Albert Kiss

Creation-based natural science pedagogy in primary schools - a guide for methodological options -

portfolio

PowerPoint

talent support

objektified creation

information resoure

experiential learning

Scientific Children's association

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Introduction

This booklet is an abridged edition of the handbook written by the Hungarian author Albert Kiss in 2011. He attempts to find a solution for a current, nation-wide educational problem. The number of those students who wish to continue their studies in the field of natural science has decreased to a great extent. Only few school-leavers decide to apply for university admission at one of the faculties of engineering or natural science. One has no reason to suppose that students interested and talented in these fields have disappeared in Hungary. The distortion is the consequence of the theory-based science education built on course books depriving pupils of the opportunities for direct experience and extinguishing the curiosity of children with an interest in nature and environment in general.

This methodological guide presents the target system of a research-proven education of natural science including the methods of its practical realization. The underlying pedagogy involves having students acquire the ways of empirical learning as well as the methods of analysis and interpretation. Pupils' knowledge gained from direct experience is connected to the knowledge available in libraries or on the internet.

In the course of having pupils learn the ways of subjective creation, the whole process of scientific research is kept in focus with its main stages ranging from the recognition of a problem to the final conclusion and the publication of the results.

The author thoroughly unfolds the pedagogical methodology that has been verified by his own educational practice and experimental work. The analysis of the activities carried out in Scientific Children's Association also contributes to the validity of the offered methodology.

Such a detailed presentation makes it possible for teachers to plan the creative activities of their pupils provided that they have undertaken the reformation of their pedagogical views in order to generate a collective discourse. The criterion of the efficiency of all this depends on whether or not teachers are able to regard theoretical learning based on experience to be self-evident.

It is not the author's aim to publish a handbook of descriptive methodology. He develops a conception on which methodological solutions built on each other may be based.

The purpose of publishing this version is to acquaint its readers with the goals, processes and achievements of a creation-based science pedagogy initiated in Hungary, verified by empirical research embracing ten years.

The booklet is divided to chapters following the structure of the original version. The chapters contain figures and tables, descriptions are included to unfold the content of them in case it needs further explanation or when demonstration by figures and tables cannot replace textual argumentation.

1. The need for a pedagogical revolution in the subject pedagogies of natural science

Frontal classroom management and verbal transmission of knowledge needs to be replaced by a subject pedagogical methodology supporting those learning processes that are based on learners' independent activities including creation, experimentation and exploration. In order to achieve this, thoroughly developed, interdependent pedagogical methodoligies are to be worked out.

Methodologies for teaching science in primary schools should be published with special regard to the empirical and theoretical acquisition of knowledge as well as the options for documenting, presenting and evaluating the act of creation and the objectified works.

In order to implement this reform, creative and devoted teachers are needed, who are capable of including the specific elements of scientific approach in their daily practice within the framework of an ability developing, creation- and action-based pedagogy. This reform could be efficient only when this pedagogical principle predominates in each lesson belonging to the *humans in nature* subject.

2. The creation-based science pedagogy

In the pedagogical practice of those who teach science in primary schools, it is mainly frontal classroom management, verbal transmission of information, repetition, and the lack of an experience-based acquisition as well as learners' self-motivated creation that dominates in the process of learning these days.

We believe that the creation-based science education advocated by us may transform the situation of the daily practice described above.

Our views have been verified by a great deal of experience based on our empirical research embracing ten years. [1] (KISS 2009.185-207p) In light of this experience we can conclude that the motivation for creating something new and the interests of learners between the age of 9-14 cannot be served by a teacher-centered approach that can be characterized by classrooms organized according to age and dominated by course books, educating the mass by verbal transmission of knowledge, a technology for the management of learning related to homogenous groups of learners. The results of our research prove the development of an interactive teacher-student relation, in which a great emphasis is placed on complexity, creation, the ability to create, the relevant knowledge for creation and the process of coaching students to achieve all this.

[1] Kiss, Albert: Tudományos diákkör az általános iskolákban – Zalabér szerepe az első tíz évben. (Scientific Children's Association in primary schools - The role of Zalabér during the first ten years.) Pannon Egyetem ÉKP Országos Központja Pápa, 2009.185-207p

class	Title of the scientific creation
3rd	Examination of the pollution of Tarasica stream in Osztopán
	The development of bread mold in various conditions
4th	Beavers and their reintroduction
	The uses of laser
	Allergy as today's endemic
	My beach (the observation of living creatures)
5th	The effect of different types of earth on the sprouting of seed
	The communication between predators
6th	Wasp spider, the eight-legged danger
	Plastics
	The quartz
	Senior section students' attitude to alcohol consumption in my school
7th	Planning digital teaching tools for the empirical examination of chemicals
	Protected xilofag insects living in the oak and meadow forests in Kisgombos
	The effect of Eros appearing in the everyday life of adolescents in our school
8th	My first physical experiment, the pump
	The changing of the structure of Erth types due to effects of solutions – micro- and macroscopic examinations
	The screwed up space-time

Table 1. Examples for the titles of creations presented in the national final of Scientific Children's Association.

class	Our Earth and environment	Humans in nature	percentage
3rd	1%	4%	5%
4th	5%	15%	20%
5th	3%	8%	11%
6th	5%	16%	21%
7th	11%	14%	25%
8th	8%	10%	18%
all	33%	67%	100%

Table 2. Distribution of science projects related to fields of knowledge

Further analyzing the works we can conclude that during processing the fields of interest it is mainly complexity (an integrative and interdisciplinary approach) that predominates. To achieve this, an interactive relation between teachers and learners and an individual talent support had to be realized.

	Our Earth and environment	Humans in nature	percentage
complex, integrated	14%	31%	45%
geography	4%		4%
environment protection	15%		15%
biology		17%	17%
physics		5%	5%
chemistry		4%	4%
healthy lifestyle		10%	10%
all	33%	67%	100%

Table 3. The emergence and distribution of complexity during the creation of the works.

Furthermore, our analysis clearly shows that empirical examination has priority over the use of printed and digital information resources. The fieldwork in students' own micro-environment was also significant.

	Our Earth and environment	Humans in nature	All	
Information resources (printed and digital)	14%	29%	43%	
Empirical examinations	11%	21%	32%	57%
Fieldwork in micro-environment	8%	17%	25%	
All	33%	67%	100%	

Table 4. Information resources and experiential learning in the act of creation

Based on the research results presented above we can draw the conclusion that a creation-based pedagogy is a challenge for the teachers of science as well.

Since the results verify our position that a creation-based science pedagogy needs to be worked out, we attempt to outline the essence and the primary goals of its process following the so-called *pedagogikum* model of Zsolnai. (ZSOLNAI 1996. 60-63.p)

2.1. The essence of a creation-based science pedagogy

The essence of a creation-based science pedagogy can be modeled in a relation system of three major elements with the help of which the relevant learning processes can be described. The elements of this relation system are the *valuable thing*, the *learning the valuable thing* and the *facilitation of learning the valuable thing*. [2] (ZSOLNAI 1996. 61p)

The essence of a creation-based science pedagogy		
the valuable thing	*learning the valuable thing*	*facilitation of learning the valuable thing*
experience	experiential learning	Providing the conditions of empirical recognition
information resources	use of information resources	cooperation with information resource centers
objectified creation	subjective creation	techniques of creation
presentation of the objectified creation	presentation of the objectified creation	facilitation of the application of presentation techniques
portfolio	making a work portfolio	facilitation of making a work portfolio, making an evaluative portfolio
Scientific Students' Association	creation in the Scientific Students' Association	transmitting the elements of scientific research methods

Table 5. The essence of a creation-based science pedagogy

[2] József, Zsolnai: Bevezetés a pedagógiai gondolkodásba. (An introduction to the pedagogical way of thinking). Nemzeti Tankönyvkiadó, Budapest, 1996.61p

2.2. The goals of a creation-based science education

The establishment of the goals of a creation-based science pedagogy was based on the analysis of our experience gained from an empirical research carried out within the framework of Scientific Children's Association that has been operating for 10 years.[3] (KISS 2009. 16. p)

- Those institutes of primary education that are devoted to implement the creation-based science education are required to adjust the creation-based learning to their programs in a way that facilitating students to become individuals capable of creation is a primary goal that needs to be realized. To achieve this, those learning processes in that a great emphasis is placed on the experiential recognition of our natural environment, being informed about scientific research results by using information resources and the encouraging effect of creating and presenting objectified works are to be kept in focus.
- Pupils participating in the processes of creation-based science pedagogy are supposed to get acquainted with the responsible ways of:
    - experiential recognition
    - using information resources
    - subjective creation in or out of the school
    - making a presentation
    - taking part in Scientific Children's Association.
- Teachers applying the methods of creation-based science pedagogy must be able to provide the conditions of empirical research, manage the cooperation with the information resource centers, convey the techniques of creation, help pupils to make good use of the opportunities for the application of presentation techniques, and transmit the elements of scientific research methods.

3. The facilitation of subjective creations in natural science classes

In this approach we do not strive to work out a creation-based education program that counts as valid for all natural science subjects. Furthermore, we are not eager to describe a methodological system with didactical purposes for teachers conveying scientific facts. Our goal is to shed light on the facilitation of subjective creations during science classes relying on the research results published on the website of the Hungarian Institute for Educational Research and Development entitled as *The Situation of Subjects*. In addition, we offer methodological options for conveying techniques of creation and developing students' creativity based on the experience of an empirical research entitled as *Scientific Students' Association in Primary Schools.*[4] (KISS 2009.17-20.p)

3.1 Methods for experiential learning

The methods of experiential or empirical learning are observation, description, measurement and experiment. For those who teach natural science subjects, experiential learning is self-evident, considering they conducted an experiential learning during their teacher training both in courses at the laboratory and in the field. They carried out observations, measurements, experiments and other activities. They were interested learners lacking knowledge to a certain degree. Hence, they also gained the relevant experience about nature as students and the activities they carried out accumulated and became conscious in their minds to varying degrees.

[3] Kiss, Albert: Tudományos diákkör az általános iskolákban – Zalabér szerepe az első tíz évben. (Scientific Children's Association in primary schools - The role of Zalabér during the first ten years.) Pannon Egyetem ÉKP Országos Központja, Pápa, 2009. 16.p)

[4] Kiss, Albert: Tudományos diákkör az általános iskolákban – Zalabér szerepe az első tíz évben. (Scientific Children's Association in primary schools - The role of Zalabér during the first ten years.) Pannon Egyetem ÉKP Országos Központja Pápa, 2009. 17-20.p

3.2 Objectified works of subjective creation in the lesson

The objectified works of the creation-based experiential learning can be systematized related to the activities of learners with regard to the relevant methods.

Activities	Methods and products of experiential learning			
	observation	measurement	description	experiment
following teacher's activities	models provided by the teacher to complete the sets of learning activities			
the completion of self-motivated sets of activities	rules and requirements of the self-motivated activities of learners			
posing a question	What is the thing that I do not know? To which question am I looking for an answer? (interrogation)			
hypothesis	What can be the answer to the posed question? (affirmation)			
planning	planning the set of actions and tools (texts, drawings, figures)			
performance	realization of the set of actions and the usage of tools (by series of photos, video recordings)			
recording experience	entries, drawings, figures, photos, films values, data, tables,	drawings, figures, photos, recording films descriptive texts,	entries	drawings, figures, photos, films
processing	content-based arrangement of entries and illustrations	counts, graphs, diagrams	knowledge-centered, descriptive texts	records of the experiment
assessment of experience	affirmative sentences related to the observation, quantification	result of measurement	summative conclusion	comparing hypothesis with experience
communication related to the process and results of experiential learning	publishing objectified works: on wrapping paper, as decoration, in the cabinet, gallery etc., electronically: with Word, Excel and PowerPoint programs, presentation			

Table 6. . Objectified works of the creation-based learning in the lesson.

3.3 Options for applying methods of experiential learning

The methods of a creation-based experiential learning (observation, description, measurement, experiment, subjective creation) can be applied in the classroom, in a special classroom and in a built environment outside school. The main stages are:

- *Preparation for experiential learning*
- *Systematic planning*
- *Performing experiential learning*
- *Having students process the results of experiential learning*

The subjective acts of creation applied in the course of empirical learning close to nature result in objectified works that can be systematized related to the methods of empirical learning and the sites of experiential learning close to nature.

<table>
<tr><td rowspan="2">Methods of empirical learning</td><td colspan="3">Sites of experiential learning close to nature</td></tr>
<tr><td>live corner</td><td>built environment</td><td>field</td></tr>
<tr><td>observation</td><td rowspan="3" colspan="3">questions, hypotheses, plans, execution, recorded experience</td></tr>
<tr><td>measurement</td></tr>
<tr><td>experiment</td></tr>
<tr><td rowspan="2">description</td><td colspan="3">text about the experience gained from observation, measurement, experiment</td></tr>
<tr><td colspan="3">text about the process of learning</td></tr>
<tr><td>illustration of description</td><td colspan="3">drawing, photo, film, model</td></tr>
<tr><td rowspan="3">processing gained experience</td><td>collection of experience gained from planning, setting and operating live corner</td><td colspan="2">model on a display table, rock and plant collection, animal preparation</td></tr>
<tr><td colspan="3">Posters, photos, films, texts of environment pollution</td></tr>
<tr><td colspan="3">exhibition of descriptions and illustrations related to the process of experiential learning</td></tr>
</table>

Table 7. Objectified creations of the experiential learning close to nature

4. The use of information resources

Students’ attention should be directed to printed and digital information resources conveying knowledge in the field of natural science and providing a logically structured and experience- proven picture of reality. The use of information resources activates students’ interest in facts, causal relations, laws and models of natural sciences as well as in explanation of models, findings and solving problems. Studying descriptions of problem-solving may reveal to children the way to scientific discoveries and the relevant experiential and theoretical methods. In addition, children can get acquainted with the key problems to solve in natural sciences.

4.1 Broadening theoretical knowledge

4.1.1 Finding the relevant knowledge in the library

4.1.2 Finding the relevant knowledge on the internet

4.2 Broadening experiential knowledge in resource centers

4.2.1 Museums of natural science

4.2.2 Botanic gardens

4.2.3 Zoos and wildlife parks

4.2.4 Conservation areas

4.2.5 Trails for study

4.2.6 Forest schools

4.2.7 Research institutes of natural science

4.2.8 Institutes applying the methods of natural science

4.3 Objectified works created during the use of information resources

<table>
<tr><th colspan="2">The use of information resources</th><th>Objectified works</th></tr>
<tr><td rowspan="2">Theoretical knowledge</td><td>the use of library</td><td>tags, bibliographies, notes and sketches, book presentations, works propagating general knowledge</td></tr>
<tr><td>the use of internet</td><td>downloads, Word documents, PowerPoint presentations</td></tr>
<tr><td rowspan="8">Experiential knowledge</td><td>in a museum of natural science</td><td>museum diary, interview with an expert in a museum, exhibition</td></tr>
<tr><td>in botanic gardens</td><td rowspan="5">descriptions (descriptive texts) of experience (of observation, measurement, experiment), illustrations of descriptions (drawings, photos, films, maps, models), collections, exhibitions</td></tr>
<tr><td>in zoos and wildlife parks</td></tr>
<tr><td>in conservation areas</td></tr>
<tr><td>in trails to study</td></tr>
<tr><td>in forest schools</td></tr>
<tr><td>in research institutes of natural science</td><td rowspan="2">interviews, illustrations, accounts of experience gained from research institutes, exhibitions, works propagating general knowledge</td></tr>
<tr><td>in institutes applying methods of natural science</td></tr>
</table>

Table 8. Objectified works created during the use of information resources

5. Presenting objectified creations

So that the objectified creation can reach the final status of its development, students are supposed to present them in public when further discussion takes place related to it. Following the presentation, the works are collected, evaluated and archived.

5.1 Publishing objectified creations, documents

5.2 Presentation

6. Documentation of objectified creations, introduction to the options of making a work-portfolio

Creations presented in science classes and on *creation days* are documented. Teachers should have pupils collect their creations and give feedback on a regular basis. Finally the works are to be evaluated and archived. The process of documentation can be divided into phases:

6.1 Purposes of documentation

6.2 Planning documentation

6.3 Preparing for documentation

6.4 Feedback on the documents and the process of documentation

6.5 Evaluation of the documents and the process of documentation

7. Scientific Children's Association

Scientific Children's Association has been set up for those pupils who achieve outstanding results in the course of presenting their creations and preparing their collection of documents. Based on our experience of empirical research embracing 10 years (KISS 2009.), we can conclude that the creation-based pedagogical climate of Scientific Children's Association further increases pupils' creativity. Regarding the role of educational institutes, self cultivation, the preference of the value of a subjective creation and the facilitation of learning them are considered to be the main criteria of success, that cannot be achieved without learners' undertaking all this.

7.1 Raising students' interests in problems of natural science

7.1.1 Posing questions, developing sensitivity for problems

7.1.2 The effect of teachers' active attention and sensitivity for problems

7.1.3 The effect of teachers' scientific interests

7.1.4 Activities within the territory of natural science serving the common good

7.2 Micro-research in natural science, interpreting local problems and finding options to solve them

7.3 Creating objectified works in Scientific Children's Association

7.3.1 Works propagating general knowledge in natural science

7.3.2 Inclusion of research methods applied by natural sciences

7.3.3 Objectified creations as results of the micro-research carried out within the framework of Scientific Children's Association

7.3.4 Facilitating pupils' preparation for the presentation of the creation

7.3.5 Working out an evaluation portfolio of the creations

Student's name, class, school		**Subject of the presentation**
communication	verbal	articulation
		stress, pause
		pace of speech
	non-verbal	gesturing
		eye contact with the audience
		contact with the text, illustration
content		facts, data
		illustrations
		structure of the presentation
		summary, conclusion
		resource (tertiary, secondary, primary)
		problem-raising
		adequate application of research methods
		appearance of the elements of micro-research
handling text		read out
		learnt
		sketch-supported
		free performance
reflection, answer to the posed questions		content coherence
		style, elegance
self-reflection		content coherence
		style, elegance
Total points		
category		work propagating general knowledge
		research methods applied
		micro-research
points to give: 1p to be developed 2p adequate 3. outsanding		

Table 9. Evaluation sheet for presentations

8. Possibilities of talent support and catching up pupils in Scientific Children's Association

Teachers undertaking a creation-based pedagogy need to identify themselves with the pedagogical approach focusing on „values instead of disadvantages, achievements instead of failures" and with the finding of modern psychology highlighting that everyone is a potential talent. *Our research results show that those pupils who take part in Scientific Children's Association with poor communication skills, are more interested in an experiential understanding of the world by observation, measurement and experiment."*[5](Kiss 2010.63.p) In light of our experience, we can conclude that the main reason for the lack of communication skills are the socio-cultural disadvantages that may help students to become future talents, considering they seem to be especially eager to take part in Scientific Children's Association even if they often lag behind. Dr. László Balogh's interpretation supports our findings: *The talents who haven't*

[5] Kiss, Albert: Tudományos diákkör az általános iskolákban – A diákkör létrehozása és működtetése. (Scientific Children's Association in primary schools - The establishment and operation of the Association.) Zalabér, 2010. 63.p

unfolded yet hide themselves, consequently it is often difficult to recognize them. Therefore, we have to be careful when regarding them to be non-gifted. […] Ability and performance are two different matters, there are quite a few talented pupils who lag behind and achieving good academic results does not necessarily show a person's talent. [6] (DR. BALOGH 2010. 15.p)

Consequently, in Scientific Children's Association catching up pupils and supporting talent must be realized simultaneously as intertwining pedagogical processes.

8.1 Catching up pupils in Scientific Children's Association

Talented students as well as future talents may need to be caught up in certain skill domains. Following the model of Françoys Gagné[7] these domains include intellectual (inductive/deductive argumentative memory, observation, judgment etc.); creative (genuineness, imagination, humor, etc.); socio-affective (leading skills, tact, empathy, consciousness etc.); perceptual/motor (strength, coordination, endurance, flexibility etc.); other (extrasensory, perception, healing skills etc.). In the course of catching up pupils we facilitate the development of the skills listed above by applying intrapersonal (physical and psychological) and environmental (environment: physical, social, macro/micro; persons: parents, teachers, peers, mentors; tasks: activities, courses, programs; events: challenges, rewards, accidents) catalysators during learning and practicing.

8.2 Talent support in Scientific Children's Association

8.2.1 Recognition of talents

8.2.2 Enrichment

8.2.3 Permeability (Scientific Students' Association for secondary school students)

8.2.4 Successful practice

8.2.5 Entering for competition

[6] dr. Balogh, László: Fogalomtár a Tehetségpontok számára (alapváltozat). (A Collection of concepts for Talent Points.) (initial version) 2010. március, http://geniuszportal.hu/sites/default/files/fogalomtar.pdf

[7] dr. Balogh, László: A tehetség összetevői, fogalma, fajtái, fejlődési tényezők. (The components, concept, types and developmental issues of talent.)
www.tehetsegpont.hu/dokumentumok/tehetsEgmodellek1.ppt

9. The role of Scientific Children's Association in coaching pupils to scientific creation

We sought for the possibilities of talent support in Scientific Children's Association with the help of action research. Our research results have been published in detail.[8] (ZSOLNAI 2004. és KISS 2009.)

In the first phase of the action research (1998-2003) we tested the following hypothesis:
Pupils learning within the framework of mass education can be involved in scientific creation from the age of 10 and a nation-wide Scientific Children's Association for primary school students can be established and operated.
In the second phase (2004-2008) we gained experience related to our second hypothesis namely that the established nation-wide network of the Association is capable of having students get acquainted with the process of scientific creation.
Scientific Children's Association was established in five different regions. The main goal was to facilitate pupils' acquisition of research methods that are applied in those fields of science that pupils are interested in taking therir skills and previous knowledge into consideration.

Between 2003-2009 1686 scientific works had been completed by pupils aged 10-14. Based on our research results we can conclude that the opportunity to prepare a scientific creation raises pupils' interest, pupils are motivated by the persons living in their environment, their everyday experience, their curiosity, the pleasure of understanding, the supportive attitude of their parents, the acknowledgement of their performance, their developing self-respect and self-confidence, the opportunity to liberate themselves from the constraints of school and to learn according to their own lights and plans.

One third of the pupils involved in the process were capable of creating scientific works of their interests (20-30 pages) with the support of teachers cooperating with them as tutors keeping their interests, skills and knowledge in focus.

Pupils are enthusiastic to use the available resource centers and the means of information communication technology.

Being involved in the work of Scientific Children's Association pupils soon become capable of choosing a scientific subject on their own. During the creative self cultivation they become more and more independent and self-motivated in the development of their creations.

Half of the projects presented in the national final included the application of adequate research methods. A large number of pupils managed to place the focal research problem in their own social, natural, economic and linguistic micro-environment, launch a micro-research and interpret their experience taking these contexs into consideration with the help of the tutors.

As an additional gain, pupils' communication, problem-solving, creative, digital reading and writing skills develop to a great extent. Their growing self-respect and their ability to process success may enable them to cope with the challenges of a knowledge society."[9](Kiss 2010 49-51.p.)

[8] Zsolnai, József: Kutatói utánpótlás már tízéves kortól. (Education of the new generation of future researchers from the age of ten.) *Magyar Tudomány,* 2004. 2. sz. 242–248; Kiss, Albert: *Tudományos diákkör az általános iskolákban – Zalabér szerepe az első tíz évben.* (Scientific Children's Association in primary schools - The role of Zalabér during the first ten years.) Zalabér – Pápa, 2009.

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