The Journal of Environmental Education, 2002, Vol. 33 No. 2 22–31

The Influence of an Educational Program on Children's Perception of Biodiversity

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ABSTRACT: In this study, the author investigated the influence of the educational program Nature on the Way to School on children's everyday perception of species. More than 4,000 children (8–16 years old) from 248 classes in Switzerland participated in the study. Possible influences of the program were evaluated with the help of pretest and posttest questionnaires completed by test-group and control-group teachers and students. Participation in the program significantly increased the number and diversity of species that children noticed on the way to school; the positive effects increased with the time spent on the program. The program had a similar positive effect on both younger and older children and on girls and boys.

Key words: biodiversity, educational program, evaluation, perception

There is increasing concern among scientists about the state of the environment worldwide (Botkin & Keller, 1995; Robinson, 1993). Biodiversity is a major focus of this concern (see overview in Heywood, 1995); the accelerating decline in biodiversity because of human activities is one of the most urgent environmental issues (Meffe & Carroll, 1994; Wilson, 1992). To safeguard the global richness of life forms, it is essential to raise public awareness about the need to preserve biological diversity (United Nations Educational, Scientific, and Cultural Organization, 1993; World Resources Institute & The World Conservation Union/United Nations Environment Program, 1992). However, biodiversity has only recently become an important focus of scientific research and political discussion (Wilson & Peter, 1988). It is also a relatively new issue in educational research and formal education (Chipeniuk, 1995; Crisci, McInerney, & McWethy, 1993; Mayer, 1992).

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Weilbacher (1993) has argued that individuals will only miss a species if they know it and have developed a relationship with it. The study of organisms and their diversity used to be a focus of traditional biology education; in recent decades, however, biology education has become increasingly dominated by physiology, molecular biology, and genetics (Mayer, 1993; Yore & Boyer, 1997). The biodiversity crisis has generated renewed interest in organismic biology and has evoked demands for greater emphasis on the study of organisms and their diversity in education (Mallow, 1994). Nevertheless, students should not be passive recipients of meaningless names and information as in classic taxonomy education (Crisci et al., 1993). In a German survey, most experts thought that biodiversity education should be an active process, in which students (a) observe and investigate plants and animals in their immediate environment, (b) become knowledgeable about local species, and (c) understand and value biodiversity (Mayer, 1992).

Recently, educational programs and materials have been developed in European countries in an effort to foster an understanding of biodiversity (Crisci et al., 1993; Cuche & Gigon, 1996; Nagel, 1997; Schweizerischer Bund für Naturschutz, SBN, 1995). One needs suitable evaluations to assess the effectiveness of these programs (Bennett, 1988; Leeming, Dwyer, Porter, & Cobern, 1993; Stokking, van Zoelen, van Aert, & Young, 1995). At present, little is known about the outcomes of modern biodiversity education.

Previous studies have concentrated on the effects of environmental education (EE) on students' environmental knowledge, attitudes, and behavior (see reviews in Hines, Hungerford, & Tomera, 1986; Langeheine & Lehmann, 1986; Leeming et al., 1993; Leeming, Dwyer, Porter, Cobern, & Oliver, 1997). Few researchers have investigated the effect of taxonomy education on children's knowledge about particular species; taxonomy education can increase children's knowledge about plants and animals (Pfligersdorffer, 1984; Rexer & Birkel, 1986; Scherf, 1985; Starosta, 1990; see also Killermann, 1996). As one study indicates, taxonomy education can also increase students' protective attitudes toward a particular species (Scherf, 1985). In an Austrian study, Pfligersdorffer (1984) showed that seventh graders who participated in a half-day excursion to a forest and investigated organisms in their natural environment learned more about forest organisms than students who received a theoretical 2-hr classroom instruction on the same topic. Similar results were found in a German study in which sixth graders received four lessons about aquatic species either at a pond or in the classroom (Starosta, 1990). In both studies, students with poor learning abilities (in particular) profited from the field trips (Pfligersdorffer, 1984; Rexer & Birkel, 1986; Starosta, 1990). In a German study of fourth graders, a 3-hr classroom instruction about local ruderal plants combined with a field trip was more effective than classroom instruction only (Scherf, 1985). However, all these studies included only a few classes and did not compare different age groups.

Educational programs are usually designed for a certain type of school (e.g., primary or secondary) and not for particular class levels. Nonetheless, to improve the suitability of programs, it is important to know if children of different ages benefit to a similar degree from a program (Leeming et al., 1993). German researchers have found that children's interest in biology increases until the beginning of adolescence and then declines significantly between the ages of 12 and 15 (Löwe, 1992). Researchers in the United States found a similar trend in a 10-year longitudinal study (Simpson & Oliver, 1990); the large population of study participants (4,500 students in Grades 6–10) showed that positive attitudes toward science and motivation to achieve in science steadily declined with age. Educational programs, therefore, might not be equally effective for students of different ages.

My aim in the present study was to investigate the influence of the educational program Nature on the Way to School on children's everyday-life perceptions of species and diversity. More than 4,000 children from 248 classes (of different grades) participated in the study, which was part of a larger project on children's cognition of biodiversity in Switzerland (Lindemann-Matthies, 1999). The main questions that I explored in the study were (a) Did the educational program increase Swiss children's perception of species? If so, which additional species did the children notice? (b) Did the program lead to the children's acquaintance with species that they previously did not know? (c) Was the program's outcome related to the time spent on the program? (d) Did the children's age and sex influence the program's outcome?

Method

The Educational Program

The Swiss conservation organization Pro Natura developed the Nature on the Way to School program as an educational supplement for primary schools. The main aims of the program were the promotion of (a) opportunities for children to experience nature first hand on the way to school, (b) children's awareness of nature in their everyday lives, and (c) interest in and tolerance for local species. Pro Natura provided a brochure and a poster to help teachers and students investigate nature and take action in nature conservation (SBN, 1995). The program was designed to be implemented during the spring and summer (the vegetation period). Between March 1995 and July 1995, more than 500 classes and 14,000 students from all over Switzerland participated in Nature on the Way to School.

In the educational material, teachers were given instruction on how to engage their students in active investigations of nature during lessons and how to observe nature during their daily walks to school. (In Switzerland, primary school children usually live in walking distance of their school.) The educational material included information on (a) the life of the sparrow; (b) snails, slugs, and earthworms; (c) ladybirds; (d) insects on plants; (e) trees in the city; (f) climbing plants; (g) life in cracks and crevices; (h) lichens and mosses; and (i) native and nonnative plants. Each topic was presented on two pages of a brochure. One page contained relevant information for the teachers, including methodological and didactic aids. The other page contained suggestions for observation tasks for the students. Illustrations of common species were also included. In addition, the brochure included songs, poems, riddles, suggestions for action to further nature conservation, and detailed instructions about how to participate in a nature gallery involving "framing" favorite plants or animals (SBN, 1995).

In May 1995 (on the way to school) students placed a picture frame around a plant—or, if possible, animal—that they especially valued. The children were encouraged to stay with their frames for about 1 week, explaining to other children, to parents, to passers by, and in some cases also to the media why they had selected these particular objects.

Thus, the children tried to increase adults' awareness of native species and diversity, with the hope of promoting a behavior that is compatible with the conservation of species.

The program was flexible. Teachers were free to select suitable topics and methods for their classes. The teachers completed a questionnaire that provided information about the activities undertaken during the program. Moreover, teachers engaged their students in hands-on activities outside the classroom (i.e., the observation, identification, and study of plants and animals, and the nature gallery). Students also collected natural objects and presented them in the classroom, drew plants and animals, and kept animals (i.e., snails, slugs, and earthworms) in the classroom for observation. Some children maintained diaries in which they recorded their observations about plants and animals that they encountered on their way to school.

Study Design and Treatments

All teachers who had ordered the educational material for Nature on the Way to School were asked to participate in the present study. Along with the educational material, these teachers received a questionnaire, questionnaires for their students, a letter containing an outline of the aims of the present study, and detailed instructions about how to perform the evaluation.

Evaluations can be biased if a teacher administers both the intervention (treatment) and the questionnaires (see Bogner, 1998). In the present study, however, it was not possible to control for researcher versus teacher influences by personally administering the questionnaires to randomly selected classes. The only way to address the program participants (teachers and their classes) was via the program organizers, who asked for as little interference as possible. Moreover, there is a strict data protection law in Switzerland and, therefore, the researcher knew neither the schools nor the teachers. The participants' anonymity was guaranteed, but—to be able to match the questionnaires of classes with those of their teachers—I marked each set of questionnaires with a number.

I evaluated possible influences of the program on participants using a pretest or posttest design with a test group and a control group (Figure 1). The control group consisted of classes that did not participate in the program but completed the questionnaires. The necessity of a control group was explained to the teachers who were asked to select a matching class to serve as the control group.

Teachers were asked to administer the questionnaires in the classroom. The pretest questionnaires were completed immediately before the start of the program; the posttest and teachers' questionnaires were completed immediately after the end of the program. All of the children's questionnaires were identical, although a few additional questions about the program were included in the posttest for the test group.

FIGURE 1. Study design and number of classes in the test group and control group.

Test group	Control group
Pretest (166 classes)	Pretest (82 classes)
↓	↓
Educational program "Nature on the Way to School"	No special school program
↓	↓
Posttest (166 classes) and questionnaire for teachers	Posttest (82 classes)

Instrument

The pretest questionnaires (for the test group and control group) and the posttest questionnaire (for the control group) consisted of 18 items; the posttest questionnaire (for the test group) consisted of 25 items. The items investigated children's perception of biodiversity in everyday life and their preferences regarding plants and animals. The teachers' questionnaire comprised 13 items, which asked for the activities undertaken during the program, the number of lessons spent, teachers' assessment of the educational material, and the activities undertaken. (A set of questionnaires is available in English from the author, petral@uwinst.unizh.ch)

A panel of four environmental education experts evaluated the content validity of the items in the questionnaires; the final items were formulated and tested in a pilot study on the basis of their comments. To test whether all children understood the questions, individual children were asked to describe the meaning of each item and to comment on the language (see recommendations in Friedrichs, 1990; Presser & Blair, 1994). The instrument was then tested in four classes in a primary school that did not participate in the program. During the trial, the teachers were asked to review the questions and to comment on the format.

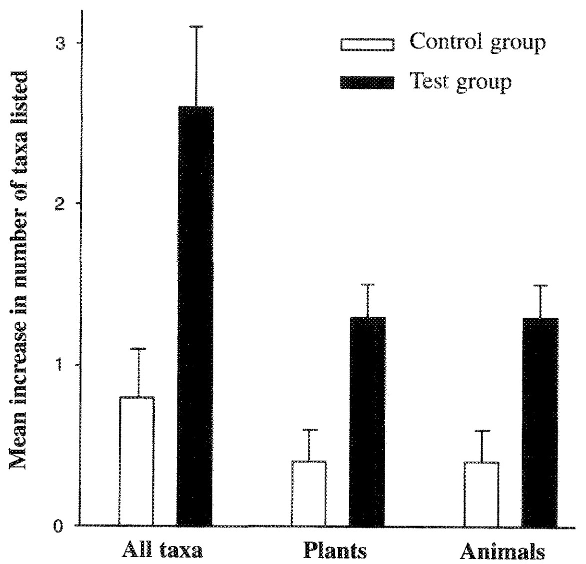
The children were asked (in both the pretest and the posttest) to list and name as many of the plants and animals they encountered on their way to school as they could. In the posttest, the test group was also asked if they had become familiar with plants or animals that they had never seen before. The children could choose between the answers "yes," "no," and "don't know." In addition, they were asked to record the names of the organisms with which they had become familiar. The children were also asked to record their age (in years) and sex; the teachers were asked to indicate the time (number of lessons) spent on the program.

Response Rate and Respondents

The questionnaires were sent to 525 Swiss schools. The pretest questionnaires were returned by 38% of the schools; the posttest questionnaires were returned by 31% of the schools. The data were collected during a 5-month period (March through July 1995).

Only classes that participated in both the pretest and the posttest were included in the analyses (248 classes from 146 schools). The test group consisted of 166 classes and the control group consisted of 82 classes (Figure 1). Although the teaching material was designed primarily for primary schools, some secondary schools also participated in the program. (In Switzerland, students start secondary school as seventh graders.) The mean age of children in the participating classes ranged from 8–16 years, but the largest group was 10 years old. Children in the test group and the control group were of similar age (10.6 years and 10.9 years, respectively; $p = .39$). The proportion of girls was 51% in the control group and 49% in the test group.

FIGURE 2. The effect of the educational program on the number of taxa that Swiss children noticed on the way to school.



Statistical Analysis

Because of the hierarchical design of the study (classes in schools, children in classes), I analyzed the data about changes in species perception using nested analyses of variance (Sokal & Rohlf, 1981). This type of analysis is necessary to avoid pseudoreplication, which is a frequent problem in environmental education research (Leeming et al., 1993). The unit of analysis for the effects of the mean age of children and of the educational program was the class, because the children's mean age was known for each class and the treatment (participation in the educational program) was applied to the individual classes. Individual children in a class do not constitute independent experimental units because they are all taught by the same teacher and interact in various ways with each other. The effects of mean age, treatment, and number of lessons spent on the program were, thus, tested against the residual variation among classes, whereas the effects of the sex of the children and of the interactions with this factor were tested against the residual.

TABLE 1. Nested ANOVA of the Effects of Treatment (Participation in the Educational Program)

		All taxa		Plants		Animals	
Source	*df*	*MS*	*F*	*MS*	*F*	*MS*	*F*
School	145	52.67	1.1	15.74	1.2	13.99	1.0
M age	6	19.03	0.4	6.01	0.5	4.87	0.3
Age (linear)	1	9.91	0.2	1.82	0.1	3.24	0.2
Age (quadratic)	1	76.66	1.6	17.14	1.3	21.31	1.5
Age (residual)	4	6.91	0.1	4.28	0.3	1.17	0.1
Treatment (T)	1	418.63	9.0**	106.80	8.2**	102.54	7.3**
Age (linear) × T	1	66.97	1.4	4.81	0.4	35.90	2.6
Age (quadratic) × T	1	147.25	3.1	60.32	4.6*	19.08	1.4
Age (residual) × T	4	20.68	0.4	5.87	0.5	7.82	0.6
Class	101	46.57	6.6***	13.03	5.9***	14.01	4.9***
Sex	1	94.21	13.3***	13.90	6.3*	35.73	12.5***
Age (linear) × Sex	1	8.08	1.1	3.74	1.7	0.83	0.3
Age (quadratic) × Sex	1	27.14	3.8	11.19	5.1*	3.48	1.2
Age (residual) × Sex	4	12.93	1.8	4.98	2.3	3.02	1.1
Treatment × Sex	1	0.04	< 0.1	0.55	0.3	0.29	0.1
Residual	228	7.09		2.20		2.85	
Total	501						

Note. The effects of school, age, treatment, and their interactions with treatment were tested against the residual variation among classes. All other effects were tested against the residual. Age and sex on the mean increased from pretest to posttest in the number of taxa Swiss children noticed on the way to school.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

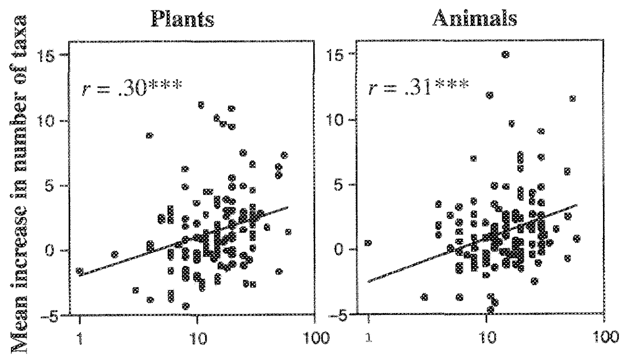
TABLE 2. Nested ANOVA of the Effects of the Number of Lessons Spent on the Educational Program

		All taxa		Plants		Animals	
Source	*df*	*MS*	*F*	*MS*	*F*	*MS*	*F*
M age	6	51.76	0.8	15.31	0.8	13.97	0.8
Lessons (log)	1	786.95	11.9***	202.90	11.0***	190.67	10.4**
Age × Lessons	6	21.83	0.3	7.46	0.4	5.54	0.3
Class	129	66.41	8.5***	18.39	7.4***	18.33	6.2***
Sex	1	62.34	8.0**	15.10	6.1*	16.08	5.5*
Sex × Lessons	1	2.98	0.4	1.81	0.7	0.14	< 0.1
Residual	119	7.80		2.48		2.94	
Total	263						

Note. Age and sex on the mean increased from pretest to posttest in the number of taxa Swiss children noticed on the way to school.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

To investigate the relationship between the mean age of children and the studied variables in more detail, I fitted linear and quadratic contrasts. These contrasts are more useful than a simple test of the effect of age because they answer more focused questions (see Rosenthal, Rosnow, & Rubin, 2000; Sokal & Rohlf, 1981). For instance, whereas an overall test gives no indication of the form of the relationship between age and the change in species perception from spring to summer, a linear contrast indicates if the increase in species perception increases with age and a quadratic contrast indicates if there is an age at which the increase is maximal (parabolic relationship). Because of the hierarchical design, I calculated Type I sums of squares (Potvin, 1993). I performed all analyses with the program SPSS for Windows (SPSS, 1998).

FIGURE 3. The effect of the amount of time (number of lessons) that teachers spent on the educational program Nature on the Way to School.



Results

On average, the posttest was carried out 7 weeks after the pretest. In the posttest, the mean number of taxa that children noticed on their way to school was higher in both the control group and the test group (Figure 2). However, the increase in the mean number of taxa listed was significantly larger in the test group than in the control group (2.6 and 0.8, respectively; Table 1). Thus, the program was successful and increased the perception of species. This increase was similar for both plants and animals (see Figure 2).

The mean age of children in a class had no effect on the mean increase in the number of taxa that the children in a class noticed. The effect of participation in the program on the mean increase in the number of animals and the total number of taxa noticed was similar for children of different ages. However, the increase in plant perception because of participation increased until age 10 and then decreased (see significant interaction between quadratic trend component of age and treatment in Table 1).

The residual variation among classes within schools was significant. Because of the hierarchical analysis, this result shows that there were differences among the individual classes that could not be explained by differences among the schools or among the mean ages of the children (by effects of the educational program). These disparities may be attributed to differences among teachers.

The mean increase from spring to early summer in the number of taxa noticed was larger for girls than for boys, both in the control and in the test group (Table 1: all taxa = 2.4 and 1.5 respectively; plants = 1.1 and .8, respectively; animals 1.3 and .7, respectively). Regarding the increase in plant perception, the difference between girls and boys increased until age 11 and then decreased (see significant interaction between sex and age in Table 1). Participation in the program improved girls' and boys' perception of taxa to a similar degree (no significant interaction between sex and treatment; see Table 1).

Teachers spent between 1 and 60 hr of lessons (M = 17 hours) on the various activities of Nature on the Way to

School. The number of lessons taught had a strong effect on the mean increase from spring (pretest) to early summer (posttest) in the number of taxa that a class noticed (Table 2). This effect was similar for plant and for animal taxa. The more time that teachers spent on the program, the more additional plant and animal taxa the class was able to list from the pretest to the posttest (Figure 3). The number of lessons taught changed the perception of children of different ages to a similar degree (no significant interaction between age and number of lessons; see Table 2). The influence on changes in girls' and boys' perceptions was also similar (There was no significant interaction between gender and number of lessons; see Table 2).

Participation in the program influenced not only the number of plant and animal taxa that children noticed on their way to school, but also the identity of the taxa they listed. Children in both the test group and the control group tended to list more

FIGURE 4. Changes between spring and early summer in the number of taxa that Swiss children noticed on the way to school.

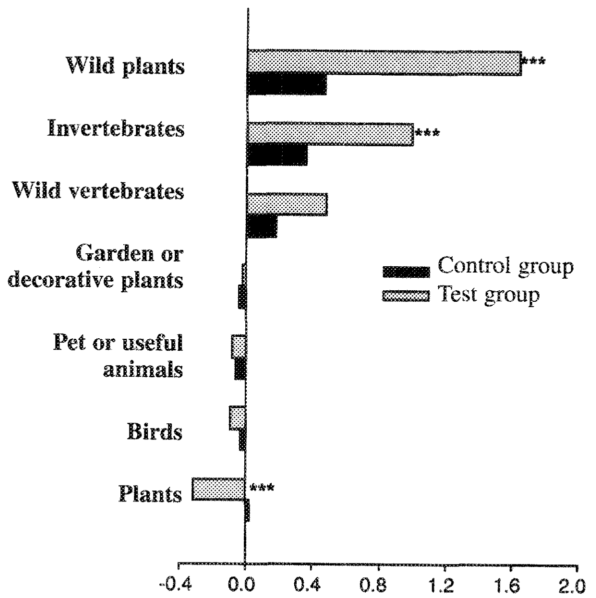


TABLE 3. Effect of the Educational Program on Children's Acquaintance With New Taxa of Plants and Animals

Groups of taxa	Total no. of answers	Proportion of children (%)
Wild flowers and grasses	898	75.1
Insects and spiders	328	27.4
Wild trees and shrubs, woody climbers	243	20.3
Wild birds	236	19.7
Ferns, mosses, lichens	119	10.0
Other groups of plants	291	24.3
Other groups of animals	161	13.5

Note. The plant and animal taxa were grouped into broad categories. Responding children numbered 1,195. Percentages do not equal 100% because more than one answer was allowed.

TABLE 4. Nested ANOVA of the Effects of Age and Sex on the Mean Proportion of Children Per Class Who Stated That They Had Become Familiar With New Taxa of Plants or Animals During the Educational Program

Source	*df*	*MS*	*F*
M age	6	4,122.72	2.7*
Age (linear)	1	19,840.24	13.1***
Age (quadratic)	1	1,881.29	1.2
Age (residual)	4	753.61	0.5
Class	161	1,511.04	6.0***
Sex	1	2,814.40	11.3**
Age (linear) × Sex	1	7.94	< 0.1
Age (quadratic) × Sex	1	256.02	1.0
Age (residual) × Sex	4	239.89	1.0
Residual	149	249.86	
Total	329		

Note. The effects of age, number of lessons spent, and their interactions were tested against the residual variation among classes; all other effects were tested against the residual.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

FIGURE 5. The effect of mean age on the mean proportion of children in a class that became familiar with new taxa of plants and animals during Nature on the Way to School.

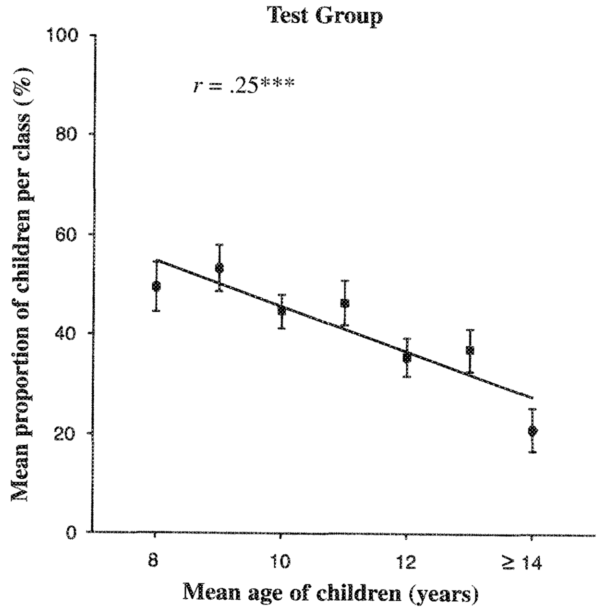


TABLE 5. Nested ANOVA of the Effects of the Number of Lessons Spent on the Mean Proportion of Children per Class Who Stated That They Had Become Familiar With New Taxa of Plants or Animals During the Educational Program

Source	*df*	*MS*	*F*
M age	6	5267.62	4.1**
Lessons (log)	1	30445.18	23.6***
Age × lessons	6	1124.32	0.9
Class	126	1292.67	6.0***
Sex	1	1405.06	6.5*
Sex × lessons	1	0.36	< 0.1
Residual	116	216.19	
Total	257		

Note. The effects of age, number of lessons spent, and their interactions were tested against the residual variation among classes; all other effects were tested against the residual.
*$p < .05$. **$p < .01$. ***$p < .001$.

wild plants and animals in summer than in spring and less domestic species or unspecified taxa (i.e., birds, trees, shrubs, grasses, and flowers; Figure 4). Nevertheless, this effect was much larger in the test group than in the control group.

On average, 43% of the children stated that they had become familiar with new plants or animals during the program, 21% were not sure, and 36% believed that they had not become familiar with new organisms. Overall, the participants listed 483 new plant and animal taxa; they listed wild flowers, grasses, insects, and spiders most frequently (Table 3). Individual taxa listed most often were lichens, geraniums, firebugs, bugles, and ivy.

Participation in the educational program affected girls and boys differently regarding their perceptions of new taxa (Table 4a). A higher proportion of girls (46.6%) than boys (39.7%) in a class stated that they had become acquainted with new plant or animal taxa during the program. This effect was similar for all age groups (no significant interaction between age and gender; see Table 4a).

The children's mean age had a strong influence on their acquaintance with new taxa. With increasing age, the mean proportion of the children who became familiar with new plant or animal taxa during the educational program decreased (significant linear effect of age in Table 4a; Figure 5). The amount of time that teachers spent on the educational program had a strong positive influence on the children's perception of new taxa (Table 4b). The more time that a class took for the program, the more the children in that class believed that they had become familiar with plants or animals they had not noticed before.

Discussion

The main aim of Nature on the Way to School was to increase children's everyday-life perception of plants and animals (SBN, 1995). As the results of the present study show, the program was successful. Young participants increased the number of plant and animal taxa they noticed in their local environment and also increased their ability to distinguish plants and animals at the genus or species level. Nevertheless, children in the untreated control group also noticed more taxa in early summer (posttest) than in spring (pretest), although the increase was much larger in the test group than in the control group (2.6 and 0.8 taxa, respectively). The control group's increase in species perception might have resulted from a learning effect induced by the pretest questionnaire or because of the time of year; in early summer, more plants and animals are visible than in spring. Thus, the result demonstrates that—in pretest/posttest designs—the researcher needs a control group to determine if the effects observed result from treatment or other influences during the study period. Other researchers have discussed the necessity of including suitable control groups in experimental studies on the effect of EE (Langeheine & Lehmann, 1986; Leeming et al., 1993).

From spring to early summer, the children noticed more wildflowers and invertebrates, in particular, which could be related to changes in the abundance of these taxa with the changing season. The observed effect of the season suggests that the time of the year during which a study on nature perception is carried out may affect the results.

The increase (because of the program) in the number of taxa that the children noticed may not seem very large. After participating in the program, however, children named more specific organisms. They listed general taxonomic units (i.e., trees, flowers, or birds) less often; instead, they often listed specific genera and species. As intended, participation in the program increased the number of wild plants and animals that the children noticed. Program participants also became familiar with local wild plants and animals that were previously unknown to them. This process of becoming acquainted with new species was most prominent in young children.

I find these results pleasing because several studies have shown that children's perception and knowledge of local organisms is poor and that they are generally aware of only a few species (e.g., Demuth, 1992; Hesse, 1983, 1984; Trommer, 1980). This taxonomic illiteracy does not result from a lack of opportunity for children to see plants and animals in their immediate environment (Lindemann-Matthies, 1999); it reflects students' lack of classroom training in taxonomy (Hershey, 1996; Pfligersdorffer, 1991). Without training in school, children's perception of species will reflect their preferences for particular plants and animals (Lindemann-Matthies, 1999) and will usually be restricted to mammals such as cats and dogs (Bell, 1981; Kellert, 1985; Morris, 1982) and garden plants with colorful or fragrant flowers (Mayer & Horn, 1993; Scherf, 1988). Children are generally more interested in animals than plants (Flannery, 1991; Hershey, 1996; Löwe, 1992) and, as a consequence, know less about plants and have more difficulties in naming them than in naming animals (Ryman, 1974).

Thus, the increase in participants' perception of both plant and animal taxa is encouraging because it shows that—with the help of stimulating educational programs—children can become interested in plants (see Hershey, 1996).

The positive effects of the educational program increased with the amount of time teachers spent on the program. When teachers reserved more time for the program, students noticed a higher number of taxa from spring to early summer; furthermore, more children became familiar with new plants and animals. I find this result pleasing because it shows that the teachers' efforts were rewarded. On average, teachers spent 17 hours of lessons on Nature on the Way to School, although the program was an educational supplement and not part of the normal curriculum.

In comparison, primary school teachers in Germany spend an average of eight lessons on environmental issues during the school year (Bolscho, Eulefeld, Rost, & Seybold, 1990). The amount of time spent on Nature on the Way to School indicates that it was interesting for both teachers and students and diverse enough to occupy both for a long time. However, teachers participating in the present study are probably not representative of Swiss teachers in general. It is likely that they are especially interested in nature education because they voluntarily included the educational supplement in their lessons. Thus, the participants in the present study might represent a biased sample.

These participating teachers use nature education programs and, thus, comprise a representative sample for an evaluation of the effect of such supplementary programs. Teachers who feel a personal obligation to help solve environmental problems more often engage their students in local environmental activities (Bolscho et al., 1990) and may promote environmental concern among their students (Palmer & Suggate, 1996).

In the present study, program participation increased—to a similar degree—the number of animals that students of different ages noticed. The increase in plant perception, by contrast, was highest in 10-year-old children; therefore, approaches to foster plant perception might be most effective with students of that age group. Studies in the field of developmental psychology have shown that humans become open to ideas of adult society (i.e., social equality) with the onset of adolescence (Piaget & Inhelder, 1983; Schenk-Danziger, 1983). Löwe (1992) has suggested that, as a consequence of this increased interest in social issues, interest in plants and animals decreases. Because children have less interest in plants than in animals (Flannery, 1991; Hershey, 1996; Löwe, 1992), these developmental changes might affect perception of plants more than that of animals and, thus, may have influenced the program's outcome.

Several studies have indicated that girls are generally more interested in biology (Löwe, 1992), have a higher motivation to achieve in science (Simpson & Oliver, 1990) and are more concerned about conservation than boys (Ashworth, Boyes, Paton, & Stanisstreet, 1995). In the present study, the increase in species perception because of the changing season was more pronounced for girls than for boys; both girls and boys, however, benefited from the program to a similar degree. Nevertheless, girls—more often than boys—thought that they had become familiar with new species during the program. These results suggest that girls pay more attention to individual species than do boys. Similarly, a British study showed that, although boys experienced vegetation as intensely as girls and enjoyed it just as much, they mainly used vegetation for play and adventure, whereas girls were more interested in vegetation as food or ornament (Harvey, 1993).

Conclusions

The results of the study are encouraging. Participation in the educational program increased children's perception of common local species and their ability to distinguish them. The positive effect of the educational program increased with the number of lessons spent, indicating that teachers' increased efforts were rewarded. However, the children in the untreated control group also increased their perception of taxa, although to a lesser degree. This result illustrates the need for more rigorous designs in educational studies, in particular the need to include meaningful control groups. Moreover, the time of the year may affect the outcome of studies on nature education.

Because the program was flexible, teachers could choose and modify the number and length of activities and use the most promising approaches in their classes. Hence, there was considerable variation in program implementation; it is, therefore, impossible to attribute the observed positive effects on species perception to specific activities. Future researchers should compare the effectiveness of different types of intervention on species perception by placing stricter controls on teachers' activities. However, large variation in the implementation of programs is normal in most schools; studies (like the present one) may provide a more realistic assessment of the impact of environmental education supplements. Evaluations that impose strict controls on teachers' behavior may produce a biased estimate of the potential of such programs (Armstrong & Impara, 1991).

Another constraint of this study is that the participating teachers may have been particularly interested in nature education and may not have been representative of all Swiss teachers. Whenever possible, study classes should be randomly selected. However, the participating teachers may well have been representative of teachers willing to use voluntary educational supplements on nature education. In conclusion, educational programs such as the present one may lead to a better understanding of biodiversity and might represent a small but important contribution to its preservation.

ACKNOWLEDGMENTS

I thank Bernhard Schmid for valuable statistical advice and comments on an earlier version of this article. I also thank Penelope Oertli-Barnett for improving the English.

REFERENCES

Armstrong, J. B., & Impara, J. C. (1991). The impact of an environmental education program on knowledge and attitude. *The Journal of Environmental Education, 22*(4), 36–40.

Ashworth, S., Boyes, E., Paton, R., & Stanisstreet, M. (1995). Conservation of endangered species, what do children think? *Journal of Environmental Education and Information, 14*(3), 229–244.

Bell, B. F. (1981). When is an animal, not an animal? *Journal of Biological Education, 15*(3), 213–218.

Bennett, D. (1988). Four steps to evaluating environmental education learning experiences. *The Journal of Environmental Education, 20*(2), 14–21.

Bogner, F. X. (1998). The influence of short-term outdoor ecology education on long-term variables of environmental perspective. *The Journal of Environmental Education, 29*(4), 17–29.

Bolscho, D., Eulefeld, G., Rost, J., & Seybold, H. (1990). Environmental education in practice in the Federal Republic of Germany, an empirical study. *International Journal of Science Education, 12*(2), 133–146.

Botkin, D. B., & Keller, E. A. (1995). *Environmental Science*. New York: John Wiley & Sons.

Chipeniuk, R. (1995). Childhood foraging as a means of acquiring competent human cognition about biodiversity. *Environment and Behavior, 27*(4), 490–512.

Crisci, J. V., McInerney, J. D., & McWethy, P. J. (1993). *Order and diversity in the living world, teaching taxonomy and systematics in schools*. Reston, VA: National Association of Biology Teachers.

Cuche, F., & Gigon, P. (1996). *A la decouverte de la biodiversite* [The discovery of biodiversity]. Neuchâtel, Switzerland: Département de l'Instruction Publique et des Affaires Culturelles.

Demuth, R. (1992). Elemente des "Umweltwissens" bei Schülern der Abgangsklassen der Sekundarstufe I [Elements of environmental knowledge of students leaving secondary school]. *Naturwissenschaften im Unterricht–Chemie, 3*(12), 36–38.

Flannery, M. C. (1991). Considering plants. *The American Biology Teacher, 53*(5), 306–309.

Friedrichs, J. (1990). *Methoden empirischer Sozialforschung* [Methods in empirical social research]. Opladen, Germany: Westdeutscher Verlag.

Harvey, M. R. (1993). *Learning about ecology through contact with vegetation*. In M. Hale (Ed.), *Ecology in education* (pp. 99–121). Cambridge, UK: Cambridge University Press.

Hershey, D. R. (1996). A historical perspective on problems in botany teaching. *The American Biology Teacher, 58*(6), 340–347.

Hesse, M. (1983). Artenkenntnis bei Studienanfängern [First-year students' taxonomic knowledge]. *Der Biologieunterricht, 19*(4), 94–100.

Hesse, M. (1984). "Artenkenntnis" in der Sekundarstufe I (Hauptschule) [Taxonomic knowledge in secondary school]. *Naturwissenschaften im Unterricht Biologie, 32*(5), 163–165.

Heywood, V. H. (Ed.). (1995). *Global biodiversity assessment*. Cambridge, UK: Cambridge University Press.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986). Analysis and synthesis of research on responsible environmental behavior, a meta-analysis. *The Journal of Environmental Education, 18*(2), 1–8.

Kellert, S. R. (1985). Attitudes toward animals, age-related development among children. *The Journal of Environmental Education, 16*(3), 29–39.

Killermann, W. (1996). Biology education in Germany: research into the effectiveness of different teaching methods. *International Journal of Science Education, 18*(3), 333–346.

Langeheine, R., & Lehmann, J. (1986). *Die Bedeutung der Erziehung für das Umweltbewusstsein* [The importance of education for environmental awareness]. Kiel, Germany: IPN.

Leeming, F. C., Dwyer, W. O., Porter, B. E., & Cobern, M. K. (1993). Outcome research in environmental education, a critical review. *The Journal of Environmental Education, 24*(4), 8–21.

Leeming, F. C., Dwyer, W. O., Porter, B. E., Cobern, M. K., & Oliver, D. P. (1997). Effects of participation in class activities on children's environmental attitudes and knowledge. *The Journal of Environmental Education, 28*(2), 33–42.

Lindemann-Matthies, P. (1999). *Children's perception of biodiversity in everyday life and their preferences for species*. Unpublished doctoral dissertation, University of Zurich, Switzerland.

Löwe, B. (1992). *Biologieunterricht und Schülerinteresse an Biologie* [Biology education and students' interest in biology]. Weinheim, Germany: Deutscher Studien Verlag.

Mallow, D. (1994). Biodiversity. *The Science Teacher, 61*(4), 19–21.

Mayer, J. (1992). *Formenvielfalt im Biologieunterricht* [Biological diversity in biology education]. Kiel, Germany: IPN.

Mayer, J. (1993). Bedeutung der Formenkunde für die Umweltbildung [The Importance of species knowledge for environmental education]. *Verhandlungen der Gesellschaft für Ökologie, 22*, 379–384.

Mayer, J., & Horn, F. (1993). Formenkenntnis—wozu [Species knowledge: What for?]. *Unterricht Biologie, 17*(189), 4–13.

Meffe, G. K., & Carroll, C. R. (1994). *Principles of conservation biology*. Sunderland, MA: Sinauer.

Morris, D. (1982). *Der Mensch mit dem wir leben* [Manwatching]. München, Germany: Droemersche Verlagsanstalt.

Nagel, U. (1997). *Stadtentdeckungen–Natur vor der Tür* [City discoveries: Nature at your doorstep]. Zürich, Switzerland: Pestalozzianum Verlag.

Palmer, J. A., & Suggate, J. (1996). Influences and experiences affecting the pro-environmental behavior of educators. *Environmental Education Research, 2*(1), 109–121.

Pfligersdorffer, G. (1984). *Empirische Untersuchungen über Lerneffekte auf Biologieexkursionen* [Empirical studies on learning gains during biology excursions]. In R. Hedewig, & L. Staeck (Eds.), *Biologieunterricht in der Diskussion* [Biology education in discussion] (pp. 174–186). Köln, Germany: Aulis–Verlag.

Pfligersdorffer, G. (1991). *Die biologisch-ökologische Bildungssituation von Schulabgängern* [Biological and ecological knowledge of school-leavers]. Salzburg, Austria: Abakus Verlag.

Piaget, J., & Inhelder, B. (1983). *Die Psychologie des Kindes* [Child psychology]. Frankfurt am Main, Germany: Fischer Taschenbuch Verlag.

Potvin, C. (1993). ANOVA: Experiments in controlled environments. In S. M. Scheiner & J. Gurevitch (Eds.), *Design and analysis of ecological experiments* (pp 46–68). New York: Chapman and Hall.

Presser, S., & Blair, J. (1994). Survey pretesting: Do different methods produce different results? *Sociological Methodology, 24*, 73–104.

Rexer, E., & Birkel, P. (1986). Größerer Lernerfolg durch Unterricht im Freiland [Greater learning gains through outdoor education?]. *Unterricht Biologie, 117*, 43–46.

Robinson, N. A. (Ed.). (1993). *Agenda 21: Earth's action plan, annotated*. IUCN Environmental Policy and Law Paper 27. New York: Oceana.

Rosenthal, R., Rosnow, R. L., & Rubin, D. B. (2000). *Contrasts and effect sizes in behavioral research: a correlational approach*. Cambridge, UK: Cambridge University Press.

Ryman, D. (1974). Children's understanding of the classification of living organisms. *Journal of Biological Education, 8*(3), 140–144.

Schenk-Danziger, L. (1983). Entwicklungspsychologie [Developmental psychology]. Wien, Austria: Österreichischer Bundesverlag.

Scherf, G. (1985). Zur Bedeutung pflanzlicher Formenkenntnisse für eine schützende Einstellung gegenüber Pflanzen und zur Methodik des formenkundlichen Unterrichts [The significance of knowledge of plant species for protective attitudes toward plants and the methodology of species-focused instruction]. Dissertation. Ludwig-Maximilians-Universität München, Germany.

Scherf, G. (1988). Kenntnis häufiger Pflanzen des Straßenrandes und Vorstellungen über Pflanzen bei 9–12jährigen Schülern und bei jungen Erwachsenen (Lehramtstudenten und Schülern einer Fachakademie für Sozialpädagogik) [Knowledge of common roadside plants and ideas about plants of 9–12 year-old students and young adults (students of a teachers' training college and students of an academy of social work)]. *Sachunterricht und Mathematik in der Primarstufe, 16*(5), 196–204.

Schweizerischer Bund für Naturschutz. (Ed.). (1995). *Natur auf dem Schulweg* [Nature on the way to school]. Basel, Switzerland: Author.

Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education, 74*(1), 1–18.

Sokal, R. R., & Rohlf, F. J. (1981). *Biometry*. 2nd ed. New York: Freeman.

SPSS. (1998). *SPSS for Windows* (release 8.0.1). Chicago, IL: Author.

Starosta, B. (1990). *Erkundungen der belebten Natur nach dem Prinzip des entdeckenden Lernens–didaktische Konzepte und Ergebnisse einer empirischen Untersuchung* [Discoveries in living nature according to the principle of learning by discovery: Didactic concepts and results of an empirical study]. In W. Killermann, & L. Staeck (Eds.), *Methoden des Biologieunterrichtes* [Methods of biology education] (pp. 316–326). Köln, Germany: Aulis–Verlag.

Stokking, K., Zoelen, L. van, Aert, L. van, & Young, R. (1995). *Evaluating activities in environmental education–a helping hand*. Utrecht, The Netherlands: ISDR University of Utrecht.

Trommer, G. (1980). Naturschutz im Biologieunterricht—Begriffsbilder bei Schülern der Primarstufe und Sekundarstufe I [Conservation in biology education: Ideas of primary and secondary school students]. *Verhandlungen der Gesellschaft für Ökologie, 8*, 503–508.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). (1993). *UNESCO, Agenda 21 and UNCED follow-up*. Paris, France: UNESCO.

Weilbacher, M. (1993). The renaissance of the naturalist. *The Journal of Environmental Education, 25*(1), 4–7.

Wilson, E. O. (Ed.). (1992). *Ende der biologischen Vielfalt* [The end of biological diversity?]. Heidelberg, Germany: Spektrum Akademischer Verlag.

Wilson, E. O., & Peter, F. M. (Eds.). (1988). *Biodiversity*. Washington, DC: National Academy of Sciences.

WRI (World Resources Institute) & IUCN (The World Conservation Union)/UNEP (United Nations Environment Program) (1992). *Global biodiversity strategy: Guidelines for action to save and use earth's biotic wealth sustainably and equitably*. Washington, DC: WRI, IUCN/UNEP.

Yore, L. B., & Boyer, S. (1997). College students' attitudes towards living organisms: The influence of experience & knowledge. *The American Biology Teacher, 59*(9), 558–563.