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Education in the Field Influences Children's Ideas and Interest toward Science

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This paper explores the idea of informal science education in scientific field laboratory (The Science Field Centre). The experimental group of pupils ($N = 153$) was experienced with approximately 5-day lasting field trips and experiments in the Field Centre in Slovakia. After finishing the course, two different research methods were used to discover their interest and ideas toward science. Pupils from the experimental group showed significant differences from those that did not experience education in the Field Centre (control group, $N = 365$). In comparison to the control group, pupils of the experimental group highly preferred book titles that were related to their program in the Field Centre. There were differences between the drawings of ideal school environment from both pupils groups. In the drawings of the experimental group, we found significantly more items connected with the educational environment of the Field Centre (e.g. laboratory equipment, live animals). We suppose field science education would be one of the most effective ways to increase interest of pupils to study science and to invaluable intrinsic motivation at the expense extrinsic motivation.

KEY WORDS: science field education; informal learning; children's interest; children's drawings.

INTRODUCTION

The most natural learning is realised through personal experience. Everyday we experience the world around us and acquire new information about the environment. This process is unconscious, and thus we can consider it as a base of optimal survival. If we cannot receive enough information from own surroundings, we are unable judge the situation and cannot behave in an optimal way. Experience is base response for our personal need to know.

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The greatest advantage of experiential learning is that learner is not limited in his or her acceptance of information from a perceived environment. We usually use all of the senses at appropriate levels to receive an experience. We, as learners, perceive the situation in its complexity with all included phenomena and objects. Everyone uses an individually preferred learning style, that is an individual approach to data selection and an individual way of implementing new constructs (Bertrand, 1993) to a presently existing knowledge (process of accommodation in Piaget's learning theory, Piaget and Inhelder, 1993).

In traditional Slovak school (to perform well) pupils need to primarily use visual and auditory processes to acquire knowledge offered via teachers and textbooks. Although several studies have shown that practical works positively influence pupils' attitudes and achievement in science (e.g. Freedman, 1997), it is usually difficult to create an interesting lesson via formal education. Some of the reasons that make it difficult might be: lack of planning time, lack of materials due to money, formal environment and also some prejudices of the pupils (fear, anguish, aversion, dislike, etc.).

Biology education is an ideal situation where practical works with living organisms should take a place. Ideally pupils should observe animals and plants in their natural habitats. This can be realised through extra-curricular programs such as field trips or various summer courses (e.g. Fernández-Manzanal *et al*., 1999; Gibson and Chase, 2002; Knox *et al*., 2003, for a review see Dillon *et al*., 2006; Leeming *et al*., 1993).

In a formal educational system, the science education has been removed from its natural environment (nature) to an artificial environment (a school class). How can this change influence pupil's attitude toward science education? In the first place, pupils have only few possibilities to perceive real stimulus from the nature, and they cannot perceive the global surrounding of an observed phenomenon or object. This problem exists in the majority of formal educational systems in the world. We are attempting to discover a suitable solution to bring the science education back to its natural environment and to not affect the existing educational system.

Learning by doing (*sensu* Dewey, 1938) in the nature (field education) is one of the oldest and the most natural learning methods that help us explore our surroundings and to understand the life on. We suggest to move a part of science education to the nature and give pupils, the possibility to "see what they are learning about" in limits of an informal education.

Informal science education in the field varies in level of its commercial orientation, content and goal orientation, but the main principles are common:

- Use a natural environment for exploring phenomena and objects of the nature,
- use real scientific methods (observation, creating hypothesis, performing experiments) in a science education of all levels,
- increased importance of active engagement,
- more flexible use of previous and present own experience,
- naturally integrated knowledge, a reinforcement of inter-discipline relationships (a globalisation and assimilation of the knowledge system),
- support of a social nature of learning processes (discussions, co-operative learning).

Science education in the field centres is primarily based on observational and experimental activities. The natural environment is the main source of information for learning activities. Pupils learn how to use the scientific methods for the solving problems of assigned projects. They take and analyse samples, create hypothesis and plan experiments. Small co-operative learning groups are highly motivating (Johnstone and Al-Naeme, 1995). Dialogues, discussions and presenting their own findings in these groups are more interactive methods of learning than individual work. In other words, informal learning may help to overcome distinctions traditionally made between formal learning (at school) and informal learning (field centres or field trips) (Dillon *et al*., 2006; Falk and Dierking, 2000; Hofstein and Rosenfeld, 1996).

Recently, Salmi (1993, 2003) showed that visiting science centre increased pupils' intrinsic motivation. Knox *et al*. (2003) and Markowitz (2004) showed that summer science programs significantly influences students' attitudes and knowledge in science. Fernández-Manzanal *et al*. (1999) found that field trip to freshwater ecosystem and following activities focused on students' concepts about ecology similarly positively influenced students' knowledge and attitudes toward ecology and environment. All these studies explore effects lasted about two to four weeks. However, real effectiveness of field trips in children learning processes is still not been definitely known due to inappropriate experimental design or weak statistic reported in numerous studies (Leeming *et al*., 1993).

"The field trip is one of the most complex and expensive activities in the educational system. Therefore, it is important to achieve optimal educational results that will justify investment..." (Orion and Hofstein, 1994, p. 1117). Thus, evaluation of the effectiveness of field trips needs to be explored. Time and financial resources often do not allow science teachers to carry relative long-time courses of which positive effects seem to be less disputable (Leeming *et al*., 1993; Lisowski and Disinger, 1991). However, effects of short-time courses remain to be less understood. Orion and Hofstein (1994) conducted a 1-day geologic field trip and found significant increase of students' achievement and attitudes toward field trip. However, lack of studies examining relative short-term effects of field trips on pupils' ideas and interest toward science has been conducted. In the present study, we investigated if approximately five-day lasting biology field trips in a science field centre could influence (1) pupils' interest toward science and (2) if in those field centres the principles of field education are really implemented into pupils' ideas about science.

Science Education Centre in the field

We created the Science Field Centre in an unpolluted area of the Slovak mountains (Male Karpaty). The Centre consists of a field laboratory for biological and chemical experiments.

The main goal of this project was to create a model of the Field Centre for science teachers in Slovakia. The main learning method is experiential learning (learning by direct experiencing the nature in the field).

The method of creating the Science Field Centre was influenced by set goals. Mainly we wanted:

- to make science more interesting for pupils via real experimental methods of science and to increase the importance of observational and experimental methods in science education;
- to motivate pupils to observe and investigate the nature right in the field; the principle is to arouse an intrinsic motivation based on the basic need to understand the environment we live in (in regard of processes of assimilation and an accommodation to the environment, Criswell, 1986);
- to join together pupils' theoretical knowledge and experience of native phenomena; to support using any kind of personal experience for building a stable knowledge system (means to create a keystone of intellectual development);
- to support pupils' science learning via informal education;
- to acquire everyday experience, ideally it means to eliminate a separation of school and everyday children's life;
- to effectively join physical and mental activities.

In motivational research we expect that partial transfer of a science education into the Science Field Centre (with implemented method of experiential learning in natural surroundings) will positively influence pupils' ideas about an ideal science education environment.

Orion and Hofstein (1994) proposed that 'field trips factors' such as learning conditions at each learning station, duration and attractiveness of the trail and weather conditions influences educational effectiveness of the field trips. The 'environmental novelty' (Falk, 1983) or the 'novelty space' (Orion and Hofstein, 1994) means that extremely great (or small) novelty of the learning environment inhibit pupils' learning. We followed these criteria either by (1) relative free introducing pupils into Field Centre surrounding soon after pupils arrived (elimination of the novelty space), (2) avoiding field works when bad weather conditions, and (3) conducting rather short trips to eliminate pupils tiredness. In addition, all pupils have everyday enough time for free playing or other activities with their science teachers.

METHOD

We investigated the influence of field education towards pupils' interests to science education by using two different methods that are not mutually exclusive. The first method was used on examination of pupils' interest. The method is based on simply choosing 5 out of 45 fictitious book titles. 16 of the titles were directly related to our field education courses. The others were related to other possible interests of the pupils (potentially competitory interests) partly selected following Jones *et al.* (2000). Three biology teachers reviewed the list of the books in order to maintain validity of the instrument. Reliability was calculated out of pupils' responses (0 and 1). Cronbach's alpha for the experimental group has value 0.79 and 0.76 for the control group. Thus, reliability of the instrument can be considered appropriate. A complete list of the book titles is available at the corresponding author. The second method was used to investigate pupils' ideas about science. This method is based on children's drawings of an ideal science learning environment. We set the methods at the last day of every short-term stay of pupils at the Field Centre. The data obtained from experimental group were compared with data from the control group. We have deliberately chosen method of drawing, because this technique has been described as an 'innovative' method and able to 'provide an empirical demonstration of the high quality and sophisticated nature of data which can be collected from young children' (Pridmore and Bendelow, 1995). More often it is used in diagnosis of different mental characteristics (as a tool of psycho-analysis; Backett-Milburn and McKie, 1999), but also to investigate pupils' biology knowledge (e.g. Tunnicliffe and Reiss, 1999). The use of drawing in our case avoided direct question about the content of what pupils like or dislike in the new environment. Instead we tried to gain evidences for the effect of filed trips and the new environment indirectly, beyond pupils' knowledge about our intention.

The first task for experimental and control group was to draw their idea of an ideal science education environment, for example the class or place where learning would be pleasant for them. Then, both of us scored drawings independently and separately for the presence elements bearing with the ideal environment. In the few cases where our scorings differed we discussed the drawing until we agreed on the category to be awarded in order to maintain validity and reliability of the instrument. Finally, we were able to assign every drawing element into one of the following seven categories:

1. *Nature* – placing a classroom into an outside environment or putting the outside environment (or parts of the nature) into a classroom.
2. *Laboratory* – putting a laboratory or its equipment into a classroom.
3. *Computers* – putting computers or other electronic equipment into a classroom.
4. *Non-traditional class settings* – an implementation of new elements to the class, group work in the class, new layout of desks, learning via internet, etc.
5. *Athletics/Sport* – using various types of athletic activities or fields.
6. *Rest* – items of the class or its surrounding used for resting.

Participants

Pupils from the both groups (experimental and control) were selected from the same schools and in all cases they were taught by the same science teachers. Pupils of the experimental group were chosen randomly, regardless of pupils' interests. This approach helped to eliminate the potential effect of the pupils' previous experience and attitudes toward science education. All pupils in the field courses (experimental group) were educated in the Science Field Centre by the authors of the article. More details about the content of the field courses in the Science Field Centre can be found in Žoldošová and Prokop (2006).

The experimental group included 153 pupils from 7 different elementary schools (70 boys, 83 girls) and the control group includes 363 pupils from the same 7 elementary schools (165 boys, 198 girls). Pupils were 10–14 years old. Length of the courses was in average 5 days.

Hypotheses

We expected that the new educational form of field education will influence a pupils' motivation toward science. We suppose that pupils from the experimental group, unlike pupils from the control group, will prefer book titles related to field science education, and they will implement items of this educational form to their idea of an ideal science educational environment.

Statistical Analysis

Using the drawing method, we have got frequencies of drawn elements in the seven categories for both pupils groups. Also, in method of book title choice we have got frequencies of the pupils' choices. For analysis of the data we used non-parametric statistics method Chi-square χ^2 test.

RESULTS

Pupils' Interest

All 16 book titles that were related to the field courses were significantly more preferred in the experimental group (311 out of 765 preferences, 40.65%) contrary of the control group (582 out of 1830 preferences, 31.80%) (Chi-square test, $\chi^2 = 18.72$, d.f. $= 1, p < 0.0001$). For further analyses, we used ten most preferred book titles (i.e. titles with highest preferences) for a side-by-side comparison.

The analysis of the preference comparison (Table I) showed that pupils from the control group were more interested in books relating to the internet, computers or books that would be generally regarded as interesting, but without any deeper relationship to the field courses. On the other hand, pupils from the experimental group markedly preferred titles that were more closely related to the field education.

Gender Differences

Boys from the control group significantly differed from the girls in preference of 6 out of 10 most preferred book titles (Table II). Boys were more interested in technical topics such as computers, flame tests, wood. The girls differed in eight out of top 10 book titles selection from the boys of the control group. They preferred traditional topics about scents, colours, flowers etc.

Table I. Ten of the Most Preferred Book Titles (Pupils Age 10–14), (χ^2)

Control group (N = 366)			Experimental group (N = 153)		
Book title	Percent of choices (%)[a]	p	Book title	Percent of choices (%)[a]	p
Your guide for Internet surfing	31.69	< 0.01	Cannibalism in the animal kingdom	38.56	< 0.01
Gold from lead	26.5	n.s.	Home chemical laboratory	28.75	n.s.
Basics for the PC	25.68	< 0.01	Spiders	27.45	< 0.01
Cannibalism in the animal kingdom	25.68	< 0.01	Life of insects	26.79	< 0.01
Make your own perfume	25.4	n.s.	Recognising birds by their song	21.56	n.s.
Home chemical laboratory	25.13	n.s.	Gold from lead	20.91	n.s.
Dissolving a diamond in a test-tube	24.31	n.s.	What can I see through the telescope?	18.3	< 0.05
What can I make from wood?	19.39	n.s.	Chemistry and ourselves	17.64	< 0.01
Why are the flowers colorful?	16.93	n.s.	Little chemists	17.64	< 0.01
Handmade matches	16.93	n.s.	Make your own perfume	17.64	n.s.

[a]Basic of percentage calculation is a number of pupils multiplied by five choices, because every pupil had five choices.
n.s. = not significant.

Table II. Gender Differences in Control Group (χ^2)

Boys (N = 165)			Girls (N = 201)		
Book title	%[a]	p	Book title	%[a]	p
Gold from lead	33.93	< 0.01	Make your own scent	40.79	< 0.01
Basics for the PC	31.51	< 0.05	Your guide to Internet surfing	30.3	n.s.
Cannibalism in the animal kingdom	31.51	< 0.05	Why are the flowers colourful?	29.35	< 0.01
Your guide to Internet surfing	30.3	n.s.	How to remove spots from fabric	23.38	< 0.01
Home chemical laboratory	26.66	n.s.	Home chemical laboratory	22.38	n.s.
Flame tests	24.84	< 0.01	Basics for the PC	20.89	< 0.05
What can I make from wood?	24.24	< 0.01	Gold from lead	20.39	< 0.01
Dissolving a diamond in a test-tube	23.63	n.s.	Cannibalism in the animal kingdom	20.39	< 0.05
Handmade matches	20.6	n.s.	Recognising birds by their song	18.9	< 0.05
Fishing from biological point of view	20.91	< 0.01	Small biological encyclopaedia	18.4	< 0.01

[a]Basic of percentage calculation is a number of pupils multiplied by five choices, because every pupil had five choices.
n.s. = not significant.

Gender differences in the experimental group were not as significant as in the control group (Table III). Boys differed from girls in only 4 of the top 10 book topics. The most preferred titles had been presented as science topics in the field courses (such as Cannibalism or Spiders).

Table III. Gender Differences in Experimental Group (χ^2)

Boys (N = 70)			Girls (N = 83)		
Book title	%[a]	p	Book title	%[a]	p
Cannibalism in the animal kingdom	38.57	n.s.	Cannibalism in the animal kingdom	38.55	n.s.
Spiders	31.42	n.s.	Life of insects	33.73	< 0.05
Home chemical laboratory	30	n.s.	Recognising birds by their song	28.91	< 0.05
Gold from lead	27.14	n.s.	Home chemical laboratory	27.71	n.s.
Plants and fungi poisons	22.85	< 0.05	Make your own perfume	27.71	< 0.01
Little chemists	20	n.s.	Spiders	21.09	n.s.
Flame tests	20	< 0.05	Why are the flowers colourful?	20.48	< 0.01
Handmade matches	18.57	n.s.	What can I see through the telescope?	19.27	n.s.
I will make an iron	18.57	< 0.05	Chemistry and ourselves	18.57	n.s.
Life of insects	18.37	< 0.05	Little chemists	18.57	n.s.

[a]Basic of percentage calculation is a number of pupils multiplied by five choices, because every pupil had five choices.
n.s. = not significant.

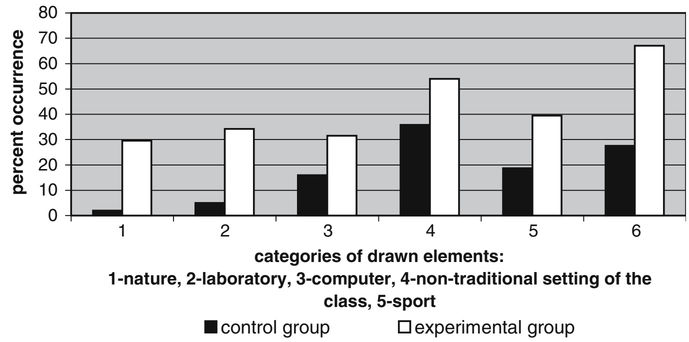

Fig. 1. Differences between control and experimental group of pupils in the defined categories of drawn elements. 1: Nature, 2: laboratory, 3: computer, 4: non-traditional setting of the class, 5: sport. ■ – Control group, □ – experimental group.

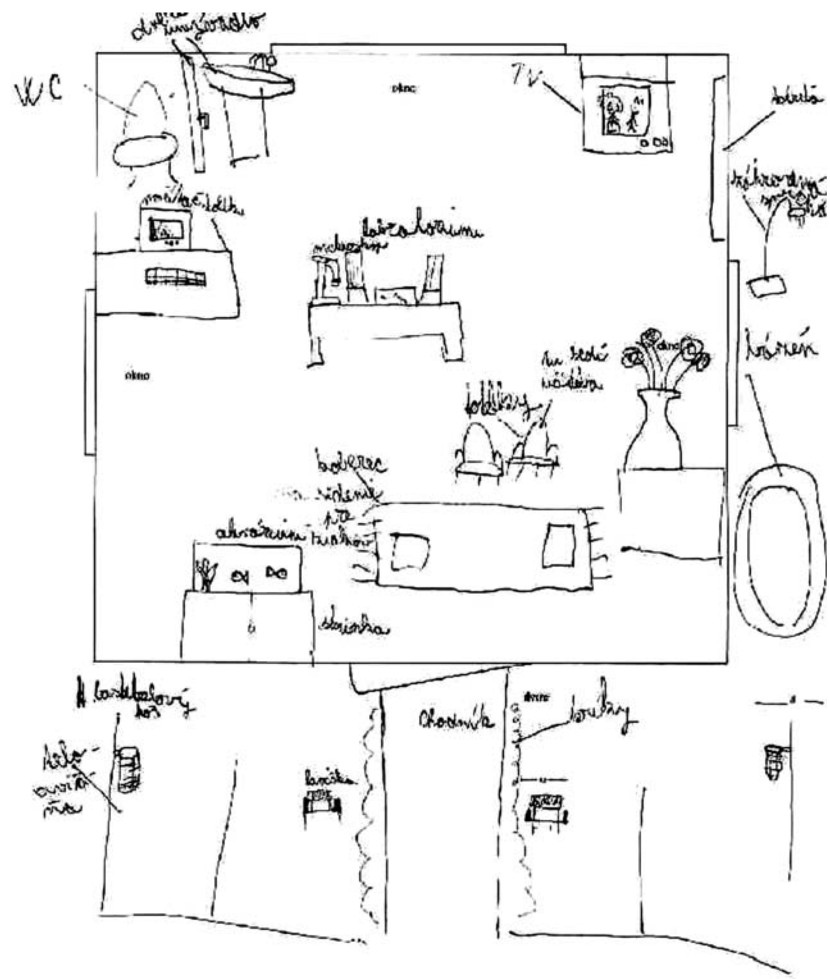

Fig. 2. Drawing of girl 10 years old from the experimental group. The girl drew non-traditional composition of school class; she would prefer to work in a peer-group. In the drawing we can find also chemical laboratory and place for observing living organisms. We found out, that the girl put some parts of the class also outdoor.

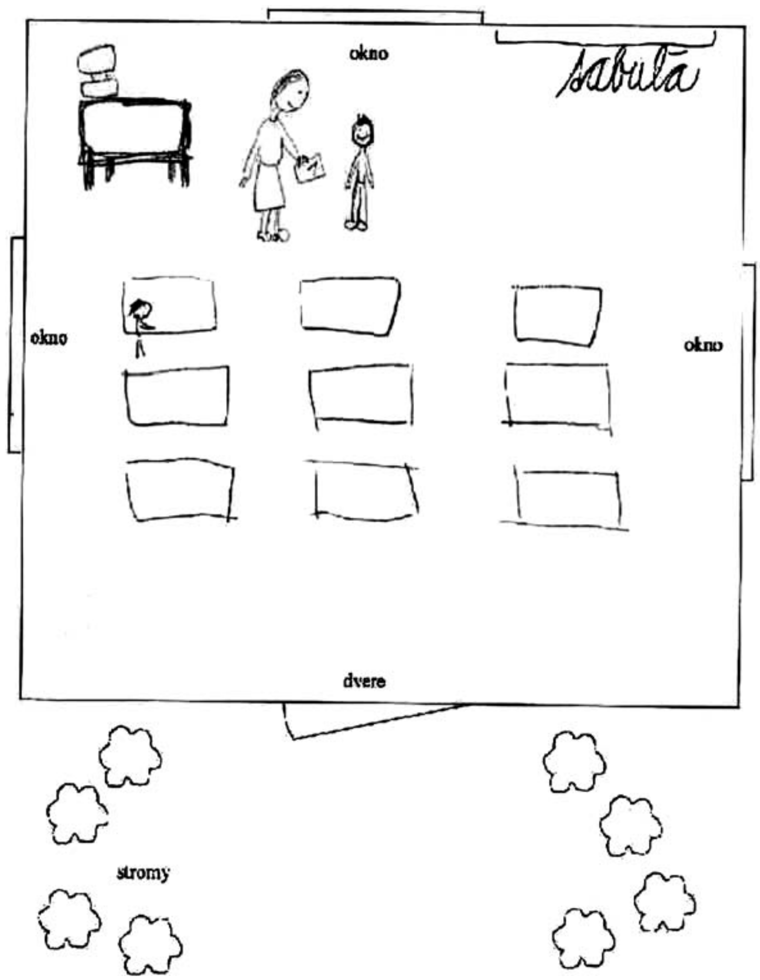

Fig. 3. Drawing of girl 10 years old from the control group. The girl drew traditional composition of a school class for frontal teaching. In comparison to the girl from an experimental group, she felt it is very important to draw also her teacher.

Pupils' Ideas about Ideal Learning Environment

In both of the groups we have counted the frequencies of the drawn elements in all seven defined categories. We have found meaningful differences between the pupils groups (Figure 1; examples of pupils' drawings: Figures 2 and 3); the experimental group drew significantly more items compared to the control group in all defined categories (Table IV).

Gender Differences

The differences were not as significant as we had expected and did not occur in the all defined categories of the drawn elements. The results are in Table V (for control group) and Table VI (for experimental group). We have found only one significant gender difference in both groups in category "*Rest*". Girls placed significantly more items of rest in their drawings in comparison with the boys sub-group.

Table IV. Significance of the Differences between Experimental and Control Group in Appearance of the Categories Elements, Detected by χ^2 Test

Element of the drawing		% Cont. group	% Exp. group	*p*
1	Nature	1.92	29.6	< 0.01
2	Laboratory	4.96	34.2	< 0.01
3	Computer	16	31.6	< 0.01
4	Non-traditional setting of the class	35.8	54	< 0.01
5	Sport	18.7	39.5	< 0.01
6	Rest	27.5	67.1	< 0.01

Table V. Significance of the Differences between Boys and Girls in the Control Group in Appearance of the Categories Elements, Detected by χ^2 Test

	Element of the drawing	% Boys	% Girls	p
1	Nature	0.7	3.02	n.s.
2	Laboratory	4.27	5.53	n.s.
3	Computer	22	11.1	n.s.
4	Non-traditional setting of the class	36	35.7	n.s.
5	Sport	21.3	16.6	n.s.
6	Rest	29.9	25.6	<0.01

n.s. = not significant

DISCUSSION

Our study clearly showed the short-term effect of informal field science education on pupils' interest and ideas about science education. The two simple methods of this study allowed us to examine large number of students over a relatively short time. Our courses run for a short period of time. Main part of the time was spent right in the field or in the field laboratory. Time limitation was the main reason why we did not use pre-test and post-tests or interviews as a research tools. However, all pupils were from the same schools and were selected randomly as whole classes. The potential effect of their previous interest in science can be eliminated. Furthermore, significant differences were obtained by both means of methods with respect to gender differences in a relatively large sample.

The results of the method based on book titles choice showed significant differences between the experimental and the control group. We can predict, that the differences were caused by science related activities in the Field Centre, but other possible explanations such as the 'Availability of Heuristic' (see Tversky and Kahneman, 1974 for more details) cannot be ruled out. Unlike the control group, pupils from the experimental group preferred book titles related to activities in the Field Centre. Another study of 1544 Slovak pupils from several elementary schools (Prokop and Prokop, unpublished data) showed that pupils do not consider arachnids and insects as attractive animals. Pupils who had contact with these invertebrates in the Field Centre preferred book title which deals the invertebrates topics. More surprisingly, chemistry books were among the top ten titles and were significantly more preferred in comparison with the control group. Pupils perceive chemistry and physics as some of the most difficult subjects (Stronk 1974; Prokop and Prokop, unpublished data). We expected that there is a real possibility to make chemistry more attractive using non-traditional methods of science education, especially when the learning environment is the Field Centre. Except that pupils have possibility to observe and investigate animal communication, especially ants (for activities with ants that were also performed in the Science Centre see Skinner, 1988), spiders and birds, they have had also possibility to receive experience with microscopes, chemical substances and other scientific equipment. They investigated the chemical properties of flowers and fruit colours. They also learned how minerals and rocks are created and how to name them upon their properties.

These motivational incentives affect pupils' interest towards learning process. The traditional educational environment is usually neither variable nor interesting as the natural environment. That is why it is quite clear to say, that science field centers provide greater resources to increase pupils' interest in comparison with the traditional school classroom.

However, how long can the increased interest last? Interest has been recognized as individual and situational (Hidi, 2000; Renninger, 2000). While individual interest is relatively stable and difficult to change (Renninger, 2000); situational interest can be easily elicited and may lead the development of new individual interest in the content area (Hidi and Berndorf, 1998). Following these definitions, we can expect that situational interest can affect pupils for a relatively long time. However, additional data is needed for confirming such a prediction. Salmi (2003), for example, showed that 85% students studying natural sciences at university previously

Table VI. Significance of the differences between boys and girls in the experimental group in appearance of the categories elements, detected by χ^2 test

	Element of the drawing	% Boys	% Girls	p
1	Nature	25	33	n.s.
2	Laboratory	31	37	n.s.
3	Computer	38	26	<0.01
4	Non-traditional setting of the class	50	57	n.s.
5	Sport	34	44	n.s.
6	Rest	56	76	n.s.

n.s. = not significant.

visited a science centre. Yet, the question whether these students were previously interested in nature (individual interest) or, became interested through experiencing work in the science centre (situational interest) remains unresolved. Markowitz (2004) confirmed that two-three week lasting summer science courses reported by Knox *et al.* (2003) have significant, long-term outcomes on participants' achievement and attitudes toward science. Other researchers such as Fernández *et al.* (1999) do not provide evidences whether science field courses have longitudinal impact or not.

The diagnostic method of children's drawings helped us to identify not only change in the children's ideas about interesting science education, but also helped us to understand children's attitudes toward science education and also helped us to characterize their knowledge (see Backett-Milburn and McKie, 1999 for a review). The greatest advantage of the method is in freedom of an idea expression. Children can express via the drawing more information than via written expression. Better said, children are unable to express via verbal expressions some of the information contained in the drawings.

Children draw the most important concepts of their ideas related to the investigated phenomenon (Kidd and Kidd, 1995). Drawing analysis can show untold realities hidden in child's psychics (Czenner, 1986). Use of children's drawings in pedagogical research is unspecific, but it comes from the same principles as it has been stated previously. Results of this study showed obvious differences between experimental and control group. Pupils that visited the Field Centre included into their drawings significantly more items related to the field science environment compared to those that did not. Both used methods showed an influence of the Field Centre on pupils' interests and ideas about science education. We propose that field science education has a significant effect on pupils' motivation to learn science.

Boys are generally more interested in technical sciences than girls (Farenga and Joyce, 1999; Jones *et al.*, 2000; but see also Greenfield, 1997). Interestingly, inspection of pupils' drawings did not demonstrate gender differences in the occurrence of computers. In general, boys are more likely to use computers than girls (e.g. Greenfield, 1995; Jones *et al.*, 2000). Similarly, we expected gender differences in the occurrence of laboratory experimental equipment in the children drawings. But we did not find clear differences. Our expectation was built on study of Milett and Lock (1992), who discovered higher inclination of boys' subgroup to experiment with live organisms. Furthermore, Jones *et al.* (2000) discovered out more positive attitudes toward the use of microscope and chemicals in the boys' group.

Despite the fact that the results of gender differences (using the drawing method) were vague, we do not consider our results as controversial to the mentioned results of different similar studies. All participants were asked to draw an ideal educational environment and, both boys and girls experienced the same environmental conditions. The idea of an ideal science education environment was therefore very similar.

Following the aforesaid comparison we can validate the assumption that pupils who experienced the course in the Field Centre were positively influenced by the implementation of the experience learning in the field. As a main factor of the influence, we can regard changes in a situational interest. The role of scientists in the natural environment of the Field Centre motivated pupils to learn more about natural phenomena and objects of their daily experience.

In Slovakia another field centre with similar programming does not exist yet. Therefore, we would like to address such countries, where science education field centers and informal learning is still rare. We hope that our experience with the development of the Field Centre will assist in establishing similar science centers in the field.

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