences are so important in comprehensive school level?

It could be acknowledged that natural sciences, according to their specifics, play a very important role in broadening pupils' world outlook. Science subjects, such as biology, physics, chemistry, etc. are taught at school. These subjects theoretically and empirically examine the world of experience – reality: nature that surrounds pupils, technical and human being who is a part of nature. All these objects, things, descriptive and motivated relations of science subjects are researched and explained by natural sciences and can always be checked and practically proved. Herewith received and made conclusions are correct and have not any doubts…The science classes always discuss real, concrete things and phenomena which are a part of pupils' reality and even every day life...

…A weak position of natural sciences in the development of pupils' world outlook is the disunity of the sciences but not imagination or empiric experience (their strength is exactly here).

(*According J. Vaitkevičius, 1999*).

Next Reading

Cobern, W. (1998). *Socio-Cultural Perspectives on Science Education*. Dordrecht: Kluwer.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Matthews, M. R. (1994). *Science Teaching: The Role of History and Philosophy of Science*. Routledge, New York.

Nola, R. (1997). Constructivism in Science and in Science Education: A Philosophical Critique. *Science & Education,* 6(1-2), p. 55-83.

Sjoberg, S. (2001). Why don't they love us any more? Science and Technology Education: A European high priority political concern! Pp. 19-21. Psillos, D., Kariotoglou, P., Tselfes, V., Bisdikian, G., Fassoulopoulos, G., Hat-

zikrnaiotis, E. & Kallery, M. (Eds.) *Science Education Research in the Knowledge Based Society*. Proceedings of ESERA in Thessaloniki.
Smolicz, J.J., & Nunan, E.E. (1975). The philosophical and sociological foundations of science education: The demythologizing of school science. *Studies in Science Education*, 2, p. 101-143.
Solomon, J. &, Aikenhead, G, (Eds) (1994). *STS Education: International Perspectives on Reform. Ways of Knowing Science Series*. New York: Teachers College Press.
Terhart, E. (2003). Constructivism and teaching: a new paradigm in general didactics? *Journal of Curriculum Studies*, 35(1) 24-36.
Wheatley, G.H. (1991). Constructivist Perspectivists on Science and Mathematics Learning. *Science Education*, 75(1), p. 9-22.
Ziman, J. (1984). *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press.

References

Gedrovics J., Wäreborn I. (1999). Integrationssträvanden inom naturvetenskapling undervisning. *Nordisk Pedagogik*, Vol.19, Nr.2, p.130-137.
Gräber W., Nentwig P. et.al. (2001). Scientific literacy: from theory to practice. In. H.Behrendt, H.Dahncke, R.Duit et al. (eds). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers, p. 61-70.
Vaitkevičius J. (1999). Pasaulėžiūros formavimas dėstant gamtos mokslų ciklo dalykus vidurinėje mokykloje. Kn.: *Gamtamokslinis ugdymas bendrojo lavinimo mokykloje* (V respublikinės mokslinės konferencijos straipsnių rinkinys). Vilnius: Žaliasis pasaulis, p. 108-112.
Гельман З. (1991). Интеграция общего среднего образования на базе идей истории науки и культуры. *Вестник высшей школы*, №11, С. 21-23.

Unit 3

The Main Tendencies of Integrated Science Education Development

Objectives:

- To analyze the reasons determining the need for integrated science education;
- To identify the basic terms describing the integration of sciences;
- To perceive integrating the content of subjects as the most efficient way of integration offering possibilities, advantages and links with the principles of constructivistic teaching/learning?

Complex knowledge, its application for a certain activity becomes a crucially important object for the various fields of the man's life. Integrated education should decrease the objections between the knowledge gained from the teaching subjects and the necessity and inevitability of their synthesis. The presentation of content only (knowledge, information, etc.) is not a core of teaching.

What are the main reasons that determine the need of teaching integration? They are diversely described by pedagogy literature. J. Rimkutė and E. Motiejūnienė (1993) point out the following arguments:

- the integration of natural sciences (there are more and more fields of research combining traditional subjects (physics, chemistry, biology) and the modern branches of science such as biochemistry, biophysics, biogeochemistry, astrophysics etc.);
- the undividedness of the world and the knowledge of it (individual traditional subjects of biology, physics and chemistry reflect the theoretic structure and evolution of science, have no close links with the learner's daily life, his/her interests outside school);

- the implementation of new technologies (a broad background is requisite for working people of a number of the areas of production and service);
- ecology issues (integrated education will help to perceive the correlation between animate and inanimate nature and to adopt the approach to the environment based on ecology culture);
- the need of the correlation between education content and a socio-cultural life (natural science knowledge related to a social and cultural life and science history of Lithuania and the world is very important to the process of fostering personal and value-based attitudes).

Raja Roy Singh (1993) has examined the education issues under the circumstances of the rapidly rotational world and distinguished the succeeding reasons:

- the enlargement of the radius of knowledge the basis of which is automatic communicative technologies;
- the growth of the world's interdependence (globalization);
- global problems and the obligation to find decisions;
- need to anticipate education to the most advanced (front) cognition (science), i.e. to get schoolchildren acquainted with various subjects, to seek to develop interdisciplinary skills and abilities in order to identify and clarify the problem and to effectively apply gained knowledge and skills to solve it, etc.);
- a direct correlation between teaching and global questions (the application and development of problematic integrated teaching, etc.).

I. Suravegina and R. Ivanova (1990) indicate the ensuing reasons of integration: 1) the necessity to concentrate attention in order to know the wholeness; 2) the opportunity for pupils to choose the subjects considering their interests; 3) a need to decrease the number of individual educational subjects at every stage of teaching. On the basis of the papers of other researchers, A. Blum (1994) identifies the following main reasons: 1) the boundaries of different subjects constantly change, and therefore new subjects appear (for example, biochemistry, bioengineering, etc.); 2) integrated natural sciences teaching increases the transformation of teaching, i.e. the learners easier notice an intrinsic correlation among notions, principles, concepts; 3) children cannot logically study the same subject that is scientifically framed. The structures of knowledge acquisition and spread are similar to those of physics and biology; 4) the

integrated course of natural sciences affords an opportunity for the teachers of different subjects to plan and teach together as then they can feel more relaxed and less tired, their cooperation rises up. Some educologists of the USA notice (Collins, 1994; Frederiksen, 1994; Stodolsky, 1988) that:

- knowledge acquired at school is perceived using a pattern that is digressed from the methods applied to use information to solve the problem;
- the correlation between obtained knowledge and life is weak (efficiency, scholasticism etc., is insufficient).

Scientific literature suggests such concepts as ***integration variants*** (Paulauskaitė, 1994), ***integration types*** (Case, 1991), ***integration forms*** (Beitas, 1995), ***integration varieties*** (Bagdonas, 1994; Pečiuliauskienė, 1992), ***integration method*** (Salite, 2000); ***integration approach*** (Chepelev, 2003). The above information confirms that we use different concepts in the discussions on the same subjects, and therefore there is plenty of confusion and lack of a uniform concept. Finally, a thick accent should be put on the efficiency of integrated teaching. If it is not effective under specific circumstances or do not correspond to the requirements of training, the approaches to natural sciences teaching can be definitely diverse.

Hence:

- the experience of integrated teaching is diverse and rich;
- experience is personal in every country - history, practice and experimentation etc. S. Sjøberg notices that many countries have introduced more or less radical reforms, and there has been support for curriculum development and experiment (Sjøberg, 2002);
- there is no country, the experience of integrated teaching of which should be extremely advanced and the most efficient;
- the major task is to find out the essential factors that crucially influence the efficiency of natural science education and the circumstances preventing from successful integrated teaching. One of the most frequently named aspects – a professional competence of natural science teachers (Lamanauskas, 2003b; Pak, Solomin, 2003);
- two competing paradigms are obvious:

- the interception of the experience of other countries needs a thorough analysis;
- the teachers of natural sciences should constantly be engaged in the innovations of natural science education and conditions for that should be established. Finally, the concept of integrated teaching of every teacher is unique. Thus, the best way out is the cooperation of natural science teachers when planning and introducing integrated curricula. Research reveals that the main differences exist in the city site school and that of the rural area. According to K. Tobin, W. M. Roth and A. Zimmermann (2001) teaching in urban schools, with their problems of violence, lack of resources, and inadequate funding, is difficult /it is even more difficult to learn to teach in urban schools/.

All over the world, educators and scientists have joined forces to produce different integrated programs such as the Biological Sciences Curriculum Study (BSCS), the Chemical Bond Approach (CBA) and CHEM Study program in chemistry, Physical Science Study Committee (PSSC) and Harvard Project Physics (HPP) and the Earth Science Curriculum Project (ESCP) etc. It is clear that not all these programs made identical success. Despite of this realization in a school practice of the different integrated programs there was a bright promotion in didactics of science teaching.

It is clear that the most important and relevant goal of science education is to prepare young people for a full and satisfying life. According to A.Toldsepp (2003) we need to implement future oriented paradigm of science education (figure 1).

There were three main waves of science education reforms (De Jong, 2007).

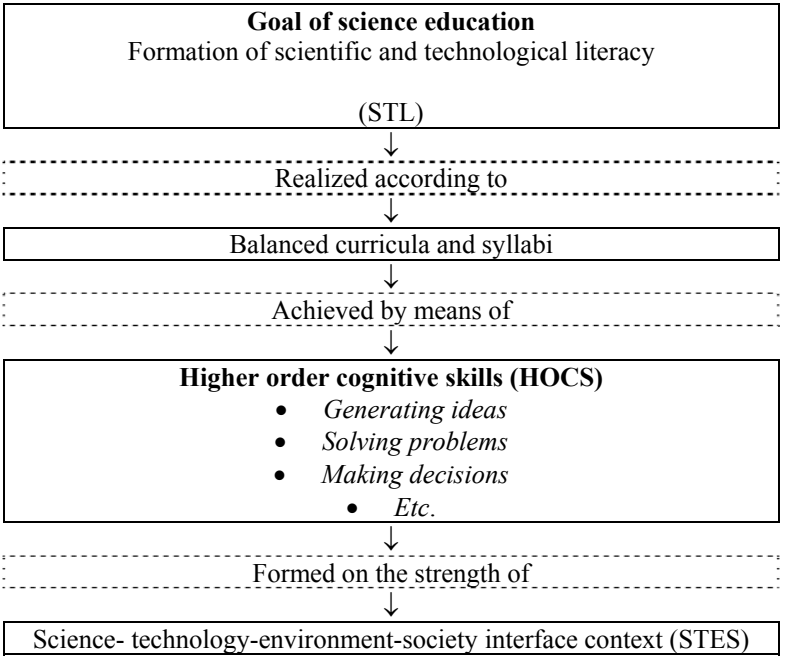


Figure 1. Future oriented paradigm of science education (Toldsepp, 2003)

Table 2. Science education reform and influential psychological theories

Wave of reform	Influential theory that shapes curricula and courses	Issue of growing interest
* 1960s	* Descriptive behaviourism * Stages of cognitive development	* Programmed instruction * Sequence of science topics
* 1980s	* Guided discovery learning * Information-processing perspectives	* Lab work for school students * Learning cycle
* 2000s	* Social constructivism * Socio-cultural perspectives	* Students' ways of reasoning * Role of context and language

After 1990 special interest to integration of science subjects has arisen in the countries of Central and Eastern Europe. It has been closely connected with the begun reforms of education systems. It is obvious that science education is currently going through a process of change worldwide.

Tasks (assignments)

1. Use the presented material to identify separate areas under the indicated topics grouping the reasons determining the necessity of integrated science education:

Reasons determined by changes in teaching content	**Reasons determined by the process of teaching/learning**	**Social/socio-cultural reasons**

2. Use the offered literature to define the following terms:

Term	**Definition**
Integration types	
Integration forms	
Integration method	
Integration approach	

3. Try to express a personal opinion to define the core of integrated science education, for instance, *Why is it required? What are the ways of implementation? etc*.
4. Briefly discuss the development of integrated science teaching in Europe from the 1990 until now.

Case study

Every part has unique experience in this field: an intended different level of integration at different education stages, varying intensity of educational content, different forms and methods of integration etc. However, some common points exist. Recently, ecological education is frequently integrated in different subjects, for example, the above mentioned integration of content. Use the documents regulating the content of education in comprehensive schools (curricula, education standards etc.) as well as other major tools for science education (course books, work books etc.) to analyze the situation of integrating the content of ecological education into general education in your country.

Questions to Case Study

1. What is the stage and which are the subjects containing the major part of indications of ecological educations? What is the stage and which are the subjects having the highest intensity? Point out the reasons.
2. How does the examined integration of subject content influence the quality of the educational process and the results of self/education?
3. Find the links between the integration of the content of ecological education and the principles of constructivistic teaching/learning?

Summary

Natural sciences closely correlate; their content reflects a united reality. These points cannot be isolated from one another in the educational process. On the contrary, their interaction should be encouraged and only then the efficiency of the educational process will equally increase. Physics and chemistry as well as biology research describe the phenomena taking place in nature.

From this viewpoint, their interpretation is supposed to be similar in order pupils should get a solid concept of natural phenomena.

Along with the integration of teaching content, the conveyance of the holistic view of the world, the application of training aids and methods to the level of pupils' development (without respect of age), teaching pupils to systematize and implement interdisciplinary relations, etc. are very important to education. Different patterns of integrated teaching/learning exist. A promising method (particularly in primary school) is when the content of natural science education is integrated into each educational subject in all forms. At last, the life of an exact school community may have a natural science context (various projects, community environment protection education, practic environment protection work, etc.).

Frequently Asked Questions

What is important from the historical point of view?

From the viewpoint of history it is obvious that science education should combine natural history achievements and prognostic future victories. Children need conditions to be imposed and possibilities to be perceived how the ideas of natural sciences have been changing throughout the time, how they have been realized and used and what their social, inward, cultural context has remained.

Next Reading

Behrendt, H. Dahncke, H. Duit R. et al. (eds). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers.

Chambers D.W., Turnbull D. (1989). Science Worlds: An Integrated Approach to Social Studies of Science Teaching. *Social Studies of Science*, Vol. 19, No. 1, p. 155-179.

Keith M. Lewin (1992). Science education in developing countries: issues and perspectives for planners. Paris, UNESCO: International Institute for Educational Planning.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.
Lamanauskas V., Gedrovics J. (2005). Modern natural science education development tendencies in Lithuania and Latvia. *Gamtamokslinis ugdymas/Natural Science Education*, Nr. 2(13), p. 20-26.

References

Bagdonas A. (1994). Visada problemiškas švietimas. *Mokykla*, Nr.1, P. 1-3.
Beitas K. (1995). Apie biologijos integruotą mokymą. Kn.: *Švietimo reforma ir mokytojų rengimas: Konferencijos tezės*. Vilnius, T.2, P. 118-119.
Blum A. (1994). Integrated and General Science. In.: T.Husen, T.N.Postlethwaite (eds.) *The International Encyclopedia of Education*, Vol.5, P. 2897-2903.
Case R. (1991). *The anatomy of curricular integration* (Forum on Curriculum Integration: Tri University Integration Project, Occasional Paper, 2). Burnaby, BC.
Chepelev N.G. (2003). Authorized course of natural sciences for humanitarian classes of lyceum. In.: *Importance of Science Education in the Light of Social and Economic Changes in the Central and East European Countries* (The materials of the IV IOSTE symposium for Central and East European Countries). Kursk, p.82-86.
De Jong O. (2007). Trends in Western science curricula and science education research: a bird`s eye view. *Journal of Baltic Science Education*, Vol. 6, No. 1, p. 15-22.
Frederiksen, N. (1994). The Integration of Testing with Teaching: Applications of Cognitive Psychology in Instruction. *American Journal of Education*, Vol.102, p. 527-537.
Lamanauskas V. (2003). Natural science education in Lithuanian secondary school: some relevant issues. *Journal of Baltic Science Education*, No.1, p. 44-55.
Pak M.S., Solomin V.P., Zelezinsky A.L. (2003). Professional competence of a chemistry teacher in a context of social changes. In.: *Importance of Science Education in the Light of Social and Economic Changes in the Central and East European Countries* (The materials of the IV IOSTE symposium for Central and East European Countries). Kursk, p. 137-139.
Pečiuliauskienė P. (1999). Integruotų ir neintegruotų fizikos vadovėlių užduočių turinio abstraktumas bei realumas. *Pedagogika*, 39, p.45-54.

Rimkutė J., Motiejūnienė E. (1993). Gamtamokslinių dalykų integracija. Kn.: *Lietuvos švietimo reformos gairės*. Vilnius: Valstybinis leidybos centras, P.230-238.

Salite I. (2000). Integrated teaching in ecosystem and spiritual context. In.: A.Salitis et al. (eds.) *Natural Sciences and Teacher Training* (Collected articles of the international conference, Part 2). Daugavpils, p.82-90.

Stodolsky S. (1988). *The Subject Matters: Classroom Activity in Math and Social Studies*. Chicago: University of Chicago Press.

Tobin K., Roth W. M., Zimmermann A. (2001). Learning to teach science in urban schools. *Journal of Research in Science Teaching*, Vol. 38, Issue 8, p.941-964.

Toldsepp A. (2003). Research and Development Work from the Perspective of Compiling Balanced Curricula for Science Education. *Journal of Baltic Science Education*, Vol. 2, No. 1, p. 5-11.

Раджа Рой Сингх. (1993). Образование в условиях меняющегося мира. *Перспективы: вопросы образования*, №1(81), С. 7-21.

Суравегина И.Т., Иванова Р.Г. (1990). Идеи и структура интегрированного курса „Естествознание"(V-VII классы). *Химия в школе*, №6, С. 42-46.

Unit 4 & Unit 5

Integrated Science Education in the Context of the Constructivism Theory.

Integrated Science Teaching in Terms of the Constructivist Approach

Objectives:

- To perceive the idea of integrated science education in the context of constructivism as a theory of learning;
- To understand and name the specificities of integrated science education implemented following the principles of constructivistic teaching/learning;
- To manage to predict the possibilities of integrating the content of different subjects of science related to the specificities of students at different age stage as well as to material and human resources.

Constructivism may be considered an epistemology (a philosophical framework or theory of learning) (Jean Piaget, 1967), which argues humans construct meaning from current knowledge structures. Knowledge should not be divided into different subjects or compartments, but should be discovered as an integrated whole (McMahon 1997; Di Vesta 1987).

The fact is that constructivism carries a major influence in contemporary science education, although it has been the subject of a heated debate. Remarkably, one of the most important implications of radical constructivism challenges the processes by which individual students actively construct their own knowledge.

Constructivism has always skirted round the actual learning of an established body of knowledge ... students will find that words are used in new and standardised ways: problems which were never even seen as being problems,

are solved in a sense which needs to be learned and rehearsed. For a time all pupils may feel that they are on foreign land and no amount of recollection of their own remembered territory with shut eyes will help them to acclimatise. (Solomon, 1994, p. 16). Learning science involves being initiated into the culture of science. If learners are to be given access to the knowledge systems of science, the process of knowledge construction must go beyond personal empirical enquiry. Learners need to be given access not only to physical experiences but also to the concepts and models of conventional science (Driver et al., 1994, p. 6). Most science teachers try their best to explain things clearly, to make use of metaphors, to use demonstrations and practical work to flesh out abstractions, to utilise projects and discussions for involving students in the subject matter, and so on. They realise that many, if not most, things in science are beyond the experience of students and the capabilities of school laboratories to demonstrate. The cellular, molecular and atomic realms are out of reach of school laboratories, as is most of the astronomical realm. Most of the time even things that are within reach do not work. It is a rare school experiment that is successful. For children, a great deal of science has to be taken on faith. Good teachers do their best in the situation, and try to point out why faith in science is warranted. In that case the approach of integrated teaching/learning is the best choice.

The processes of integration are visible in science, technologies and economy including education. The discussions about integrated education focused on the integration of teaching content are frequently held. The future will show whether it is fashion or necessity. One point is clear – the integration of teaching content is a burning issue of contemporary didactics. The following main objectives make the dignity of integrated teaching evident:

- to conclude and classify knowledge imparted by sciences;
- to reveal the affinity of the key (general science) concepts;
- to reduce the flow of secondary information, to concentrate on teaching how to use the sources of information (for example, encyclopaedia, reference books, dictionaries, audio-video material, etc.);
- to make teaching/learning interesting, attractive, true to life, etc.
- to train pupils to adopt various classified courses in higher forms, etc.

Thus, integration is the development of a new wholeness from the previous different units, components, for example, the content of teaching subjects, the kinds of activities, etc. The characteristic features of the child or teenager should not be forgotten along with the theoretic examination and practic solution of the questions of integrated natural sciences teaching. ***F i r s t***, the proc-

esses of the child's memory in terms of quality and quantity change (for example, visual-sensorial, emotional memorable, etc.); ***s e c o n d***, the qualities of pupils' cognitive activities (thinking, observation) are remarkably diverse (a particular group of pupils should manage to perceive integrated material); ***t h i r d***, a successful solution of the issues of psychologic adaptation is considered to be an important point (new textbooks, new curricula, requirements, etc.); ***f o u r t h***, contemplation on the basis of concepts prevails at school age, i.e. the world is accepted as the generalization of the main features of objects and phenomena. Incidentally, such thinking form only in childhood (Vygotskij, 1934); ***f i f t h***, the level of abstraction increases together with the degree of integration.

The younger the child the less s/he knows and manages, and therefore in terms of him/her, the degree of the integration of subjects has to be limited

Certainly, teachers themselves should know more about the styles of teaching/learning and different patterns of work organization (Eric W.K.Tsang, 1997). Pedagogues must communicate, argue and seek effective ways in order to hold teaching material in pupils' memory (Schlesinger, 1996). The author maintains that every integrated curriculum has to include two modules – thematic and functional. The teaching curricula that should reproduce the integration of content as well as of the process become notable. The integrated courses of natural sciences should be coordinated with the systemic ones. The integrated course of teaching has to be undertaken by the complex of training aids/resources for learning such as textbooks, workbooks, didactic material, teacher's book (teaching methodology), visuals, etc. They guarantee increased activities that are directly proportional to the efficiency of teaching/learning.

Table 3. Some factors on integrated natural science education efficiency (Lamanauskas, 2003)

Aspects of the significance of integrated natural science education	Circumstances preventing efficiency of integrated natural science education
* helps to model the entire (holistic) world-view; * forms pupil's individuality; * deepens and develops the kid's	* the unsuitable, perverted view to natural science education; * lack of teachers' initiative and creativity;

world outlook (understanding of nature); * establishes conditions for better mastering, perceiving and structuring natural sciences knowledge; * establishes conditions to comprehensively perceive relations between reason and result; * establishes conditions to practically apply knowledge; * helps to advance practical abilities and skills; * establishes conditions for the teacher to more colorful convey information; * directly influences the quality of conveying knowledge, evolves the motivation of cognitive interaction with nature etc.	* teachers' (particularly those of primary school) weak motivation of cognitive interaction with nature; * lack of teachers' experience in the area of integrated natural science education; * sufficiently high expenditure of working hours in order to efficiently formulate strategy of natural science education; * lack of the visual aids of natural science education and the discrepancy of those to the required standards; * unequipped textbooks; the translated textbooks from foreign languages are particularly inefficient (not adapted to Lithuanian schools); * the entire concept of integrated natural science education is missing; * the teachers of elder generation are inert; * natural science education is a supporting part etc.

The constructivist theory of teaching must be based upon the constructivist theory of learning (Selly, 1999). The constructivist framework challenges teachers to create environments in which they and their students are encouraged to think and explore the scientific knowledge (Brooks & Brooks, 2001; Fosnot, 1996).

The elements of constructivist theory in the classroom may be summarized as follows (Richardson, 2003, Brooks& Brooks, 2001):

- attention to the individual and respect for students' background or prior knowledge)
- encouraging and facilitating group dialogue
- planned and often unplanned introduction of formal domain knowledge into the conversation
- provision of opportunities for students to determine, challenge, change or add to existing beliefs and understandings through engagement in tasks

- development of students' metaawareness of their own understandings and learning processes
- use of cognitive terminology such as "classify", "analyze", "predict", and "create"
- evaluating the students in process and give priority to their participation.

The objectives of integrated science are aimed at enabling the student who is exposed to it acquire the following skills:

- observing carefully and thoroughly;
- reporting completely and accurately what is observed;
- organizing information acquired;
- generalizing on the basis of acquired information;
- predicting as a result of the generalizations;
- designing experiments (including controls where necessary) to check predictions;
- using models to explain phenomena where appropriate;
- continuing the process of inquiry when new data do not conform to prediction etc.

Tasks (assignments)

1. Establish the main idea of constructivism as a theory of learning.
2. How could you motivate the idea of integrated science education based on the theory of constructivism?
3. Use the presented terminology to form a few proposals defining integrated science education from the point of view of constructivism.

Concept	Statement
Knowledge	
Key concepts	
Flow of secondary information	
Sourses of information	
Teaching/learning process	

4. Describe the impact of students' age on the possibilities of integrated science education.
5. Describe the impact of the available material and human resources on the possibilities of integrated science education.

Case study 1

Teacher A coherently, precisely and clearly presents the theoretical teaching/learning material required for solving different practical issues, defines and corrects terminology related to the educational material and constantly links the discussed topic to the earlier discussed and examined questions. Such situation encourages the students in accepting traditional facts proved by science.

The teacher frequently points to the additional information sources useful to students for individual studies, shows the links between teaching material and the content of other subjects taught (including other than science subjects), *sometimes* creates situations when the students use the already obtained knowledge to solve the encountered problems in practice. However, it is worth emphasizing that *this is not the way of learning every day or week*.

Questions to Case Study 1

1. The presented situation includes the indications of constructivistic teaching/learning. Nevertheless, some moments involves doubts whether the above mentioned teacher refers to constructivism as a basis for epistemological teaching in daily work.

2. Try to discuss the situation and the following questions in groups: *If constructivism as a theory has to be a basis for every lesson? How can the work format of the above mentioned teacher be useful for students?*

Case study 2

The teachers of school X have formed a creative and employable team. In the run of a school year, they decided to prepare and implement an integrated curriculum of teaching sciences for basic school (forms from 8 to 10). The teachers scheduled the use of the required tools (course books, work books, teacher books, visual aids etc.) and selected training material. The prepared integrated content of teaching embraces two modules – theoretical and practical. The preserved main principle of constructivistic teaching/learning is oriented towards developing the ability to operate information resources.

Questions to Case Study 2

1. Do you think the teachers can feel certain about the successful implementation of the integrated curriculum??
2. Try to predict the impediments to making impact on the implementation of the integrated curriculum of teaching sciences? Can a team of science teachers succeed in preparing the integrated teaching curriculum without outside help?

Summary

Constructivism has done a service to science and mathematics education: by alerting teachers to the function of prior learning and extant concepts in the process of learning new material, by stressing the importance of understanding as a goal of science instruction, by fostering pupil engagement in lessons, and other such progressive matters. Constructivism has also done a service by making educators aware of the human dimension of science: its fallibility, its connection to culture and interests, the place of convention in scientific theory, the

historicity of concepts, the complex procedures of theory appraisal, and much else.

The integrated course of natural sciences should form the base amount of natural science knowledge (in a broad sense), i.e. "a formal component", as every teacher tries to identify the priorities of his/her teaching subject and the criteria of the efficiency of peculiar teaching methods and forms. The preparation of the integrated course of natural sciences is a concurrent part of teaching, optional, extracurricular, etc. courses. The educational curricula have to reflect the integration of the content of the teaching/learning process. The integrated and systemic courses of natural sciences should be combined. A real correlation and its reflection in the child's psycho physiologic abilities, skills, aptitudes and interests during the educational process at different age range is acclaimed to be a very important indicator of the content of natural sciences integration. The integration of the educational process has to be coordinated with didactic differentiation that is determined by unequal pupils' knowledge, different interests and teaching motivation, unlike intellectual motivation, self-control skills, etc. Self-sufficiency, the principles of freedom of choice and responsibility, psychologic learners' adaptation should be stressed when preparing the integrated courses of teaching/learning. More attention should be paid to schoolchildren's personal perfection, the development of differentiated teaching and evaluation, the accumulation, classification, assessment and usage of information and to the development of other skills, the alteration of group and individual work in the educational process. The integrated teaching course has to be guaranteed by the means of teaching/learning such as textbooks, workbooks, didactic material, visual aids, etc. as well as by the teacher's proficiency to work at qualitatively new level in a new century. A crucial point is a practic check of the set patterns of the content of integral natural science education that could be applied for a particular socio-cultural environment.

Frequently Asked Questions

Why we are usually talking about priority and importancy of science education?

Because, that the priority of science education is easily understandable as it includes the whole locality inhabited by pupils, their spectrum of self-expression, and also their interaction with nature. Children`s participation is an extremely important component in this case. Teaching scientific material without pupils` active participation in the experiment and research makes the learning process insignificant for them.

Next Reading

Bodner, G. M. (1986). Constructivism: A Theory of Knowledge. *Journal of Chemical Education*, 63, 10, 873-878.

Collins, H.M. (1985). *Changing order: Replication and induction in scientific practice*. London: Sage.

Dykstra, D. I., Boyle, C. F., & Monarch, I. A. (1992). Studying conceptual change in learning physics. *Science Education*, *76*(6), 615-652.

Driver, R. (1995). Constructivist Approaches in Science Teaching. In: L.P. Steffe & J. Gale (Eds), *Constructivism in Education* (pp. 385-400). Lawrence Erlbaum Assc. Inc.

Lawson, A. (1995). *Science teaching and the development of thinking*. Belmont, CA: Wadsworth.

Matthews, M.R. (1993). Constructivism and science education: Some epistemological problems. *Journal of Science Education and Technology*, *2* (1), 359-370.

Millar, R. (1989). Constructive criticisms. *International Journal of Science Education*, *11*, 587-596.

Osborne, J. (1996). Beyond constructivism. *Science Education*, *80*(1), 53-82.

Slezak, P. (1994a). Sociology of scientific knowledge and science education: Part I. *Science & Education*, *3*(3), 265-294.

Slezak, P. (1994b). Sociology of scientific knowledge and science education: Part II. *Science & Education*, *3*(4), 329-356.

Rogers, S., Ludington, J. and Graham, S. (1999). *Motivation and learning: Practical teaching strategies and tips.* Evergreen, CO: Peak Learning Systems.

Tsai, C. C. (2000). Relationships Between Student Scientific Epistemological Beliefs and Perceptions of Constructivist Learning Environments. *Educational Research*, 42 (2), 193-205.

Unal G., Akpinar E. (2006). To what extent science teachers are constructivist in their classrooms? *Journal of Baltic Science Education*, No. 2(10), p. 40-50.

References

Brooks, J. G., & Brooks, M.G. (2001). *In Search of Understanding: The Case for Constructivist Classrooms*. New Jersey: Prentice-Hall Inc.

Driver, R., Asoko, H., Leach, J., Mortimer, E. & Scott, P. (1994). Constructing Scientific Knowledge in the Classroom. *Educational Researcher*, 23(7), 5-12.

Fosnot, C. T. (1996). *Constructivism: Theory, Perspectives and Practise*. Teachers College Press, Columbia University.

Lamanauskas V. (2003). Natural Science Education in Lithuanian Secondary School: Some Relevant Issues. *Journal of Baltic Science Education*, No.1, p. 44-55.

Matthews, M.R. (2000). Constructivism in Science and Mathematics Education. In.: D.C. Phillips (ed.), *National Society for the Study of Education, 99th Yearbook*, Chicago, University of Chicago Press, pp. 161-192.

Selley, N. (1999). *The Art of Constructivist Teaching in the Primary School*. London. David Fulton Publishers Ltd.

Solomon, J. (1994). The Rise and Fall of Constructivism. *Studies in Science Education* 23, 1-19.

Schlesinger Phyllis F. (1996). Teaching and Evaluation in an Integrated Curriculum. *Journal of Management Education*, Vol. 20(4), P.479-486.

Richardson, V. (2003) Constructivist Pedagogy, *Teachers College Record*, 105, 9, 1623-1640.

Tsang Eric W.K. (1997). Organizational Learning and the Learning Organization: A Dichotomy Between Descriptive Research. *Human Relations*, Vol.50 (1), P. 84-85.

Выготский Л. (1934). *Мышление и речь*. Москва, С. 119-147.

Unit 6

The Models of Integrated Science Education

Objectives:

- To meet up with and carefully analyse one of the possible models of integrated science education emphasizing the classification of the subjects taught:
- Define the advantages of integrated science education;
- Understand the levels of integration in science education.

A practic relevant problem which is patterning of integrated teaching becomes pronounced when proceeding to integrated teaching. The patterns of such teaching can vary. K. Pigdon and M. Woolley (1993) presents the following pattern of teaching/learning.

Information	Nature of activity	Subjects involved
Facts		**Learning about**
	Prior knowledge	• social education
	• **making prediction**	• science
	• **asking questions**	• environmental education
	Shared experience	• personal development
	• observation	• technology studies
	• collecting information/data	
Concepts	**Processing information**	**Learning through**
	• listing	• language
	• grouping	• art
	• categorising	• drama
	• classifying	• mathematics
	• labelling	• movement
	• organising ideas	• music

Generalisations	**Synthesising** • making statements • generalising • looking for relationships	**Learning about** • social education • science • environmental education • personal development • technology studies
Further information	**Refinement and extension of knowledge** • elaborating • justifying • reflecting	

Figure 2. A model of integrated learning (Pigdon, Woolley, 1993)

The authors think that the pattern of integrated teaching is delivered to classify the knowledge of subjects, to include the overall ideas of how the world acts. Two groups of subjects are specified:

- the subjects of content (social sciences, natural sciences, environment sciences, the evolution of personality, technologies);
- the subjects of a process (language, art, drama, mathematics, music, plastics). Integration creates opportunities for learners to investigate, conclude, process information, improve knowledge and impart information on different topics without embarrassment and leaving the barriers of traditional subjects behind. One of the practical arguments for integration, particularly in the middle school years, is that it enhances pupil engagement with school. Several studies show that providing an authentic curriculum, well connected to pupils` needs and interests and to the world outside of school, can result in reduced alienation and increased participation and engagement (Venville, Wallace, Rennie, Malone, 2002).

The process of the integration (in the light of content, forms, activity, etc.) of natural sciences is acclaimed to be very important. We suppose that the model defining the key components of the integration process at every level is possible.

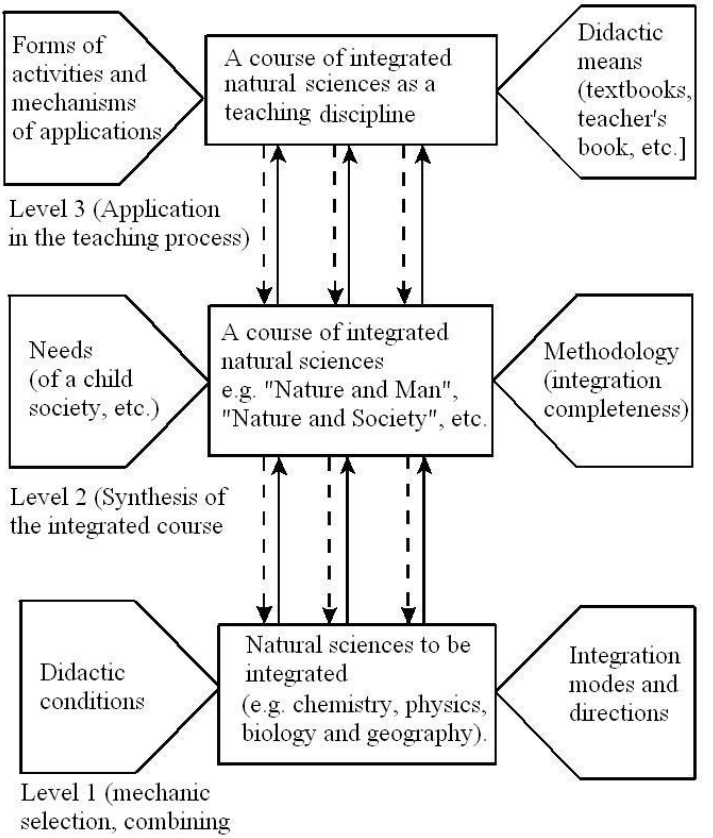


Figure 3. The model of the process of natural sciences integration (Lamanauskas, 2003)

Three fundamental levels can be sorted out:

- mechanic selection and combining / the main components are didactic conditions and integration trends and methods /;
- synthesis of the integrated course / the main components are needs and integration methodology (completeness)/;
- application in the teaching process / the main components are activity forms and application mechanisms and the complex of didactic means

(textbooks, workbooks, teacher‘s books, extra didactic material, computer programmes, etc. /.

A close correlation and interaction exists between these levels. The correlation is not equivalent (*level 1* ↔ *level 3*). The integrated course of natural sciences as a teaching subject, as a matter of fact, is not changed but refreshed and complemented regarding the essential alterations of the educational system. In case of infraction of at least one of the links, integrated teaching will not be effective.

Also is interesting the Berlin-White Integrated Science and Mathematics Model developed to address the need for a definition of the integration of science and mathematics education. There are six main aspects (Berlin, White, 1994):

- ways of learning;
- ways of knowing;
- process and thinking skills;
- content knowledge;
- attitudes and perceptions;
- teaching strategies.

It is obvious, that the choice of model of integration first of all depends on what form of integration prevails, for example:

- integration of experiences;
- integration of students activities;
- social integration;
- integration of knowledge;
- integration as a curriculum design etc.

Also, it is possible to notice varied levels of integration (Palmer, 1991, p. 59):

- developing cross-curriculum subobjectives within a given curriculum guide;
- developing model lessons that include cross-curricular activities and assessments;
- developing enrichment or enhancement activities with a cross-curricular focus including suggestions for cross-curricular "contacts" following each objective;
- developing assessment activities that are cross-curricular in nature;
- including sample planning wheels in all curriculum guides.

According A. Miller, teachers who use cooperative, integrated methods will produce students more competent in using problem-solving techniques, in communicating effectively and in working cooperatively. Finally, it can be mentioned that at the heart of the interdisciplinary educational philosophy (interdisciplinary science education) is the psychological theory of constructivism.

Tasks (assignments)

1. Name the advantages of integrated science education:

Subject field	Social field

2. What is the basis for classifying subjects into two groups presented in the integrated model of science education K. Pigdon and M. Woolley (1993)?

Case study

In state X, following the approved educational curriculum developed for comprehensive school, primary school classes are taught a course on the world study covering 2 parts - *Social Education* and *Science Education* – which are relatively singled out to underline the problems and links between the topics occurring in every field of education. The course book on this subject freely operates the topics included in both parts and retains notional and subject coherence. In turn, the area of science education consists of 4 components:

- research of nature;
- animate nature (component of biology);
- substances and their variations (component of chemistry);
- physical phenomena (component of physics).

Moreover, science education closely relates not only to social but also to technological-artistic training, mathematics and languages. These subjects either complement one another or make the complete entirety.

The concentre of basic school is divided into three parts having a different degree or extent of sciences integration:

- integrated course on sciences *Nature and Human* including biology, physics, chemistry, earth science, healthy living, ecology, technology and agriculture is taught in forms 5 and 6. The course on sciences is properly integrated considering all subjects taught;
- still maintaining close interdisciplinary relations in forms 7 and 8, biology, chemistry and physics are taught as separate subjects;
- revision courses on biology, chemistry and physics are taught in forms 9 and 10;
- from the point of view of structure, the field of education in forms 11 and 12 consists of 4 subjects:
  1. biology;
  2. chemistry;
  3. physics;
  4. integrated sciences.

The students choose an appropriate course on sciences – physics, chemistry, biology or integrated sciences. Those who are not intend to study sciences in the future or do not think of any other activity related to sciences but still want to gain more knowledge about this area of study, choose either general courses on separate sciences or the integrated course on sciences. The students interested in carrying on the studies of sciences or those who would like to keep proceeding with this field choose the advanced courses on separate sciences. Although the courses on physics, chemistry and biology are most frequently taught separately in secondary school, these sciences have much in common – concepts and conceptions, methodological principles, solving science and practical issues etc. Thus, a deeper ***integration*** of the content of science education is pursued. In addition, the content of science education often relates to the problems of ecology, healthy living, demographical situation and the use of technologies and nature. Plenty of contacts can be noticed between sciences and mathematics.

The integrated course on sciences for secondary school students of forms 11 and 12 focuses on the learners preferring a humanitarian profile and those who are not going to proceed with professional science activities in the

future. This course concentrates on modern achievements in science, life experience and environmental problems. All topics are examined in broad outline, the evolution of sciences is discussed as a method of acknowledging nature, the issues of personal and public life are highlighted, natural phenomena and scientific ideas are carefully analysed and observation and experimentation are carried out. The integrated course on sciences is devoted to help the student with pursuing general science education and developing the ability to distinguish between scientific and non-scientific issues as only a sufficiently sophisticated person can be actively involved in solving the problems of a modern country. The course assists the learners in perceiving the significance of sustainable development ideas and protecting biosphere and the quality of public life.

Questions to Case Study

1. What is the level of integration at every stage of comprehensive school?
2. Indicate the observed key components having influence on your position.

Summary

There are different models of integrated science education. Teachers can choose suitable model of integration depending on different circumstances. The main circumstances - a level of knowledge of students, presence of accompanying didactic materials, quantity of students in a class, support of administration of school, etc. In a school practice more often as a core of integration three main subjects - chemistry, physics and biology - act. Science teachers can use interdisciplinary integration or integration inside teaching subject. The real problem to teaching integrated science courses is that there are no enough appropriate models or widely-accepted materials available. Integrated science courses gives for teachers a chance to really take a broader look at the nature of science in new ways. It is not the simply teaching. It is obvious that primary goal of integrated science is to teach students how science is done, how to ana-

lyze problems and situations, and how to investigate scientific (or pseudo-scientific) claims. Educators and researchers agree that teaching integrated science is a suitable approach for producing scientifically literate citizens. In general, integrated science is a great idea for the students.

Frequently Asked Questions

What makes integrated science a unique subject?

It is evident that integrated science emphasizes organization of learning experiences around a topic/theme. It is likely that this unification of concepts around a theme makes integrated science unique. The learning experiences and concepts of integrated science are organized around the different themes. Organising concepts around common themes is a good way of deliberately removing the subject mater boundaries.

Next Reading

AAAS /Science for all Americans – A Project 2061 Report on Literacy Goals in Science, Mathematics and Technology. (1989). New York: The American Association for the Advancement of Science.

Blum A. (1994). Integrated and General Science. In.: T.Husen, T.N.Postlethwaite (eds.) *The International Encyclopedia of Education*, Vol.5, P. 2897-2903.

Chepelev N.G. (2003). Authorized course of natural sciences for humanitarian classes of lyceum. In.: *Importance of Science Education in the Light of Social and Economic Changes in the Central and East European Countries* (The materials of the IV IOSTE symposium for Central and East European Countries). Kursk, p.82-86.

Emelyanova G.M. (2003). The training of a future teacher for integral-modular education realization at school. In.: *Importance of Science Education in the Light of Social and Economic Changes in the Central and East European Countries* (The materials of the IV IOSTE symposium for Central and East European Countries). Kursk, p. 179-181.

Eurydice Report (2006). Science Teaching in Schools in Europe. Policies and Research. Available on the internet at: http://www.eurydice.org

Jacobs H.H. (1989). The interdisciplinary concept model: theory and practice. *Gifted Student Quarterly*, Fall.

Palmisano, M., Barron, M., Torp, L. (May 1995). Integrative learning systems: Rationale, overview, and reflections. *NCSSSMST Journal*, p. 3-8.

Venville, Grady Wallace, John (1998). The Integration of Science, Mathematics and Technology in a Discipline-Based Culture. *School Science and Mathematics*, October 1998 Vol. 98, Issue 6, pp. 294-303.

References

Berlin, Donna F., White, Arthur L. (1994). The Berlin-White Integrated Science and Mathematics Model. School Science and Mathematics, Vol. 94, No. 1, p. 2.

Lamanauskas, V. (2003). *Natural Science Education in Contemporary School*. Siauliai: Siauliai University Press, p. 514.

Miller, K. A. (1995). *Curriculum: To Integrate or Not to Integrate*. Youngstown State University.

Palmer, J. (1991). Planning Wheels Turn Curriculum Around. *Educational Leadership* 49/2, p. 57-60.

Pigdon K., Woolley M. (1993). *The Big Picture: Integrating Children's Learning*. Portsmouth: Heinemann.

Venville G., Wallace J., Rennie L., Malone J. (2002). Curriculum integrations: Eroding the high ground of science as a school subject? *Studies in Science Education*, Vol.37, p. 43.

Unit 7

The Integrated Science Education Curricula and its Designing Principles in Comprehensive School

Objectives:

- To perceive the integral and systemic nature of the content of science education;
- To analyze different types of science education curricula, to know the qualities, drawbacks and degrees of integrity of the curricula;
- To define the concepts of *educational content* and *educational curriculum* and to know their framing principles;
- To have knowledge of conditions ensuring the possibility of successful implementation of science education curriculum.

Natural science is a subject that seeks to set out conditions for schoolchildren to adopt the basis of contemporary natural science knowledge, to cherish a modern culture of scientific thinking and activity and ability to refer to it in practice. It is very important that natural sciences should help learners to formulate a clear concept of natural history based on the latest knowledge of the world strongly emphasizing the character of the correlation between nature and society, civilization and culture. The world is multidimensional, and therefore we must strive to acknowledge it. This is a winning goal of contemporary natural science education. The objectives as concretization of this goal are supposed to be formulated at different levels. According to A.Tõldsepp (2003), the main of natural science education is to prepare young people for a full and satisfying life in the world of the 21st century. The others underline natural science-technological literacy for all and mastery for professionals (Broks, 2002).

Public society approach to natural science education (general needs, general level of culture, traditions in the light of interaction with nature, the need to have society and the young generation of a privileged natural science

background, etc.), **its optimal conditions of implementation** (the standards of natural science education and material, human, etc. resources undertaking their success), **the development of the needs and motivation of nature study (in a broad sense)** (improving the need to perceive nature throughout all studies in comprehensive school, enhancing cognitive relation with nature, etc.), **natural science results: knowledge, abilities, relations** (studying natural sciences, etc.) are the crucial components of natural science education.

Natural science and natural science education are closely and specifically interrelated at school. Natural science education can be perceived as the synthesis of the components (Lamanauskas, 2001).

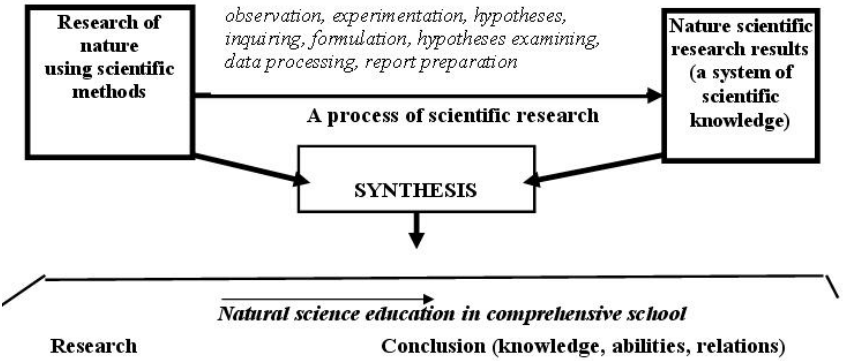


Figure 4. Natural science and natural science education at school

As can be seen from figure 1, natural science education is a specific synthetic, integral, systemic subject.

The science curriculum need to be based on such important didactic principles as:

- **humanism** (fosters respect for nature and human being, the creation of a healthy and safe environment, etc.);
- **democracy** (in terms of education methodology, content, etc. both the pupil and the teacher are given the option and a freedom);
- **spiral** (similar issues are discussed at higher level in higher forms. Training material is broadened and deepened);

- **integration** (training material is integrally produced (the complete wholeness). Educational content as well as the process and the teacher-pupil activities are sought to be integrated).

In addition, the following principles are underlined in the majority of the countries:

- **regional studies** (based on schoolchildren's knowledge and visuals acquired investigating terrene, digging, weather phenomena, waters, soil etc., of a region);
- **a seasonal principle** (objects, phenomena and their alteration of animate and inanimate nature are observed in autumn, winter, spring and summer).

Training (educational) content is defined by the curricula. They can vary and perform different functions. For example, in Lithuania the components of general natural science education are described by the General curricula indicating that the content of natural science education is constructed of the following central components (General curricula… p. 289):

I. Natural research:
1. The methods of scientific research.
2. Scientific thinking and creativity.
3. Natural sciences and society.

II. Animate nature (biology):
1. Organism.
2. Organism and environment. Biosphere and human being.
3. Continuation and variety of life.
4. Human being.

III. Substances and their alteration (chemistry):
1. The structure and composition of a substance.
2. The subordination of the properties of substances considering their composition and structure.
3. Chemical transformation.
4. The main substances used in nature, daily life and technologies.

IV. Physical phenomena (physics):
1. Physics as a natural science.
2. Substance and its structure.
3. Motion and force.
4. Energy and physical processes.
5. Physical transformations.
6. The Earth and the Universe.

The first component of natural research is integrated into the next three.

The content of natural science education gives a chance to the dynamics and structure of the educational process. However, the adaptation of natural science knowledge system depends on both the teacher (choosing and applying teaching methods and forms, etc.) and the pupil (the methods of learning, motivation, general abilities). The diversity of teaching and learning content, forms and methods, activities are typical of natural science education. All that makes the educational process effective: develop intellectual knowledge and skills, set out conditions for intense pupils' activities, shape thinking, foster aesthetic feelings, etc.

The natural science knowledge and skills gained by pupils in the educational process form the content of teaching natural science. Anyhow, the process of natural science education includes the teacher and children's activity based on direct and indirect relations. Children are interested in the classes of science when the content of the taught material is comprehensible, attracts attention and imagination, encourages to intensively work and is problematic. A highly effective component of natural science education is the presentation and examining of problems. It can be expressed in three ways:

1) asking questions about the relevant subject;

2) presenting demanding tasks;

3) facing serious problems.

Some fundamental moments can be emphasized:

- successful natural science education is a sample of the most important concepts of natural sciences (natural science). They explain the main structure of natural sciences and increases the learner's natural science perception moving to the higher form;
- successful natural science education is a sample and discernment of the concepts that deepen and broaden general natural science understanding;
- the understanding of concepts plays a leading role at school as well as in everyday life as they create an opportunity for people to better understand each other, predicates about verbal communication (Arends, 1998);
- in order to explain concepts and phenomena, primary school pupils' thinking peculiarities (ontogenetic aspect) definitely require picturesque specific cases. The most advantageous way to reach an effect is practical children's activities.

In addition, integrated natural science education is examined in the context of the ideas of constructivism. A basic premise of constructivism is that

knowledge is not passively received but developed as students construct their own meanings (Treagust, 1996). Teachers who valued their students existing ideas` and attempted to link learning to them (i.e., using a constructivist premise about learning) were more able to make relevant links and transfer of skills across curriculum areas. They were more likely to involve integration as a framework in their teaching (Waldrip, 2001). According to Bentley and Watts, learning is always an interpretative process involving individuals` constructions of meaning. New constructions are based upon previous experience and prior knowledge (Bentley, Watts, 1994, p. 24).

It is possible to indicate some basic principles for science education curricula:

- scientific character;
- unities of the substantial and remedial party of training;
- structural unity;
- conformity of the basic components of the contents to structure of culture of the person;
- socialization;
- practical importance;
- optimum combination of an educational material of regional and global character;
- conformity and necessary sufficiency etc.

According A. Toldsepp (2003) the ideal paradigm of science education today is 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.

Also we can notice three main other principles for designing of curricula:

- process orientation;
- holistic approach;
- learner centredness.

Experience and research have shown that success in curriculum innovation depends upon the active involvement of teachers in curriculum development.

The curriculum of natural science should reflect not only the integration of content, but the process should be seen as well. Integrated courses of natural sciences should agree with systematic courses, and all presented information should be bound together by sensible meaning. The efficiency of the integrated learning is directly dependant on the activities of students. Integrated courses should be well supported by a set of teaching / learning aids such as textbooks, workbooks, visual / demonstration aids, teacher's books, etc. (Lamanauskas, 2003). Integration also presupposes the increase of the abstract. The younger are the students, the less is their knowledge. Consequently, the degree of integration should be limited in this respect. The integration of content should be combined with differentiation and individualization of teaching, because every child has his / her own ways or models for learning.

In general, all of the definitions of integrated curriculum or interdisciplinary curriculum include (Lake, 1994):

- a combination of subjects;
- an emphasis on projects;
- sources that go beyond textbooks;
- relationships among concepts;
- thematic units as organizing principles;
- flexible schedules;
- flexible student groupings.

Future science curricula should recognize the interaction of science, technology, and society and should give students the skills for learning and applying scientific knowledge, an awareness of ethics and values in science, and a future perspective (Robinson, 1982). Science curricula have been criticised for ignoring the relevance of science to the health, wealth, happiness, security and curiosity of humanity and neglecting all accounts of the numerous ways in which science based technologies contribute to society (Sjøberg, 2000).

It is important to state that:

- although the educational curricula are the basis of integration, they cannot cover the whole education. Moreover, natural sciences are rather complex and the integration of a few stages (levels) only is possible. Thus, scrupulous attention should be paid to the textbooks in the field. A qualitatively prepared and experimentally based textbook improve the

schoolchild's knowledge, develop his/her intelligence. Finally, teaching is one of the main conditions that determine the quality of learners' knowledge;

- the teacher is a central figure of the educational process. The quality of natural science background acquired by pupils depends on his/her competence;
- teachers' thinking has to fundamentally change and develop. Learning should predominate over teaching. The process of sciences teaching-learning should be more holistically oriented and directed towards synthesis. The research of natural science education system requires the holistic approach. It is of a complex character and demands an experimental basis (from practice to theory). Training the whole child's personality is a contemporary educational issue. The solution mainly depends on the educational process in which the usage of the pupil's experience in imparting knowledge about the world plays an important role. Classified knowledge that helps to perceive the correlation between nature and society becomes the means linking personality and environment, helping to acknowledge reality (changing methods) as well as the basis of the learner's individual social singleness. The creation of the knowledge system depends on the following crucial points such as the level of information perception, thinking method, the development of a schoolchild's cognitive activity and individuality, a value-based system of the student and at last curiosity which is a driving force of his/her cognition, thinking and behaviour.

Some types of curriculum can be mentioned:

The curriculum of the constructive (based on a particular subject teaching) system. A strict interpretation of the subjects is characteristic of the curriculum. All subjects are taught individually, the content of teaching and the methods of activities are absent. The curriculum has its own advantages and disadvantages. The top qualities of the curriculum should be as follows:

- a constructive approach to teaching is admissible to pupils' parents;
- the curriculum is rather convenient if managed; teachers accept it more willingly than integrated teaching;
- individual scientific subjects impart specific knowledge and abilities to schoolchildren. Bright pupils that have high motivation in terms of natural sciences gratefully acquire it;

- learners' knowledge is more thorough as professional teachers work and face a higher quality, outstanding schoolchildren's achievements;

The major drawbacks of the curriculum:

- a pupil's workday is broken into many fragments (for example, 7-8 classes) that usually do not correlate (or weakly correlate);
- teachers' time planning and learners' demands disagree;
- the content of training does not reflect reality outside school as it is full of facts, most frequently uninteresting for children and hardly understandable.

The curriculum of parallel (adjacent) teaching of subjects. The exposition of the classes of an individual subject (for example, biology) correlates with other classes of the subjects of the same field (for example, chemistry, physics, geography). Moreover, teaching order changes. However, the content itself practically remains the same. The curricula of natural sciences do not artificially correlate. The main advantages of the curriculum should be:

- teachers need to change the time of the presentation of curricula rather than the curricula themselves;
- partial reconstructions are not complex, and therefore often acceptable to teachers;
- this is the way to implement the internal integration of content.

The main disadvantages are supposed to be:

- subjects correlate in passing;
- the presented concepts of phenomena are separated, do not correlate notionally, etc. (for example, "Photosynthesis", "Breathing", "Combustion", etc.);
- schoolchildren themselves have to establish the correlation between a reason and a result among unlike phenomena and cognitive fields.

The curriculum of supplementary (parallel) subjects. A characteristic feature of the curriculum is that relative natural sciences are combined into a single class or even an individual module (course). The degree of integration increases. On the other hand, the subjects of a different format correlate as much as they can explain or supplement each other. Lithuanian comprehensive secondary school applies such modules under the circumstances of profile teaching.

The following advantages can be accentuated:

- the material of the curricula can be easily linked;
- the course of such a format is understood by the participants of the educational process with no effort;
- the administration of the planning process itself is simple, pupils are given opportunities of choice.

The obvious disadvantages are:

- learners are made to reconsider a traditional approach to their knowledge and studies;
- the school syllabus of the educational process is changed, the methods of payment alter, the control of the educational process becomes more complex, etc.
- in general, the approaches to the introduction of the supplementary subjects vary. The supporters of extracurricular activities state that this kind of activities cannot be devoted to scientific education.

Interdisciplinary curricula. All teaching subjects (including those of natural sciences) correlate in the school syllabus. Classes and other occupations take place a certain amount of time, i.e. periods (some days, weeks, etc.). Clear advantages are as follows:

- versatile pupils' epistemological experience is encouraged;
- natural science courses are better scheduled;
- a timetable of classes alterates according to the opportunities and situation of a school;
- perfect conditions to apply other forms of teaching, for example, designed teaching (projects are launched and carried out) are imposed. For instance, such curricula are extremely effective when preparing long-term projects.

  Serious drawbacks are as follows:

- such an activity requires many efforts and changes, high teachers' competence;
- schoolchildren's parents often hardly accept that a curriculum of interdisciplinary education is valuable. They frequently want to see a result "here and now";
- the curriculum requires much time and endeavour to work with a school community. School executive must be able to effectively organize, administer the educational process and to constantly encourage teachers to such activities.

The curriculum of the integrated day. In the light of integrated education, this curriculum is really valuable. The majority of the followers of the latest movement (Stainer, Frene, etc.) have successfully applied it. A key point is that the organic approach to a class life is emphasized. The issues and interests of the child are the focus of the educational process the main advantages of which are:

- the day of an integrated activity is natural;
- learners' concernment is quite high;
- time planning and pupils' needs are in chime.

The main drawbacks are:

- teachers have to work a lot, they have to be experienced professionals and possess the skills of cooperation;
- a class activity and work in groups are complex to be administered (when a few forms or students' groups participate in the process in particular);
- frequent deviations from the didactic attitudes and educational objectives of the main curriculum in general.

A completely integrated curriculum. This is an extreme form of interdisciplinary work. Schoolchildren's life is completely coincident with school life. Work is very complex if followed this curriculum. A traditional (classic) school can hardly accept it. Nevertheless, the main advantages are:

- the curriculum is properly integrated;
- to reveal pupils' self-sufficiency excellent conditions are set out;
- the main idea of the educational process is a schoolchild's life at school or in other educational institution.

The major disadvantages are:

- the curriculum requires close cooperation and reciprocal understanding between children's parents and school;
- qualitative mastering of the whole educational curriculum is hardly ensured;
- this is a boarding school that suits to a certain group of schoolchildren.

Fogarty has described ten levels of curricula integration (1991).

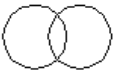
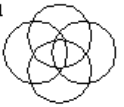
Name	Description	Advantages	Disadvantages
Fragmented 	Separate and distinct disciplines	Clear and discrete view of a discipline	Connections are not made clear for students; less transfer of learning
Connected 	Topics within a discipline are connected	Key concepts are connected, leading to the review, reconceptualization and assimilation of ideas within a discipline	Disciplines are not related; content focus remains within the discipline
Nested 	Social, thinking, and content skills are targeted within a subject area	Gives attention to several areas at once, leading to enriched and enhanced learning	Students may be confused and lose sight of the main concepts of the activity or lesson
Sequenced 	Similar ideas are taught in concert, although subjects are separate	Facilitates transfer of learning across content areas	Requires ongoing collaboration and flexibility, as teachers have less autonomy in sequencing curricula
Shared 	Team planning and/or teaching that involves two disciplines focuses on shared concepts, skills or attitudes	Shared instructional experiences; with two teachers on a team it is less difficult to collaborate	Requires time, flexibility, commitment and compromise
Webbed 	Thematic teaching, using a theme as a base for instruction in many disciplines	Motivating for students, helps students see connections between ideas	Theme must be carefully and thoughtfully selected to be meaningful, with relevant and rigorous content
Threaded 	Thinking skills, social skills, multiple intelligences, and study skills are "threaded" throughout the disciplines	Students learn how they are learning, facilitating future transfer of learning	Disciplines remain separate
Integrated 	Priorities that overlap multiple disciplines are examined for common skills, concepts, and attitudes.	Encourages students to see interconnectedness and interrelationships among disciplines, students are motivated as they see these connections	Requires interdepartmental teams with common planning and teaching time
Immersed 	Learner integrates by viewing all learning through the perspective of one area of interest	Integration takes place within the learner	May narrow the focus of the learner
Networked 	Learner directs the integration process through selection of a network of experts and resources	Pro-active, with learner stimulated by new information, skills or concepts	Learner can be spread too thin, efforts become ineffective

Figure 5. Ten levels of curricula integration (Fogarty, 1991)

Different researches shows the positive effects of curriculum integration. Lipson (1993) summarizes the following findings:

- integrated curriculum helps students apply skills;
- an integrated knowledge base leads to faster retrieval of information;
- multiple perspectives lead to a more integrated knowledge base;
- integrated curriculum encourages depth and breadth in learning;
- integrated curriculum promotes positive attitudes in students;
- integrated curriculum provides for more quality time for curriculum exploration.

School science curriculum reform is a global phenomenon, with change in the form and/or content of science courses often being allied to the specification of standards, goals or levels of attainment that students should achieve at particular stages of their schooling (Jenkins, 2000).

Tasks (assignments)

1. Motivate the statement that an assessment of science content clearly shows it has integral and systemic nature.
2. One of the components of the content of science education is creating optimal conditions for learning sciences. Refer to the circumstances ensuring the possibility of successful implementation of science education curriculum?
3. Define and compare the concepts '*content'* and '*curricula'*. Fill in the table to reach sufficient clarity:

The basic principles of science education	**The basic principles of science education curriculum**

4. Identify and describe the already known types of science education curricula and put them in sequence starting from the lowest level (1) to completed integrity (6):

Curriculum title	Curriculum specificities
1.	
2.	
3.	
4.	
5.	
6.	

5. What are the possible reasons for science curriculum reformations in many countries in Europe at secondary level?

Case study

A week of integrated education *Forest* is organized at school X. When integrating natural sciences with other educational subjects, knowledge of sciences is introduced and educational content is related to the questions considering school environment and students' living place, customs and traditions. The learners are encouraged to show their interest in surroundings, a wish for inquisitiveness is stimulated and a positive children's attitude towards nature and science education is adopted. Following a weekly plan of integrated education prepared by teacher A, the first day of the week involves the classes on the mother tongue, world study and music and discusses the topics dealing with the national lifestyle, forest birds, voices of birds, spelling of future tense verbs and folk songs about birds (listening and singing). The second day of the week includes the classes on the mother tongue, world study, music and a trip to the forest. The learners have to analyse an extract from a literature piece about forest, to get acquainted with the book *Forest Fairy-tales* by a national writer, to describe forest, to observe forest changes in spring, to collect material about nature and to prepare for coming creative work. The activities of the following week days are arranged in a similar way. Such arrangement of work at school evidently helps with acquiring a new knowledge as well as assists in broadening world outlook and forming acceptable behaviour in nature. Applying this educational form works for close relations between students' cognitive and practical activities.

Questions to Case Study

1. Establish the form of the currently designed curriculum and reason your position.
2. What are the difficulties a teacher can face when implementing the above introduced curriculum?

Summary

Training (educational) content is defined by the curricula. They can vary and perform different functions. The science curriculum need to be based on such important didactic principles as humanism, democracy, spiral, integration. Worldwide experience of science education is long and diverse. Detailed implementation of the ideas started only in the second half of the 20th century. School science curriculum reform is a global phenomenon, with change in the form and/or content of science courses often being allied to the specification of standards, goals or levels of attainment that students should achieve at particular stages of their schooling (Jenkins, 2000). Science education curricula can differ in format and purpose. They are distributed into the science education curricula of a particular country and specific integrated educational curricula of sciences. The curricula devoted to natural science development in a particular country differ from the specific curricula dedicated to teach integrated natural sciences. The assessment of science curricula of various countries reveals an essential consistent pattern – the majority of them are much the same. Therefore, the debate on these curricula discloses that they are not suitable for all sociums and ethnic-cultural regions and certainly for educational situations.

Frequently Asked Questions

Why it is necessary to improve science education curricula?

The modern curriculum must focus on various activities which enable students to get to know more about their environment. The new curricula

should be interesting for students. The main point of integrated science curricula is that natural science is now studied as a whole.

Next Reading

Bencze, T., & Hodson, D. (1999). Changing practice by changing practice: Toward more authentic science and science curriculum development. *Journal of Research in Science Teaching*, 36, 521-540.

Beane, J. A. (1997). *Curriculum Integration: Designing the core of democratic education*. New York: Teacher's College Press.

Bonnstetter, R. J. & Yager R. E. (1999). On Research: Building a Constructivitist Approach to Reform. *Science Scope*, 15 (1). National Science Teachers Association, Washington, D.C.

Brooks, J. G. & Brooks, M. G. (1993). *The case for constructivist classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Darling-Hammond, L. & Snyder, J. (1992). Curriculum studies and the tradition of inquiry: The scientific tradition. pp 41-78. In Jackson, P. (Ed.) *Handbook of Research on Curriculum*. New York: MacMillan.

Drake, S. M. (1998). *Creating Integrated Curriculum*. Thousand Oaks: Corwin.

Driver, R., Oldham, V. (1986). A Constructivist Approach to Curriculum Development in Science. *Studies in Science Education*, Vol. 13, p. 105-122.

Fensham, P.J. (1997). Continuity and discontinuity in curriculum policy and practice: case studies of science in four countries. In.: K.Calhoun, R. Panwar and S. Shrum (eds), *Proceedings of 8th Symposium of IOSTE*, Vol. 2, Policy, pp. 32-36, Edmonton.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Ledoux M., McHenry N. (2004). A Constructivist Approach in the Interdisciplinary Instruction of Science and Language Arts Methods. *Teaching Education*, Vol. 15, No. 4, p. 385-399.

Popov, O. (2008). Considering Liberal and Humanistic Values in Science Education Curriculum. *Problems of Education in the 21st Century (Current Research on ICT and Science Education)*, Vol. 3, p. 40-47.

References

Arends R. J. (1998). *Mokomės mokyti*.Vilnius, p. 337-357.

Bentley D., Watts M. (1994). *Primary science and technology. Practical alternatives*. Buckingham*Philadelphia: Open University Press.

Broks A. (2002). Congratulations. Wishing happy birthday to the Journal of Baltic Science Education. *Journal of Baltic Science Education*, No.1, p.5.

Fogarty, R. (1991). *The Mindful School: How to Integrate the Curricula*. Palatine, IL: Skylight Publishing, Inc.

Jenkins, E. (2000). "Science for all": time for a paradigm shift? In.: R.Millar, J.Leach, J.Osborne (eds), *Improving Science Education*. Buckingham, OUP, p. 207-226.

Lake, K. (1994). Integrated Curriculum. *School Improvement Research Series*. Available on the Internet at: http://www.nwrel.org/scpd/sirs/8/c016.html (10.08.2008).

Lamanauskas V. (2001). Gamtamokslinis ugdymas pirmo kurso studentų požiūriu. *Pedagogika*, T.54. p. 93-101.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Lamanauskas V. (2003). Natural Science Education in Lithuanian Secondary School: Some Relevant Issues. *Journal of Baltic Science Education*, No.1, p. 44-55.

Lipson, M., Valencia, S., Wixson, K., Peters, C. (1993). Integration and Thematic Teaching: Integration to Improve Teaching and Learning. *Language Arts,* 70/4, p. 252-264.

Sjøberg, S. (2000). Science and Scientists: The SAS-study Cross-cultural evidence and perspectives on pupils' interests, experiences and perceptions - Background, Development and Selected Results – Acta Didactica no.1. University of Oslo. Revised and enlarged version, 2002.

Available in http://folk.uio.no/sveinsj/

Robinson J.T. (1982). Designing Science Curricula for Future Citizens. *Educational Leadership*, Vol. 39, No. 8, p. 593-595.

Tõldsepp A., Toots V. (2003). Research and development work from the perspective of compiling balanced curricula for science education. *Journal of Baltic Science Education*, No.1, p. 5-11.

Treagust D., Gräber W. (2001). Teaching chemical equilibrium in Australian and German senior high schools. In. H.Behrendt, H.Dahncke, R.Duit et al. (eds). *Research in Science Education – Past, Present, and Future*. Dordrecht: Kluwer Academic Publishers, p.143-148.

Waldrip B. (2001). Primary Teachers` Views About Integrating Science and Literacy. *Australian Primary and Junior Science Journal*, Vol.17, Issue 1.

Unit 8

The Science Education Tools and Ways of Producing them in the Collaboration Process

Objectives:

- To define the peculiarities of science education;
- To perceive that the efficiency of science education and the quality of education results are determined by a mutual collaboration between a teacher and a student;
- To know the tools and ways ensuring favourable conditions for a qualitative process of science education and to have knowledge of the factors determining a choice of science educations forms.

The content of natural science education gives a chance to the dynamics and structure of the educational process. However, the adaptation of natural science knowledge system depends on both the teacher (choosing and applying teaching methods and forms, etc.) and the pupil (the methods of learning, motivation, general abilities). The diversity of teaching and learning content, forms and methods, activities are typical of natural science education. All that makes the educational process effective: develop intellectual knowledge and skills, set out conditions for intense pupils' activities, shape thinking, foster aesthetic feelings, etc.

It is logical that the educational process should be promoted keeping in mind the following regularities:

1. the textbooks, workbooks and other sorts of teaching/learning material of natural science profile, including ***observation and experimentation,*** should be creatively used as an integral part of a balanced curriculum of the educational process. The course of natural science education is mostly auspicious for the development of children's quick eye;

2. pupils have to be provided opportunities and conditions to versatile research, raise questions (general and problematic), to establish and define the main direction of activities. Textbooks should be used to extend and improve knowledge;
3. the integration of natural science material reading and individual experimentation is suitably effective.

The natural science knowledge and skills gained by pupils in the educational process form the content of teaching natural and world science. Anyhow, the process of natural science education includes the teacher and children's activity based on direct and indirect relations. Children are interested in the classes of science when the content of the taught material is comprehensible, attracts attention and imagination, encourages to intensively work and is problematic. A highly effective component of natural science education is the presentation and examining of problems. It can be expressed in three ways: 1) asking questions about the relevant subject; 2) presenting demanding tasks; 3) facing serious problems.

Hence, the following fundamental moments can be emphasized:

- successful natural science education is a sample of the most important concepts of natural sciences (natural science). They explain the main structure of natural sciences and increases the learner's natural science perception moving to the higher form;
- successful natural science education is a sample and discernment of the concepts that deepen and broaden general natural science understanding;
- the understanding of concepts plays a leading role at school as well as in everyday life as they create an opportunity for people to better understand each other, predicates about verbal communication (Arends, 1998);
- in order to explain concepts and phenomena, primary school pupils' thinking peculiarities (ontogenetic aspect) definitely require picturesque specific cases. The most advantageous way to reach an effect is practical children's activities.

Secondary natural science education, first of all, is very complicated for the teacher. It is concerned with teacher competence as well as with his/her motivation in terms of the interaction with nature. Far more relevant aspect is that teachers arrange activities from the position of the adult, i.e. they somehow 'obtrude' the opinion upon children.

Natural science education form is an intrinsic structure of the educational process. The forms of natural science education depend on various factors such as:

- the number of the pupils in the classroom/group;
- an environment/place of the educational process;
- the contingent of the pupils agreeably to the parameters of psychophysiology;
- the applied teaching technology;
- the balance between the teacher and schoolchildren's activities;
- a teacher's natural science and general didactic competence;
- the style of a training process organization, etc.

Modern didactics highly recommends to apply the methods that make the teacher and the pupil's activity more heightened and intense. The following methods could be recommended: netting, the volition-aversion method, interview, nine ribbed "diamond", mixed priority, free writing, the method *I know-I want to know-I have learnt*, the method of intensive specifying, "The book of natural complaints", the essays of variable length, etc. (Lamanauskas, 2001). Work in groups and work with projects become particularly relevant.

Integrated natural science education creates theoretic and practic conditions because (Lamanauskas, 2003):

- an integrated environment (*content, process, forms, activities, etc*.) helps pupils to properly aware that human being and nature is a concern for a number of scientists of different areas and that the concepts of the unity between nature and human being, the majesty of nature, the limitation of universal perception are further formulated;
- the combination of natural science integration with the knowledge (in a broad sense) of other areas (humanities, social, arts, etc.) creates conditions for pupils' socialization, makes their intrinsic world ecologic (*the issue of the ecologic worldview and ecologic consciousness formation*), inspires warm feelings of love, duty, respect and responsibility for nature (ecologic imperative);
- the forms of integrated natural science education (*classes, excursions, conferences, etc*.) produce the media for expressing scientific, creative, spiritual, aesthetic components. Every learner runs an opportunity to obtain interesting and useful information, to express creativity and initiative, to more precisely acknowledge the world.

Interdisciplinary integration does not satisfy the requests of regular classes, and therefore the teacher must look for distinct educational ways and methods. Interdisciplinary integration seems to be the best way to develop schoolchildren's thinking, astute observation, stimulate interest, emotions, self-expression, wish for learning, etc. The teacher must know the following algorithm of their activity:

1. the decision has to be made in order to find out the kind of the applied model of integrated natural science education (interdisciplinary, internal integration, etc.);
2. the main didactic consistent patterns are evaluated (the hierarchy of the elements of the educational system): **Educational objectives** (*Why to teach? What to teach?*) → **educational content** (*What to teach?*) → **educational methods** (*How to teach?*) → **training aids /resources** (*What is used for teaching?*) → **educational forms** (*Where and when to teach?*) → **control and diagnostics** (*What are educational results?*);
3. integrated natural science education curriculum is designed (it reflects the elements of the educational system). Scrupulous attention should be directed to content sampling. Content requires purposefulness (for example, *ecologic – environmental protection* and *value-based* orientation of content);
4. the curriculum of integrated natural science education is implemented and corrections are made.

The integration of natural science education with other educational subjects should present pupils the knowledge of natural sciences as well as the material produced in the textbooks and workbooks that are linked with the current affairs of school, with the customs and traditions of the schoolchildren and their relatives of the inhabited locality. The closest natural objects such as the park, forest, lake, mound, etc. are not out of the way. Hereby, the learners are encouraged to show interest in an environment of their inhabited locality, are stimulated to know more and more, their thoughtful evaluation of nature is developed, etc. Integral natural science education requires a different approach to the educational process itself.

The following forms of natural science education can be applied in school:

- a class/lesson;
- educational/sightseeing excursion (regional, ethnographic, biology studies, etc.);
- home tasks;
- practice;

- field research practice (research work in nature creates a considerable opportunity for developing moral and psychophysical qualities: diligence, independence, humanism, the delight of knowledge, practical research knowledge is acquired, etc.);
- extracurricular/coextensive training (coteries, sections, clubs, etc.);
- projects (local, regional, national or even international level);
- centres of interest, etc.
- advice.

The general educational methods can be applied in school:

1. *narration* (length; content; systematization; true to life; picturesqueness);
2. *interpretation* (delivering questions, encouragement to observe, compare, assess, estimate, summarize, conclude, etc.);
3. *discourse* (reproduction; interpretation; heuristics, etc.);
4. *the usage of published sources* (helps to show interest in data sources and their search; stimulates self-studying, curiosity; fosters emotions, etc.;
5. *demonstration* – observation (real visuals are used; observation and assessment; pupils are given work-material);
6. *demonstration – observation of technical training aids* (instructional videos or their passages; transparencies; audio-recordings; compact discs; computer programs, etc.).
7. *didactic games* (employed in different stages of the training process; stimulates the whole educational process, etc.);
8. *eco-mysteries* (drama performance elements are applied, etc,).

Specific educational methods of the "Introduction into the Science of the World" course:

1. *observation* – (short-term and long-term seasonal observations of natural phenomena; recording observed data; the use of simple devices, etc.);
2. *experimentation* – (objects and phenomena research; the observation of research conditions and factors; the assessment and interpretation of the obtained results; knowledge acquisition and skills development, etc.);
3. *practice work* - (modelling; graphic work; work with devices; work with a project, map, globe, etc.);
4. *experimentation*.

The success of natural science education determines a well organized educational process, properly produced didactic teaching/learning material as well as available teaching resources (stock).

One of the main problems in science education is visualization. Students usually have many problems understanding dynamic three-dimensional processes.

For example, for chemistry teaching and learning exists some interesting tools:

- ChemSense: Shared Responsibilities within A Knowledge Building Environment
- http://chemsense.org/
- ChemViz: Chemistry Visualization of Atomic and Molecular Structures
- http://chemviz.ncsa.uiuc.edu/
- The Molecular Workbench Project
- http://workbench.concord.org/
- Virtual Molecular Dynamics Laboratory
- http://polymer.bu.edu/vmdl/

Some alternative strategies for science teaching are:

- virtual fields trip;
- case studies;
- debates;
- role play;
- posters;
- mysteries;
- mini-conferences;
- concept maps;
- predict-observe-explain (POE);
- engage, explore, explain, elaborate, evaluate (Five Es);
- portfolios;
- oral presentations;
- multimedia presentations;
- collaborative work;
- creating board games etc.

Tasks (assignments)

1. Point out the specificities of science education (i.e. identify the differences between the above mentioned process and oral, mathematical and artistic education).
2. On the basis of the specified arguments prove that the quality of science education and the achieved results is determined by a mutual interaction (direct and indirect) between a student and a teacher.
3. Fill in the table.

Tools required for stimulating and maintaining the process of science education	**Methods of making the process of science education effective**	**Factors determining a choice of science education forms**
1.	1.	1.
2.	2.	2.
3.	3.	3.
...	...	...

4. Which of the teaching methods will you suggest for the teaching of integrated science in secondary school level?

Case study

Teacher X teaches an integrated course on science for upper-secondary school students not interested in studies or other professional activities related to sciences in the future. This course focuses on modern achievements in sciences, life practice and environmental problems. Despite the fact that the integrated course on sciences looks at all topics in broad outline, the teacher intently concentrates on the quality of the educational process:

- beforehand lesson planning foreseeing optimal visual and training aids, choosing relevant teaching/learning material and considering the strategy of evaluating students' achievements;
- creates helpful teaching/learning environment using modern tools that help with offering favourable possibilities of observing and testing virtual environment;
- vividly presents relevant attractive theoretical teaching/learning material in the classroom, primarily focuses on describing concepts and terminology.

The described situations only show that certain aspects of science education are paid scant attention which makes the impact on the quality of both the self/educational process and the results of self/education.

Questions to Case Study

1. Identify the problems a teacher can face during the educational process.

2. Referring to the above introduced example, create a model of the science education process based on the principles of a direct interaction between a student and a teacher and constructivistic teaching/learning.

Summary

There are different strategies and methods for teaching science. Also there are many different ways in which science teachers can effectively teach students. The problem consists in that how to choose the most effective methods and strategy in each concrete situation. It is obvious, that the information itself is known as the *content*; how that content is shared in a classroom is dependent on the teaching methods. For example, lecture is a way of providing students with basic knowledge. On the other hand it is well known that lecture has the least impact on students as well as the lowest level of student involve-

ment. It is not so good from point of view of constructivistic teaching. The one of the main points of constructivistic approach is to increase the level of impact and involvement for students. It is clear that reflective inquiry has the highest level of student involvement. On the other hand, reflective inquiry offers opportunities for students to use knowledge in a productive and meaningful way. Different methods can be effectively used in science teaching: lecture, reading information, audio-visual presentation, demonstration, observation, field trips, interviewing, brainstorming, small group discussions, experimenting, problem-solving activities etc.

Frequently Asked Questions

What is it mean "horizontal teaching"?

This term meant that when teachers take students by the hand and lead them on a voyage of discovery (discovery learning theory), stimulating their observation and experimentation skills (learning by doing), imagination, curiosity and reasoning capacity – enhances students` intellectual and manual capacities remarkably.

Next Reading

Arroio, A. (2007). The Role of Cinema into Science Education. *Problems of Education in the 21st Century (Science Education in a Changing Society)*, Vol. 1, p. 25-30.

Chang, C.Y., (2002). Does computer-assisted instruction + problem solving = improved science outcomes? A pioneer study. *Journal of Educational Research,* 95 (3), pp. 143-150.

Gunstone, R.F., Tao, P.K., (1999). Conceptual change in science through collaborative learning at the computer. *International Journal of Science Education,* 21 (1), pp. 39-57.

Hoadley, C.M., Linn, M.C., (2000). Teaching science through online, peer discussions: Speakeasy in the knowledge integration environment. *International Journal of Science Education,* 22 (8), pp. 839-857.

Hola, O. (2007). Computer-Based Education in Physics. *Problems of Education in the 21st Century (Science Education in a Changing Society)*, Vol. 1, p. 45-49.

Jonassen, D. H. (1991). Objectivism vs. Constructivism. *Educational Technology Research and Development*, 39(3), p. 5-14.

Kumpalainen, K., Mutanenen, M., (1998). Collaborative practice of science construction in a computer-based multimedia environment. *Computers & Education,* 30 (1-2), pp. 75-85.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Lamanauskas V. (2007). The Augmented Reality Teaching /Learning Platform: New Challenges and New Possibilities to the Users. In.: *Information and Communication Technology in Natural Science Education – 2007* (Proceedings of International Scientific Practical Conference). Šiauliai: Publishing House of Šiauliai University, p. 6-7.

Linn, M.*, et al.*, (1998). Using the internet to enhance student understanding of science: The knowledge integration environment. *Interactive Learning Environments*, pp. 4-38.

Parkinson, J., (1998). The difficulties in developing information technology competencies with student science teachers. *Research in Science and Technological Education,* 16 (1), pp. 67-78.

Pedersen, S., Liu, M., (2003). Teachers' beliefs about issues in the implementation of a student-centred learning environment. *Educational Technology Research & Development,* 51 (2), pp. 57-76.

Pintrich, P. R. (1995). Understanding self-regulated learning. *New Directions for Teaching and Learning*, 63, p. 3-12.

Thomas, G.P., (2001). Toward effective computer use in high school science education: Where to from here? *Education and Information Technologies,* **6** (1), pp. 29-41.

Trindade, J.*, et al.*, (2002). Science learning in virtual environments: A descriptive study. *British Journal of Educational Technology,* 33 (4), pp. 471-488.

References

Arends R. J. (1998). *Mokomės mokyti*.Vilnius, p. 337-357.

Lamanauskas, V. (2001a). *Gamtamokslinis ugdymas pradinėje mokykloje /Pasaulio pažinimo didaktikos pagrindai/*. Šiauliai.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Units 9 & 10

A Constructivist Approach to Integrated Science Education: Teaching Would-be Teachers to do Science

Designing a Integrated Science Methods Course for Initial Science Teachers

Objectives:

- To perceive the specificities of work experienced by a teacher following the instructions of constructivistic teaching/learning;
- To perceive that the specificities of work experienced by a teacher following the instructions of constructivistic teaching/learning make the impact on the process of training pre-service teachers. Find relation between the above mentioned perception and individual Experience;
- To analyze how teacher's competence in sciences as one of the constituents of professional competence is important for the process of science education;
- To know the main principles of training the teachers of sciences.

Learner-centered approaches to teaching and schooling require supportive policies for preparing effective educators. Moving from constructivist philosophy, psychology and epistemology to the characterization of constructivist teaching and learning environments presents a challenge. Constructivist philosophy does not dictate how one should teach; however, it does make it incumbent upon the teacher to deal with each learner as an individual, to value diversity of perspective, and to recognize that the learner's behavior is a direct reflection of his / her life experiences. Bandura (1977, 1986, 1995, 1997), Fullan (1993), and other self-efficacy researchers have concluded that the catalyst for educational reform is the individual teacher and that a teacher's behaviors,

values, beliefs, and ambition to act may be enhanced or suppressed during student teaching.

Constructivist science teacher preparation programs are intentionally designed to be transformational, not just informational. Preservice teachers are constantly given opportunities to make new connections in a setting focusing on personal empowerment and critical reflection. The programs challenge preservice teachers to move toward self-directed life-long learning (Ronald J. Bonnstetter, 1998).

The main mission for students in preparing to become educators is to learn procedures for proper education, the basics of teaching science, and the skill of conducting the process whereby students obtain knowledge. Young educators must be well familiar with teaching procedures, methods and methodical steps so as to be able to utiline tiese successfully in his or her work in various classes and under various conditions. When studying at university, students must not only become familiar with the theoretical foundations of science methodology, but also with their practical applications (Keirans, 2002).

Natural science competence of basic school teachers is one of the constituent parts of general professional competence. It is obvious that the students, would-be teachers should receive considerably high education in the field of natural science education in the process of studies.

Educational literature distinguishes the coming crucial moments:

- science teachers have to learn knowledge of the content of science, general psycho pedagogical knowledge, and theoretical knowledge of science education (Mellado, Blanco, Ruiz, 1999);
- science is an increasingly important component of school curriculum across much of the world; teachers` lack of subject knowledge in science has been documented and frequently identified as a barrier to implementation of curriculum reform and to pupil progress (Asoko, 2000, p.79);
- the content of school science must change. Its conceptual content must be more selective, and taught in a manner that gives these powerful ideas coherence and linkage (Fensham, 2000, p.161);
- a basic prerequisite for change is teachers` "*self-development*' or "*self-cultivation*" (Terhart, 1999).

"Teachers, as professionals, should have historical and philosophical knowledge of their subject matter quite independently of whether this knowledge is directly used in classrooms: teachers ought to know more about their subject than they are required to teach" (Matthews, 2000, p. 334).

Systemic, integral natural science training of teachers is extremely important to the process of natural science competence development. On the other hand, competence has to be examined in a general cohesive system:

Natural science background standards –natural science competence of the teacher – the mastership (pedagogic) of activity – the results of natural science education

The competence of natural sciences teachers should be perceived as a system every component of which is fundamental. Natural science literacy is a core that is basically acquired in comprehensive school (*natural science education as a component of general education*). An appropriate natural science qualification and the level of competence are obtained in higher school. A decisive moment is a permanent improvement of competence during practical activities of the teacher.

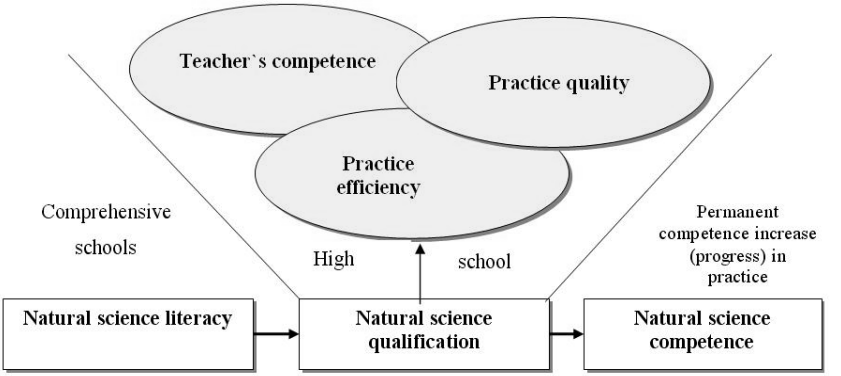


Figure 6. The competence of natural sciences' teachers as a system

Considering the changes of paradigms (for example, learning is in the prior position to teaching), the following ***objectives of natural science education*** can be raised in higher school:

- to ascertain the correlation between knowledge of nature and the phenomena important to society (for example ecology, environment protection, economics, healthy way of life, etc.);

- to extend and improve knowledge of the closest environment, to spark interest in the animate world;
- to demonstrate knowledge of the macro, mezzo and micro world as a tune of the three correlating systems and the place of human being in nature and his/her impact on it (anthropogenic aspect);
- to develop active students' relations with an environment, respect for nature (nature appreciation) and responsibility for it;
- to promote interest in the latest strategies of natural science education in the foreign countries;
- to become familiar with a world of modern technologies, to develop abilities in order to share natural science experience;
- to enhance students' understanding of the interaction and intercourse between animate and inanimate nature;
- to deepen comprehension of the most important natural science ideas and phenomena;
- to prove students' competence in natural sciences, to strengthen the cognitive interaction with nature etc.;

Objectives of methodical training (readiness):

- to learn to coordinate and concretize practical pupils' work considering the specificity of school (environment, resources, etc.);
- to perceive and realize the specificity of the integrated teaching/learning courses, to master to decide on the teaching material corresponding to pupils' experience;
- to find out and understand an individual and pedagogic-psychological readiness to teach the subject (teaching process establishment and control) in lower and upper secondary school;
- to manage to equip a material-technical facilities for the science classes;
- to succeed in applying professional and pedagogic-psychologic knowledge, to be able to plan classes and extra curricular activities;
- to establish conditions for students to develop abilities necessary to explain pupils the importance of natural science knowledge to their individual lives;
- to encourage to understand and to apply the significance of research activity methods, to develop abilities to obtain, receive and present information using the latest technologies of information (for example, natural science education database development, etc.)

- to set out conditions for students to work self-sufficiently (particularly with projects), etc.

Social training objectives are also important, and therefore cannot be forgotten. Thus, we have:

- to enhance understanding that the emphasis of value-based attitudes is an important striving of education;
- to acknowledge, perceive and respect human freedoms, rights and duties of every person as well as of the whole democratic society;
- to explore individual possibilities and ways to be involved into public life, to accept responsibility for the future of the nation;
- to realize the preconditions, possibilities and responsibility for the participation in the ruling on the contemporary democratic state and its institutions;
- to reveal contemporary tendencies of democracy evolution in the world;
- to enhance understanding that personal solutions to concrete situations most frequently are governed by value-based attitudes;
- to enrich comprehension that individual activities are very important to abilities development and value-based attitudes fostering;
- to appreciate ability to communicate and contribute, to seek and receive an answer to tricky questions;
- to manage to shape a personal opinion, to critically evaluate individual competence, to continually search for alternative decisions;
- to succeed in applying acquired knowledge in every day life.

Shulman (1986) also suggests that teachers can learn the knowledge needed during practice through stories or cases. It is clear that teachers` training programs has to be in accordabce with the following fundamental principles (Kokkotas, 2003):

- the aim of teachers` in-service training is by using teachers` views and practices to achieve appropriation of knowledge and competencies in some important teaching and learning aspects of science;
- in-service science teachers following a professional development program are learners who actively construct their own theories about teaching and learning. This is achieved through their personal teaching experience and determined by their attitudes and beliefs;
- the quality, breadth, and flexibility of teachers` practices they use in the classroom are tightly connected with their professional development;

- the teaching and learning processes receive continuously support from teachers who attend professional development programs, and offer opportunities allowing them to interact with colleagues and exchange experience on these processes.

In general, excellent science teacher preparation and professional development programs have some common characteristics. In such programs, prospective and practicing science teachers (The Association for Science Teacher Education, 2008):

- participate in collaborative professional settings with peers, expert science teachers, science teacher educators, and pure and applied scientists.
- engage in activities that promote their understanding of science concepts and the history and nature of science;
- experience strategies for effective science teaching and inquiry including meaningful laboratory and simulation activities using contemporary technology tools;
- question and evaluate evidence and justify assertions scientifically;
- develop science-specific pedagogical knowledge grounded in contemporary scholarship;
- engage in substantive clinical experiences where they develop and implement lesson plans appropriate for students from diverse backgrounds, assess their success on student learning, and plan next steps to improve their teaching;
- find and use credible information about the safe and effective use of laboratory activities, independent science projects, science fairs, field trips, simulations, computer tools, and curriculum resources.

Tasks (assignments)

1. Describe the teachers of sciences working under the instructions of constructivistic teaching/learning. Identify the specificities of the style of work and impact on the process of learning (training preservice teachers of sciences)?

2. How is teacher's competence in sciences as one of the constituents of professional competence important for the process of science education?
3. Point to the main principles of training teachers of sciences.

Case study

At least a few higher schools in state N training the teachers of sciences work towards similar goals:

- to ascertain the correlation between knowledge of nature and the phenomena important to society (for example ecology, environment protection, economics, healthy way of life, etc.);
- to extend and improve knowledge of the closest environment, to spark interest in the animate world; to develop active students' relations with an environment; to deepen comprehension of the most important natural science ideas and phenomena;
- to demonstrate knowledge of the macro, mezzo and micro world as a tune of the three correlating systems and the place of human being in nature and his/her impact on it (anthropogenic aspect); to develop respect for nature (nature appreciation) and responsibility for it;
- to become familiar with a world of modern technologies, to develop abilities in order to share natural science experience;
- to enhance students' understanding of the interaction and intercourse between animate and inanimate nature; to prove students' competence in natural sciences, to strengthen the cognitive interaction with nature etc.;
  Thus, the pre-service teachers of sciences are provided a solid theoretical basis.

Questions to Case Study

1. Do you think the above mentioned theoretical basis allows the young teachers of sciences to work in schools following the principles of constructivistic teaching/learning?

2. What are the objectives for training pre-service teachers of sciences in higher school primarily applied in your individual practice? Fill in the table pointing out 3 most important objectives for learning:

Objectives of natural science education	Objectives of methodical training (readiness)	Social training objectives

Summary

Learner-centered approaches to teaching and schooling require supportive policies for preparing effective educators. Moving from constructivist philosophy, psychology and epistemology to the characterization of constructivist teaching and learning environments presents a challenge. For pre-service science teachers is very important to understand how secondary school students interact in the classroom; to understand how secondary school students respond to different teaching techniques; to gain experience in classroom teaching under the guidance of experienced teachers; to practice teaching in their own discipline and other subject areas; to gain experience in planning thematic units and understanding how a teaching team functions. A teacher is the key of the teaching process. Along the organization of integrated teaching the teacher has a big influence on schoolchildren. The awareness and assessment of the format of this influence helps the teacher to reveal what should be changed and improved in the process of integrated teaching. Competent science teachers have a direct, positive effect on students' learning. Science teachers must have a deep understanding of how people learn science as well as skills and dispositions grounded in that knowledge that enable them to promote meaningful learning at their levels of science teaching. It is clear, that new teachers at schools need special science-specific teaching support during their first years of teaching to enable them to apply their science and pedagogical knowledge and skills successfully. Such a system of support need to be developed. Also science teachers

must be prepared to meet the needs of their students and communities, grow by participating with others in the science education community, and participate in the development of science education.

Frequently Asked Questions

Why the integrated science teaching is so important?

It is obvious, that integrated science teaching is important, because:

- such form of teaching improve coherency among the various individual science subjects: physics, chemistry, biology;
- integrated science teaching realizes interrelated experiences, which make learning effective and meaningfull;
- integrated science course provides students with opportunities to develop a wide range of skills that will be useful in future life.

Next Reading

Adams, P.E., & Krockover, G.H. (1997). Concerns and perceptions of beginning secondary science and mathematics teachers. *Science Education,* 81, 29–50.

Ashton, P.T. & Webb, R.B. (1986). Making a difference: Teachers' sense of efficacy and student acheivement. New York: Longman.

Crawford, B.A. (1999). Is it realistic to expect a preservice teacher to create an inquiry based classroom? *Journal of Science Teacher Education*, 10, 175-194.

de Vries, M. J. (1994). *Science and technology teacher training: What training for what type of teaching?* Strasbourg: Council of Europe.

Gaskell, J. P. (1982). Science, technology and society: Issues for science teachers. *Studies in Science Education*, 9, p. 33-46.

Gillies, R. M., Boyle, M. (2008). Teaching and Teacher Education. *An International Journal of Research and Studies*, Vol. 24, No. 5, p. 1333-1348.

Hansen, K. H., & Olson, J. (1996). How teachers construe curriculum integration: The science, technology, society (STS) movement as Bildung. *Journal of Curriculum Studies*, 28, p. 669-682.

James A. Rye, Andrew D. Katayama (2003). Integrating Electronic Forums and Concept Mapping With a Science Methods Course for Preservice Elementary Teachers. *Electronic Journal of Science Education*, Vol. 7, No. 4. Available via Internet: http://ejse.southwestern.edu/original%20site/manuscripts/v7n4/articles/art02_rye/RYE.PDF

Yager R., Enger S., Guilbert A. (2002). *Models of Science Teacher Preparation*. Iowa: University of Iowa.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Lamanauskas V. (2003). Several Aspects of Scientific Competence of Primary School Would-be Teachers. In.: K.M. Sormunen, V.A.Tarasov, S.R. Bogdanov (eds.) *Mathematics and Science Education in the North-East of Europe: History, Traditions & Contemporary Issues* (Proceedings of the Sixth Inter-Karelian Conference). Joensuu: Joensuu University Press, p.283-293.

Lamanauskas V., Gedrovics J., Korozhneva L., Melnik E. (2005). Teacher Training in Lithuania, Latvia and Russia: Some Theoretical and Practical Aspects. *Spring University. Changing Education in a Changing Society*, No. 1, p. 152-158.

Laporte, J. and Sanders, M. (1993). The T/S/M integration project. *The Technology Teacher,* 52(6), 17-22.

Loucks-Horsley, S., Hewson, P. W., Love, N., Stiles, K. E. (1998). *Designing Professional Development for Teachers of Science and Mathematics*. Corwin Press, Inc., A Sage Publications Company.

National Science Teachers Association (2003). *Standards for Science Teacher Preparation*, Arlington, VA: National Science Teachers Association.

Mak S. Y., Yip D. Y., Chung C.M. (1999). Alternative Conceptions in Biology-Related Topics of Integrated Science Teachers and Implications for Teacher Education. *Journal of Science Education and Technology*, Vol. 8, No. 2, pp. 161-170.

Mattoo, J. N. (1990). *Reflections of a science teacher, new trends in science teaching*. UNESCO.

Shymansky J. A. (1992). Using constructivist ideas to teach science teachers about constructivist ideas, or teachers are students too! *Journal of Science Teacher Education*, Vol. 3, No. 2.

Rubba, P. A. (1991). Integrating STS into school science and teacher education: Beyond awareness. *Theory into Practice*, 30(4), p. 303-308.

References

Alawiye, Osman; Plourde, Lee A. (2003). Constructivism and elementary pre-service science teacher preparation: knowledge to application. *College Student Journal*.

Asoko H. (2000). Learning to teach science in the primary school. In.: R.Millar, J.Leach and J.Osborne (eds.) *Improving Science Education*. Buckingham: Open University Press.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1989). Juman agency in social cognitive theory. American Psychologist, 44, 1175-1184.

Bandura, A. (1995). Self-efficacy in changing societies. New York: Cambridge University Press.

Bandura, A. (1997). Available: http://education.indiana.edu/~cep/courses/p540/bankbio.html.

Bonnstetter Ronald J. (1998). Inquiry: Learning from the Past with an Eye on the Future. *Electronic Journal of Science Education*, Vol. 3, No. 1.

Fensham P. (2000). Providing suitable content in the "science for all" curriculum. In.: R. Millar, J. Leach and J. Osborne (eds.) *Improving Science Education*. Buckingham: Open University Press.

Fullan, M. (1993). The complexity of the change process., Change forces: Probing the depths of educational reform (pp. 19-41). London: The Falmer Press

Keirans L. (2002). Development of Teaching Methodologies in the Field of Biology. *Journal of Baltic Science Education*, Vol.1, No. 1, p. 36-43.

Kokkotas, P., Piliouras, P., Malamitsa, A., Maurogiannakis, M., Stamoulis, E. (2006). In-service science teachers` professional development and the role of new technologies: a literature review. In. *Science and Technology literacy in the 21st Century*, Vol. 1. Cyprus.

Matthews M. R. (2000). *Time for science education*. New York.

Mellado V., Blanco L., Ruiz C. (1999). A framework for learning to teach sciences in initial primary teacher education. In.: *Research in Science Education in Europe* (Edited by Bandiera M., et al.). Dordrecht: Kluwer Academic Publishers, p.273-280.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(1), p. 4-14.

Terhart E. (1999). Developing a professional culture. In: M.Lang, J.Olson et al. (eds). *Changing practices/changing schools: Recent research on teachers` professionalism*. Leuven: Garant, p.193-201.

The Association for Science Teacher Education (2008). Available on the Internet at: http://theaste.org/aboutus/AETSPosnStatemt1.htm (05.08.2008).

Unit 11 & 12

Contextual Teaching and Learning of Integrated Science in Lower and Upper Secondary Schools.

The Specificities of Integrated Science Teaching in Lower and Upper Secondary School.

Objectives:

- To perceive the specificity and significance of science education at lower and higher stages of secondary school.
- To find out why a positive emotional students' disposition in terms of science education is so important for the above mentioned stages of secondary school.
- To analyze teacher's role in the process of teaching an integrated course on sciences in the forms of lower and upper secondary school.
- To specify the integration levels of different branches of sciences.

Natural science education is usually integrated in forms 5 and 6 of basic school. Obviously, this is a crucial period as:

- the fifth-formers start learning individual subjects; they are taught by several teachers, new educational subjects appear, the problems of adaptation, etc. occur. One of the key issues is the sponsion of integrated natural science education in forms 5 and 6;
- natural science background acquired in primary school is further developed in forms 5 and 6, active learning of individual science subjects in higher forms approaches; the situation partially determines a choice of sciences in forms 11 and 12. Motivation is highly important in this case. Interest in natural sciences is rather low in most of the countries (Lukason, 1997);

- a sensual – affective component is still prevailing. Effective natural sciences teaching based on children's intellect is not the only and the foremost task. Their mind and senses should be involved. In order to reach the goal, the expedient usage of art classes should be helpful.

A. Blum (1994) notices that integrated science curricula differ in the degree to which they are integrated, with distinctions being made between coordination, combination, and amalgamation (full integration) (p. 2901).

Pedagogy literature, obviously, debates and assesses various integrated teaching aspects of teaching, didactics and methodology. Different authors have unlike approaches to this issue. A part of them (Naumčenko, 1996; Makarkin, 1996; Kiričiok, 1997, etc.) agree that education space has to exist as the organic wholeness. The majority of the representatives of American educology (Boyer, 1983; Goodlad, 1983; Collins, 1989; Brown, 1989, etc.) encourage the integration of education, work and free time. However, one of the questions holds no discussions – the teacher plays a key role in the educational process. Teaching quality directly determines pupils' learning (Sandoval, 1995), and therefore teachers themselves have to know more about the styles of teaching/learning and diverse ways of work organization (Vaitkevičius, 1995; Eric V. Tsang, 1997; Gedrovics, 1997). The problems of a different format of integrated curricula exist. For example, most of the countries have the so called curricula of humanities and natural sciences (in higher forms). Lithuanian comprehensive school that gives secondary education started profiled teaching in 2000-2001. The problem remains the same – teaching natural sciences in profiled school. According to J. Gedrovics (1997), the preparation process of the integrated curriculum should evaluate that an integrated course is not a simple mixture of topics of chemistry, physics or biology. Therefore, priority has to be given to the integrated style of teaching (Gedrovics, 1997). A. Tõldsepp and V.Toots (2003) prefer balanced curricula (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). V.Dabrišienė (1997) maintains that the curricula of integrated teaching must satisfy the following requirements:

- quantitative changes of an ordinary curriculum, making it "easier" or "heavier" cannot be the means of restriction;
- the needs and opportunities of exclusive schoolchildren must be evaluated;
- should be designed in order to meet an exclusive pupils' style of learning and recommended methods of teaching;

- should reflect the specificities that make these pupils different among their contemporaries.

P. Shlesinger also pays attention to the teacher. He says that the role of the teacher becomes even more significant in the process of integrated teaching as teachers have to cooperate, take decisions, look for effective methods to retain teaching material for a longer period of time (Shlesinger, 1996). The importance of the teacher to successful systemic (integral) teaching is stressed by a number of authors (Fink, 1985; Risholm, 1997; Johannessen, 1997; Mikalsen, 1997; Gedrovics, 1997, etc.). P. Jarvis supposes that the integration of educational subjects should guarantee reflective (involved) teaching/learning through practic experience. Therefore, the author treats learning in a different way. P. Jarvis understands learning as changes of behaviour, as the result of experience and practice (Jarvis, 1993). Z. Alaunienė is certain that, "no matter how good the educational curricula or textbooks should be designed the final integration depends on the teacher. Only s/he observes how a student perceives and acquires knowledge, only s/he coordinates training, gives assignments to develop the learner's abilities and skills" (Alaunienė, 1991). Along integrated education the teacher has enormous influence on schoolchildren. With awareness and analysis of the format of this influence the teacher can be the best to notice what should be changed or improved in the process of integrated education. In this case, regular contemplation of personal activities and competence, self-assessment, understanding of the permanent alteration of educational paradigms is necessary.

Most educators would agree that the basic tenets of constructivism describe the way we have "always known that people learn." Still some teachers resist constructivist pedagogy.

Teacher education programs must begin to foster in beginning teachers of all disciplines new images of collaboration, involvement, and inquiry-images of classroom environments where students of all cultures engage in interdisciplinary activities and construct knowledge rooted in their own personal experiences.

Researchers agreed that it is important to improve science teaching in comprehensive school. For improving it is necessary to (Chi, 1992; Diakidoy, Kendeou, 2001; Smith, Maclin, Grosslight, Davis, 1997):

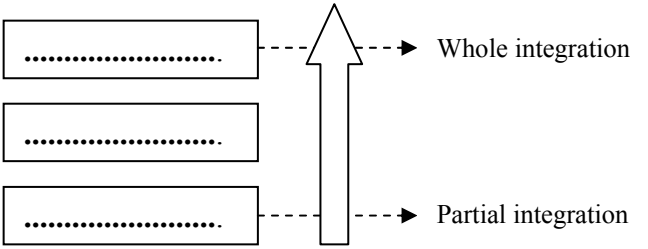
1) explicitly talk about preliminary everyday knowledge to make it conscious;
2) show the inconsistencies between everyday and scientific explanations and their reasons;

3) verbally teach the new explanations and give time to think and discuss about them;
4) use models and analogies to enhance the understanding.

We consider that integrated teaching, if involved into the sociocultural context, will help the student to comprehend the causal relations. It will develop the personality and form moral orientations and standpoints together with habits to independently apply the acquired knowledge in real life situations. Such teaching and learning are characterized by integrity. Integrated teaching diminishes inconsistencies between the knowledge that separate subjects impart as well as the necessity and inevitability of the synthesis. The only fact of presenting the content is not the essence of teaching. The main point is work, a widely sided and motivated activity. In order to direct the teaching process in the desirable direction, it is imperative to encourage the motivation for learning. In this respect the principle moment cannot be neglected. A student cannot only master but also apply the basic knowledge in practice. Therefore, the duty of every teacher is to reveal and show to the students their potential powers (Lamanauskas, 2003).

Tasks (assignments)

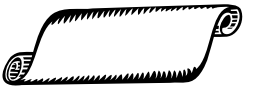
1. What are the specificities of science education at the stages of primary and secondary education? How is the significance of science education expressed at the above mentioned stages?
2. With reference to the principles of constructivistic teaching/learning, knowledge of psychology at different age stages and/or practical experience, reason the idea presented in learning material that *a sensual – affective component is still prevailing. Effective natural sciences teaching based on children's intellect is not the only and the foremost task.*
3. Define teacher's role teaching an integrated course on sciences in the forms of lower and upper secondary school.
4. Describe different integration stages of sciences: *coordination, combination* and *amalgamation* (A. Blum, 1994). Put the above introduced levels of integration considering a degree of integration starting from the lowest one:



Case study

As it was mentioned in the above presented theoretical material of the module, profiled teaching in Lithuania was introduced in 2001. On the basis of the previously mentioned provisions for learning, the integrated course on sciences is devoted to the upper secondary school students of forms 11 and 12 preferring a humanitarian profile of learning and interested in choosing the follow-up studies or types of professional activities other than sciences. This course concentrates on modern achievements in sciences, life experience and environmental problems. All topics are examined in broad outline, the evolution of sciences is described as a method of acknowledging nature, the issues of personal and public life are emphasized, natural phenomena, scientific ideas and experiments are given more thorough analysis. The integrated course on sciences is devoted to help a learner with pursuing general science education and developing the ability to distinguish between scientific and non-scientific issues as only a sufficiently sophisticated person can be actively involved in solving the problems of a modern country. The course assists the learners in perceiving the significance of sustainable development ideas and protecting biosphere and the quality of public life

Questions to Case Study



1. What is the degree of the integration (A. Blum, 1994) of sciences discussed in the above presented example? Reason your position.
2. What extent of science content should be presented to the students of the humanitarian profile?

Summary

Contextual Teaching and Learning (CTL) integrates inquiry, problem- and project-based learning, cooperative learning. Contextual teaching and learning undoubtedly is consistent with a constructivist approach for the teaching of science in secondary schools. Contextual science teaching usually include inquiry learning, problem-based learning, cooperative learning, project-based learning, and authentic assessment. It is obvious, that learners and contexts differ, there can be no single best approach for the teaching of science. Effective teaching and learning in science requires a variety of approaches.

Frequently Asked Questions

How students learn science? How this process is going on?

The most researchers agree that:

- science learning is difficult. Usually the majority of students have difficulty understanding science concepts; also students have limited experiences;
- science learning is characterised by misconceptions, which have been noted in practically all subject areas of science;
- science learning is inert. Inert knowledge is considered to be knowledge accessible only in a restricted set of situations.

Next Reading

Barman, C. (1997). The learning cycle revisited: A modification of an effective teaching model. [Monograph #6]. Washington, DC: Council for Elementary Science International.

Brooks, J. G. & Brooks, M. G. (1993). The case for constructivist classrooms. Alexandria, VA: Association for Supervision and Curriculum Development.

Hacker, R. G. (1984). A typology of approaches to science teaching in schools. *International Journal of Science Education*, Vol. 6, Issue 2, p. 153-167.

Kahle, Jane Butler, Riley, D. (1993). Gender differences in science education: building a model. *Educational Psychologist*, Vol. 28, Issue 4, p. 379-405.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practice. In V. Richardson (Ed.), Constructivist teacher education: Building a world of new understandings (pp. 3-14). Bristol, PA: Falmer.

References

Alaunienė Z. (1991). Mokymo turinio integracijos problemos. *Tautinė mokykla*, Nr.7, P.16-18.

Blum A. (1994). Integrated and General Science. In.: T. Husen, T.N.Postlethwaite (eds.) *The International Encyclopedia of Education*, Vol.5, P. 2897-2903.

Boyer E. L. (1983). *High School: a Report on Secondary Education in America*. New-York.

Brown J.S., Collins A., Duguid P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, Vol.18 (1), P. 32-41.

Chi, M. (1992). Conceptual change within and across ontological categories: Examples from learning and discovery in science. In: R. Giere (Ed.) *Cognitive models of science. Minnesota Studies in Philosophy of Science, 15* (pp. 129-187). Minneapolis: University of Minnesota Press.

Dabrišienė V. (1997). Integruoto ugdymo programų principai ir jų sudarymo modelis. Kn.: *Edukologija. Kalbotyra. Literatūrologija* (I respublikinės doktorantų ir jų mokslinių vadovų konferencijos medžiaga). Vilnius, p. 145-149.

Diakidoy, I.-A., & Kendeou, P. (2001). Facilitating conceptual change in astronomy: A comparison of the effectiveness of two instructional approaches. *Learning and Instruction*, 11, 1-20.

Goodlad J. I. (1983). *A Place Called School: Prospects for the Future*. New York.

Jarvis P. (1993). The Learning Process and Late Modernity. *Scandinavian Journal of Educational Research*, Vol.37 (3), P. 179-190.

Johannessen T.A., Gronkauy K., Risholm N.S., Mikalsen Q. (1997). What is Important to Students? Exploring Dimensions in Their Evaluations of Teachers. *Scandinavian Journal of Educational Research*,Vol. 41(2), P. 165-177.

Kaufman, D. Brooks J. (1996). Interdisciplinary Collaboration in Teacher Education: A Constructivist Approach. *TESOL Quarterly*, Vol. 30, No. 2, pp. 231-251.

Lamanauskas V. (2003). Natural Science Education in Lithuanian Secondary School: Some Relevant Issues. *Journal of Baltic Science Education*, No.1, p. 44-55.

Lukason A. (1997). Natural Science – popular or distained subjects? In.: *Science and Technology Education for Social and Economic Development* (Second IOSTE Symposium for Central and East European Countries). Liublin, p.21.

Sandoval J. (1995). Teaching in Subject Matter Areas. *Annual Review of Psychology*, Vol.46, P. 355-375.

Schlesinger Phyllis F. (1996). Teaching and Evaluation in an Integrated Curriculum. *Journal of Management Education*, Vol. 20(4), P.479-486.

Smith, C., Maclin, D., Grossligth, L., & Davis, H. (1997). Teaching for understanding: A study of students' preinstruction. Theories of matter and a comparison of the effectiveness of two approaches to teaching about matter and density. *Cognition and Instruction*, 15, 317-393.

Tõldsepp A., Toots V. (2003). Research and development work from the perspective of compiling balanced curricula for science education. *Journal of Baltic Science Education*, No.1, p. 5-11.

Tsang Eric W. K. (1997). Organizational Learning and the Learning Organization: A Dichotomy Between Descriptive Research. *Human Relations*, Vol.50 (1), P. 84-85.

Vaitkevičius J. (1995). *Socialinės pedagogikos pagrindai*. Vilnius: Egalda.

Гедровиц Я. (1997). Опыт составления интегрированной программы курса "Естествознание" для гуманитарной средней школы. В кн.: *Профессиональная культура педагога как определяющий фактор*

обновления школы. Витебск, с. 61.
Киричёк П. (1997). Интегральная форма образования. *Высшее образование в России*, №1, С. 154.
Макаркин Н., Наумченко И. (1996). *Интеграция региональных систем образования: из опыта работы регионального учебного округа Мордовского университета*. Саранск.

Unit 13

The Evaluation Strategies of Integrated Science Teaching /Learning

Objectives:

- To perceive and define an evaluation of integrated science self/education as a systemic process.
- To perceive the goal, object and methodology of the evaluation of integrated science self/education;
- To analyze the different strategies of the evaluation of integrated science self/education;
- To manage to choose an optimal strategy for evaluation considering the evaluated object.

In educational literature we can find different definitions on evaluation. Evaluation is the pay-off of description – it is the synthesis of descriptive information and criterial information according to very strict and difficult rules (Scriven, 1975). Evaluation can be characterised as the process by which people make judgements about value and worth; evaluation is the process by which people make value judgements about things (Oliver, 2000).

It is obvious that evaluation is a delicate and sensitive task. On the other hand, it is not a simple and obvious process. Usually evaluation has its formal and informal sides.

The main questions are:

- what is to be evaluated?
- when and why evaluate?
- how to evaluate?

There are two main evaluation strategies: formative and summative evaluation. The main characteristics of these two forms are presented in the table below.

Formative evaluation (usually occurs early in the teaching process)	**Summative evaluation** (usually occurs at the end of the teaching process)
specific; relevant; contextual; diagnostic; flexible	valid; reliable; based on data that measures quality; formal;

The evaluation of the integrated science teaching is carried out at different levels and with the different purposes. One of the most important evaluation object is science curriculum. In many schools, evaluation of the curriculum is often an informal undertaking. Usually science teachers discuss the development of work at team or staff meetings and plan changes for the future. Results of an evaluation must be analyzed to draw concrete conclusions and recommendations for all process of teaching and learning. If we talking about curriculum evaluation there are six steps to effective evaluation (Bentley, Watts, 1992):

- deciding on the purpose;
- what will be evaluated?
- preparing evaluation plans (who should evaluate"; drawing up the plans; planning resources; reporting the results; drawing up operational guidelines for an evaluation);
- collecting evidence;
- deciding on the evaluation methods/instruments (questionnaires and checklists; classroom observation; structured interviews; personal documents and diaries; content analysis etc.);
- using the information to make judgements.

Different models of evaluation can be used.

This model (Fig. 7) is presented by R.M Felder and R. Brent (2004). The main point in opinion of authors of the model is a triangulation in an evaluation process.

Also it is important to evaluate effectiveness of integrated science course. In this case, evaluator can use pre-course questionnaire and post-course questionnaire.

Guba and Lincoln (1981) and Nevo (1983) defined evaluation as the integration of description and judgment, in which the description part emphasizes the objective part of the assessment, while the judgment part dwells on its subjective aspect. Evaluation requires a systematic process, and the application of evaluation skills potentially enhances the objectivity of the descriptive part of the evaluation (Dori, Herscovitz, 1999).

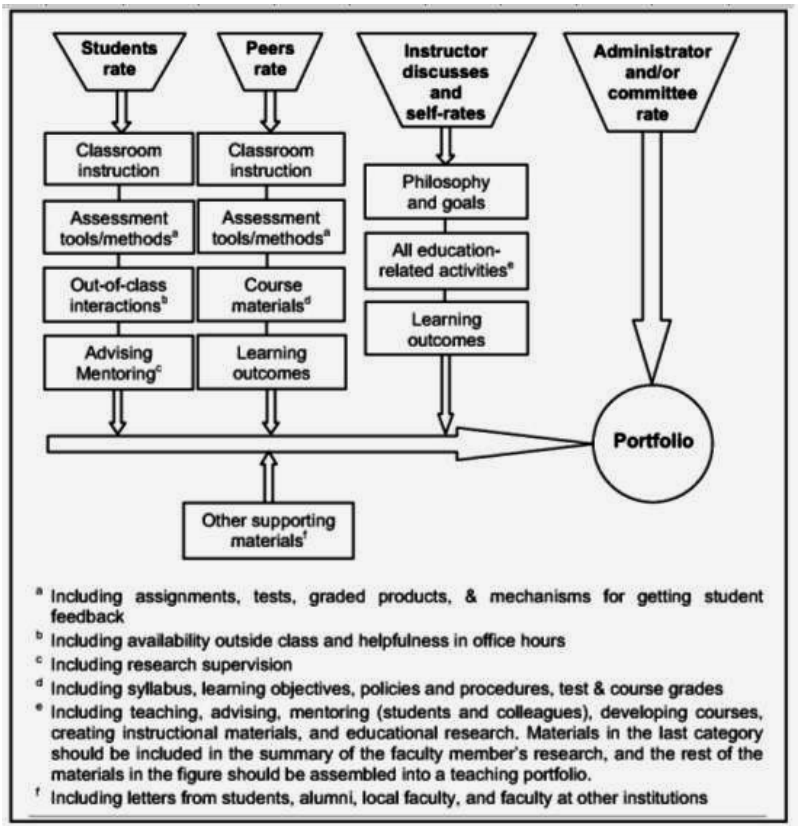


Figure 7. Teaching performance evaluation model

Another important point is how to involve all students in evaluation. Black and Wiliam (1998) encourage teachers to use questioning and classroom discussion as an opportunity to increase their students' knowledge and improve understanding.

Different methods for evaluation can be applied:

- oral and written quizzes;
- progress tests;
- achievement tests;
- diagnostic interview;
- informal feedback from all groups of students etc.

It is important to mention some relevant approaches (strategies) for evaluation (Fox, Hackerman, 2003):

- Repeated Measurements of Student Learning and Teaching Effectiveness (the typical end-of-course student evaluation form is an indirect assessment tool that can help a teacher understand what worked to assist learning in a course and what did not);
- Direct Questioning of Students (the easiest way to find out whether students understand what is being said is to ask them directly);
- Minute Papers and Just-in-Time Teaching (at the end of a class, teachers can ask students to write for a minute or two on one of the following kinds of questions: "What is the most significant thing you've learned today?" "What points are still not clear?" or "What question is uppermost in your mind at the end of today's class?" Responses can help teachers evaluate how well students are learning the material);
- Student Teams (another documented approach involves asking a team of students to work throughout the term on continuous course evaluation (Baugher, 1992; Greene, 2000; Wright et al., 1998);
- Students' Course Notes (this technique allows teachers to see what students consider to be the main points presented and whether there is misinformation or confusion about various topics);
- Chain Notes (in small classes, it may be possible to pass around a piece of paper midway through a session and ask students to jot down the main point of what is being discussed at that moment);
- Student Study Groups (students can be encouraged to form small study groups and to send representatives to discuss any difficulties or questions with the teacher);
- Informal Conversations (teachers can seek feedback through informal conversations with students during office hours, before or after class, or

through e-mail. They can ask students about what has been working well or what is problematic);

- Index Cards (several times during the term, a teacher can pass out index cards to students and ask them to respond to two questions, one on the front of the card, the other on the back. General questions can be posed, such as "What are your overall impressions of the course?" "What's good about the course?" "Do you have any suggestions for changing the course?" or "Are there any problems?");
- Outside Evaluators (a teacher can invite an educational improvement specialist from outside to conduct an oral evaluation with his or her students);
- Self-Evaluation (self-reports and self-reflections on a teacher's teaching and promotion of student learning can be important sources of information for evaluating a teacher's effectiveness (Hutchings, 1998) etc.

Usually we can describe science education as experimental activities of students. In this case it is important to evaluate students activities. W.Harlen (2000) adapted some questions connected with planned or possible activities. For example, does the activity:

- give the opportunity for children to apply and develop their ideas about scientific concepts, that is, is the content relevant and interesting to them?
- enable children to use and develop science process skills, that is, is there room for the children to do the thinking or is it all done for them?
- encourage scientific attitudes, that is, give opportunity for children to exercise some choice?
- engage the interests of the children and relate to real life and their everyday experience?
- appeal equally to boys and girls and to those of all cultural and ethnic backgrounds?
- provide experience of learning through interaction with things around?
- involve the use of simple and safe equipment and materials which are familiar to the children?
- use readily available materials and equipment?
- involve children in working cooperatively and in combining their ideas?

Tasks (assignments)

1. Referring to the definitions of evaluation listed in the teaching/learning material and the most acceptable concepts give an individual definition of the evaluation of integrated science self/education.
2. Explain the following questions used in the evaluation process:

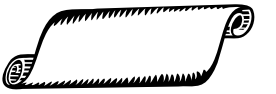
	Object of evaluation	**Time and reasons for evaluation**	**Ways of evaluation**
Interpretation	.....	.....	.....

3. What are the objects of evaluation in the process of integrated science education? To evaluate these objects, choose the most appropriate strategies of evaluation.
4. What do you consider as the essence of an Integrated Science to your students?

Case study

Teacher X applies evaluation as a component of the educational process. Within the process of integrated science education, the teacher most frequently evaluates students' achievements informally using the formative evaluation: promotes intensive students' activities and verbally and in written form makes corrections to the process of learning. In order to choose an optimal content of learning, the teacher applies declarative evaluation i.e. when starting with a new topic, s/he interprets the already available learners' knowledge and developed abilities.

Questions to Case Study



1. What are the strategies of evaluation used by the above introduced teacher in the process of integrated science education?
2. What strategies of evaluation are the most suitable to agree with the principles of constructive teaching/learning?

Summary

For an evaluation of process of science teaching and learning there are different strategy and ways. The main questions are: what is to be evaluated? when and why evaluate? how to evaluate? It is clear that for science teaching success one of the most important resources is feedback from students. Teachers can evaluate a whole science course, analyse students' learning needs, and investigate students' experiences of teaching. There are multiple methods for collecting data on science teaching effectiveness. Also it is clear that a key to effective teaching evaluation is to collect data from multiple sources (*triangulation*). Evaluation of teaching may be *summative* or *formative.*

Frequently Asked Questions

What are the major criticisms of the General Science as a subject that resulted to the change to Integrated Science?

It is obvious, that many years ago, in many countries of the world, science courses were devised that attempted to cover the whole range of science in a balanced way. Such courses were in effect coordinated surveys of biology, chemistry and physics. Little was the real unity in the presentation of the course and in the examination of it. Teachers could not achieve any real integration in their teaching and teacher-training courses rarely prepared teachers for a uni-

fied approach to their teaching. General Science courses were also regarded as too superficial, as an inadequate base from which to develop higher level science courses and they were allocated too little time by schools authorities. It is possible to state that integrated science teaching is one of the logical steps in educational development.

Next Reading

Beijaard, D., & Verloop, N. (1996). Assessing teachers' practical knowledge. *Studies in Educational Evaluation*, 22, 275-286.

Black, P. (1998). Formative assessment: raising standards inside the classroom. *School Science Review*, 80, 291, p. 39-46.

Constable, H., & Long, A. (1991). Changing science teaching: Lessons from a long-term evaluation of a short in-service course. *International Journal of Science Education*, 13, 405-419.

Darling-Hammond, L., & Snyder, J. (2000). Authentic assessment of teaching in context. *Teaching and Teacher Education*, 16, 523-545.

Duffee, L., & Aikenhead, G. (1992). Curriculum change, student evaluation, and teacher practical knowledge. *Science Education*, 76, 493-506.

Yilmaz, H., Turkmen, H., Pedersen, J., & Huyuguzel Cavas, P. (2007). Evaluation of pre-service teachers' images of science teaching in Turkey. *Asia-Pacific Forum on Science Learning and Teaching*, Vol. 8, Issue 1. Available via Internet: http://www.ied.edu.hk/apfslt/v8_issue1/turkmen/index.htm#con

Jones, C. (1998). Evaluation using Ethnography: Context, content and collaboration. In Oliver, M. (Ed.) *Innovation in the Evaluation of Learning Technology*, London: University of North London Press, 87-100.

Lamanauskas, V. (2003). Natural Science Education in Contemporary School. Siauliai: Siauliai University Press, p. 514.

Leach, J., Scott, P. (2002). Designing and Evaluating Science Teaching Sequences: An Approach Drawing upon the Concept of Learning Demand and a Social Constructivist Perspective on Learning. *Studies in Science Education*, Vol. 38, Issue 1, p. 115 – 142.

Patton, M. (1997). *Utilization-focused evaluation*, London: Sage.

Sorcinelli, M.D. (1999). The evaluation of teaching: The 40-year debate about student, colleague, and self-evaluations. In B.A. Pescosolido, and R. Aminzade (Eds.), *The social worlds of higher education: Handbook for teaching in a new century* (pp. 195-205). Thousand Oaks, CA: Pine Forge Press.

References

Baugher, K. (1992). *LEARN: The student quality team manual.*Nashville, TN: LEARN.

Bentley, D., Watts, D. M. (1992). *Communicating in School Science: Groups, Tasks and Problem Solving 5-16*. London: Falmer Press.

Black, P., and Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5 (1): 7-74.

Dori, Y. J., Herscovitz, O. (1999). Question-Posing Capability as an Alternative Evaluation Method: Analysis of an Environmental Case Study. *Journal of Research in Science Teaching*, Vol. 36, No. 4, p. 411-430.

Greene, E. (2000, June 23). Some colleges pay students to go to class—to evaluate teaching. *The Chronicle of Higher Education*, A18.

Guba, E. G., & Lincoln, Y. S. (1981). *Effective evaluation*. San Francisco: Jossey-Bass.

Felder, R. M., Brent, R. (2004). How to evaluate teaching. *Chemical Engineering Education*, 38(3), p. 200-202.

Fox, M. A., Hackerman, N. (Eds) (2003). *Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering, and Mathematics*. Washington: The National Academies Press.

Harlen, W. (2000). *The Teaching of Science in Primary Schools*. London, David Fulton Publishers.

Hutchings, P. (Ed.). (1998). *The course portfolio: How faculty can examine their teaching to advance practice and improve student learning*. Washington, DC: American Association for Higher Education.

Nevo, D. (1983). The conceptualization of educational evaluation: An analytical evaluation
of the literature. *Review of Educational Research*, 53, 117–128.

Oliver, M. (2000). An introduction to the Evaluation of Learning Technology. *Educational Technology & Society,* 3(4), p. 20-30.

Scriven, M. (1975). *Evaluation in Science Education*. Ohio.

Wright, J. C., Millar, S. B., Kosciuk, S. A., Penberthy, D. L., Williams, P. H., and Wampold, B. E. (1998). A novel strategy for assessing the effects of curriculum reform on student competence. *Journal of Chemical Education 75,*986-992.

Unit 14

The Collaboration Peculiarities of Science Teachers

Objectives:

- To understand purposes of science teachers collaboration;
- To define the concepts of collaboration and cooperation;
- To characterize the main ways of collaboration.

It is clear that *"learning is a process of construction in which the students themselves have to be the primary actors"* (von Glasersfeld, 1995). By nowadays the view of the learner has changed from that of a passive recipient of knowledge to that of an active constructor of knowledge. It must be taken into account that *"learning is a process of knowledge construction, not of knowledge recording or absorption"* and *"learning is knowledge-dependent; people use current knowledge to construct new knowledge"* (Anthony, 1996).

Collaboration and cooperation of science teachers are very important components of process of teaching and learning. It is a first step to the constructive, integrated process of teaching. Without adequate cooperation it is not possible to reach the appropriate level of integration, except for internal integration of teaching subjects at a lesson. But in that case a degree of integration is not high enough. Collaboration of science teachers is possibly at all stages of educational process. For example, such collaboration is very effective by preparation of joint teaching/learning programs (curriculum) and concrete plans of activity. Collaboration depends on many factors, for example, the psychological microclimate in collective, motivation of teachers to work better, motivations of pupils and their interest to natural sciences in general. We need teachers to go beyond traditional school science with its emphasis on "key" concepts (Eisenhart, Finkel, & Marion, 1996) and focus also on the processes of learning and thinking about learning (Watters, James, Ginns, Ian, 2000).

Some schools are completely not ready to collaboration and science teachers mostly work individually, not aspiring to find new opportunities. Science teachers` collaboration with primary school teachers also is very important factor for improving of science teaching and learning process. It is effective step for preparation of young students for further learning in secondary school level. All science teachers must agree that:

- it is possible to integrate the knowledge acquired by studying separate subjects (biology, chemistry and physics);
- students can be led into a situation of using their knowledge of different natural sciences simultaneously;
- all external resources need to be found outside the school and involved in common activities (for example, non-governmental organizations, public institutions, libraries, universities, museums etc.).

For effective science teachers collaboration is important:

- to coordinate different programs for all school year;
- to define the basic concepts and terms for each science subject (chemistry, physics, biology, geography etc.), to agree about the general/common interpretation of these terms at different lessons;
- to define the basic contacts/relations of all science subjects;
- to organize different intersubject actions during formal and informal education;
- to involve researchers from different science centers into common activity with students etc.

Nowadays an important way is “Discovery learning”. In this case collaboration of science teachers at school is as guarantor of efficacy of teaching/learning process. “Discovery Learning” requires that the teaching process should be divided into 4 steps (Xu, 2001):

a) design a proper situation according to the content of the course and then explain the problem to be solved in the situation;
b) the students provide possible solutions or hypotheses through various activities;
c) the possible solutions are tested through theories and practice;
d) discover new theories (or new knowledge).

Collaboration among teachers, administrators, a research institute and in-service activities allowedthe development of materials which reflect the

students' relationship with nature, promote responsible action, and are sensitive to the cultural aspects of the topic (Riquarts, Henning Hansen, 1998). Educational researchers (Ball, Runquist, 1993; Weinstein et al., 1991) have documented the central and critical role of collaboration in helping teachers understand new conceptions of teaching and in developing innovative clasroom practices. Also an important point is that collaboration reduces the isolation of teaching (Brickhouse, Schifter, 1991). One way to overcome this isolation and its pernicious effects is to create collaborative opportunities for professional development and learning during which teachers can obtain information, discuss ideas, classroom experiences and techniques, critique each other`s practices and support each other`s efforts (Hunsaker, Johnson, 1992). The effective forms of collaboration are (Blumenfeld, Krajcik, Marx, Soloway, 1994):

a) work sessions and conversations via telecommunications;
b) structured interviews that probed ideas about teaching and learning;
c) case reports;
d) school visits.

Modern ICT allows new forms of collaboration over time and place, bridging differences and breaking down spatial and temporal barriers. ICT allows teachers in diverse settings to collaborate.

Teachers need to plan what the program or service will look like (e.g., a peer tutoring program, a co-teaching service, a weekly team meeting), but they also need to prepare for the requirement of working together (Gable, Friend, Laycock, & Hendrickson, 1990).

Tasks (assignments)

1. Define the following concepts:
   Collaboration - ...
   Cooperation -...

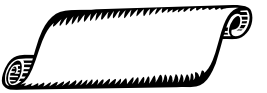
2. Fill in the table:

Science teachers' objective/s for collaboration	Factors determining the possibility of collaboration	Factors determining the quality of collaboration	Methods/forms of collaboration
1.	1.	1.	1.
2.	2.	2.	2.
...	...	...	..

Case study

In the curriculum for the next year, a school scheduled to ensure favourable conditions for students to study sciences using the method of *Discovery Learning*. Thus, 4 stages of similar teaching/learning mentioned in this chapter of the module were described. It is worth emphasizing that sciences at school are taught by the teachers having rather long work experience and pedagogical practice. Traditionally, they are tending to support individual activity.

Questions to Case Study



Having discussed the situation in groups, give recommendations that could be followed by the administration of the above mentioned school and the teachers of sciences in order to implement the principles of constructivistic teaching/learning corresponding to the process of teaching/learning sciences. Focus on the factors ensuring the efficiency of the teaching/learning process.

Summary

Cooperation (collaboration) among science teachers undoubtedly raises efficiency of teaching process. It is a first step to the constructive, integrated process of teaching. Without adequate cooperation it is not possible to reach the appropriate level of integration, except for internal integration of teaching subjects at a lesson. ***Teachers` collaboration*** in schools breaks the isolation of the classrooms. Collaboration is an important vehicle through which teachers can plan and carry out an array of services for students. One of the most promising benefits of teachers` collaboration is the increased opportunity it gives teachers to interact with one another regarding different teaching and learning issues. Specifically, teachers who collaborate are more likely to discuss with their colleagues areas of the curriculum they have difficulty teaching. The some more statements on collaboration among science teachers can be mentioned: collaboration has a direct impact on students; collaboration is becoming an essential ingredient in successful schools; collaboration is based on belief in the value of shared decision making, trust, and respect among participants; teachers collaborate only when they share a goal; teachers must make a personal choice to work collaboratively; collaboration is voluntary, not administratively mandated; each teacher participating in a collaborative effort contributes some type of resource; collaboration can only occur when it is associated with some program or activity that is based on the shared goals of the individuals involved etc. Collaboration with colleagues is helpful way for improvement of professional knowledge of science teachers.

Frequently Asked Questions

Why the integrated teaching usually is difficult for teachers?

This is generally difficult for teachers, due to the lack of pre-service courses and material for integrated science teaching, disciplinary routines and a teacher-centered style of teaching and the exclusion of a variety of socially-oriented topics.

What is cooperative learning?

Cooperative learning is a successful teaching strategy in which small teams, each with students of different ability levels, use a variety of learning activities to improve their understanding of a subject, for example, science.

Next Reading

Baud, D., & Feletti, G. (1998). *The challenge of problem-based learning* (2nd ed.). London: Kogan Page.

Bauwens, J., Hourcade, J. J., & Friend, M. (1989). Cooperative teaching: A model for general and special education integration. *Remedial and Special Education*, 10(2), 17-22.

Borko, H., & Mayfield, V. (1995). The roles of the cooperating teacher and university supervisor in learning to teach. *Teaching and Teacher Education*, 11, p. 501-518.

Czerniak, C. M., & Lumpe, A. T. (1996). Relationship between teacher beliefs and science education reform. *Journal of Science Teacher Education, 7*(4), 247-266.

Friend, M., & Cook, L. (1990). Collaboration as a predictor for success in school reform. *Journal of Educational and Psychological Consultation*, 1 (1), 69- 86.

Lamanauskas V. (2003). *Natural Science Education in Comprehensive School*. Siauliai: Siauliai University Press, p. 514.

Lamanauskas V., Vilkonienė M., Vilkonis R. (2007). Conceptual Reasoning for Didactics of Augmented Reality Teaching /Learning Platform: Some Preliminary Ideas. *Gamtamokslinis ugdymas / Natural Science Education*, No. 2(19), p. 17-26.

References

Anthony, G. (1996). Active learning in a constructivist framework. *Educational studies in mathematics*, 31, 349-369.

Ball, D.L., Runquist, S.S. (1993). Collaboration as a context for joining teacher learning with learning about teaching. In. D. K. Cohen, M. W. McLaughlin,

J. E. Talbert (Eds.), *Teaching for understanding: Challenges for policy and practice* (pp. 13-42). San Francisco.

Blumenfeld, P. C., Krajcik, J. S., Marx, R., Soloway, E. (1994). Lessons learned: how collaboration helped middle grade science teachers learn project-based instruction. *The Elementary School Journal*, Vol. 94, No. 5, p. 539-551.

Gable, R. A., Friend, M., Laycock, V. K., & Hendrickson, J. M. (1990). Interview skills for problem identification in school consultation. *Preventing School Failure*, 35(1), 5- 10.

von Glasersfeld, E. (1995). Learning Mathematics: Constructivist and interactionist theories of mathematical development, Review of the book *Learning Mathematics: Constructivist and Interactionist Theories of Mathematical Development*, P. Cobb (Ed.), in *Zentralblatt fur Didaktik der Mathematik*, 4, 120-122.

Eisenhart, M., Finkel, E., & Marion, S. F. (1996). Creating the conditions for scientific literacy: A re-examination. *American Educational Research Journal,* 33(2), p. 261-295.

Riquarts, K., Henning Hansen, K. (1998). Collaboration among teachers, researchers and in-service trainers to develop an integrated science curriculum. Journal of Curriculum Studies, Vol.30, No.6, p. 661-676.

Xu, H. (2001). The theory and philosophy, anthropology basis of creative education. *Educational Research*, 1, p. 10-14.

Watters, James, J, and Ginns, Ian, S (2000). Developing motivation to teach elementary science: Effect of collaborative and authentic learning practices in preservice education. *Journal of Science Teacher Education*, 11(4), p. 277-313.

Weinsten, R.S., at all (1991). Expectations and high school change: Teacher – researcher collaboration to prevent school failure. *American Journal of Community Psychology*, 19, p. 333-402.

EUROPEAN DIMENSION IN INTEGRATED SCIENCE EDUCATION

Training material for students

Editor prof. RNDr. Danuše Nezvalová, CSc.
Responsible Editor Mgr. Lucie Loutocká
Layout doc. RNDr. Oldřich Lepil, CSc.
Cover Design Mgr. Petr Jančík

Published and printed by Palacky University in Olomouc
Křižkovskeho 8, 771 47 Olomouc
http://www.upol.cz/vup
E-mail: vup@upol.cz

Olomouc 2008

ISBN 978-80-244-???

Unsaleable