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ABSTRACT

The aim of this research was to study applicability of a teaching method of using supplementary printed student worksheets together with two educational Web sites--"Estonian Vertebrates" and "Estonian Plants." The teaching method was fully approved by the expert group of 27 pilot teachers. A case study focused on development of secondary school students' abilities to analyze and synthesize the information presented to them. Results demonstrated the applicability of educational Web pages together with appropriate teaching methods to develop students' higher order thinking skills. The impact of computerized biology lessons on students' motivation and their attitudes toward the problems of environmental protection and Estonian nature was also examined. Students' responses to a questionnaire suggested that this approach was justified. (Author/AEF)

Usage of Educational Web Pages to Develop Students' Higher Order Thinking Skills

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Abstract: The aim of the present work was to study applicability of the relevant teaching method based on supplementary printed students' worksheets together with two educational Web sites - "Estonian Vertebrates" and "Estonian Plants". The teaching method was fully approved by the expert group of 27 pilot teachers. In case study we were concerned with enhancing students' abilities to analyze and synthesize connected with educational tasks on worksheets. The results of the study clearly demonstrated the applicability of educational Web pages together with appropriate teaching method to develop students' higher order thinking skills. Furthermore, we tried to estimate the impact of computerized biology lessons on students' motivation and their attitudes to the problems of environment protection and Estonian nature. Students' answers in the questionnaire suggested that this approach was justified.

Introduction

Estonia is currently undertaking reforms in its educational system. The implementation of the new State Curriculum in Estonian schools began in autumn 1997. The reform is taking into account Estonian aim to integrate into European Union structures. The current reform covers pre-school education in kindergartens, general basic schools, upper-secondary general schools and vocational education. Following from the new curriculum, different subjects are integrated by common themes by considering relationships between humans, nature, technology and society. "Informatics and infotechnology" is one of this (Estonian State Curriculum, 1996). The learning process and teaching methods are diversified by infotechnology. It supports systematic thinking, technological skills and enables students to have their own individual style of learning.

At the present time about 200 out of 350 Estonian secondary schools have their own computer classes with the direct or dial-up Internet connection. However, our previous investigations revealed that Estonian teachers did not use computers in science lessons (Sarapuu, 1997). The situation can be explained with the absence of educational software, in particular, in Estonian, but also with teachers' lack of knowledge and skills in application of appropriate teaching methods.

In most countries it is comparatively easy to find software to teach various subjects. But in Estonian schools, where English is the second language, educational software, except in Estonian is not applicable in learning process. Some software could be translated from other languages, as there are a lot of common problems and themes in curricula of all the countries. However, in case of natural sciences, especially in biology, each country must create its own. It is caused by the well-known fact that the nature of each country is unique, all the species of plants and animals exist in distinctive conditions with their own specific relations. Knowledge about local nature, its diversity and environmental problems can be acquired on basis of local examples and facts. One of the simplest ways to create educational software embracing the possibilities of multimedia is to

compose instructional Web pages. Therefore our Department initiated the development of two educational Web sites - "Estonian Vertebrates" and "Estonian Plants".

Educational Web Sites

The Web site "Estonian Vertebrates" (*http://sunsite.ee/loomad/*) includes information about five groups of vertebrates - fishes, amphibians, reptiles, birds and mammals. (Some parts of this site are also translated into English - http://sunsite.ee/animals/) The database concerning about 300 species of the most common Estonian vertebrates forms the main part of the site (Fig. 1.). Information about each species has been presented on two Web pages considering students' different abilities and age. The first page contains the description of particular species, its appearance, distribution, abundance, feeding, reproduction, development and endangerment. The topics are illustrated with color photos and voices. It has fewer terms and simpler vocabulary in order to be applicable in basic school biology classes. The information on the second page of each species is filled in a table including some more scientific facts. This page is supposed to be used mainly by secondary school students. Common layout, usage of hypertext, search engine and the site map facilitate application and finding information.

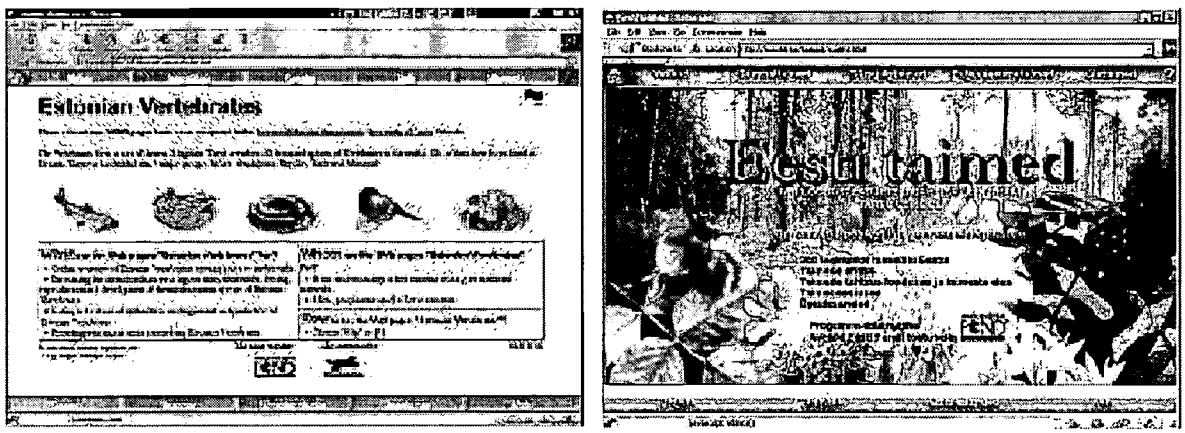

Fig. 1: The front pages of "Estonian Vertebrates" (*http://sunsite.ee/animals/*) (on the left) and "Estonian Plants" Web site (*http://sunsite.ee/taimed/*) (on the right).

The second educational site - "Estonian Plants" (*http://sunsite.ee/taimed/*) - follows the same principles of design as "Estonian Vertebrates" (Fig. 1.). The main part of the site consists of descriptions of the most widespread species of Estonian plants (ca 340) together with illustrative photos. There are general information, taxonomic specifications and local aspects about five groups of plants - Algae, Bryophytes (mosses), Pteridophytes (ferns), Gymnosperms and Angiosperms (flowering plants). One can choose the pages of herbs, plants under protection, poisonous and edible plants. Several figures illustrate morphology and structure of different groups of plants. Symptoms of becoming poisoned and methods of first aid are touched upon in case of poisonous plants. The pages of herbs explain what parts of them to use, where they grow and what diseases can be cured. As far as edible plants are concerned, there is exact information of what parts could be eaten, when and where they could be picked and used.

The skills and requests of the broad range of users have been taken into consideration in designing Web pages "Estonian Vertebrates" and "Estonian Plants". Both educational Web sites provide students with opportunities of writing reports, essays, research work and different types of projects in extra-curriculum activities. University students and all the people who are interested in studying Estonian nature can also benefit from the materials.

Educational Web sites "Estonian Vertebrates" and "Estonian Plants" are suggested to teach various themes in integrated science, biology and environmental study according to the new Estonian State Curriculum. There are opportunities to check one's knowledge and the results of tasks in the software. Computerized educational tasks composed on the basis of "Estonian Vertebrates" and "Estonian Plants" enable students to learn the particular themes independently, to acquire scientific facts, but also to develop their memory, comprehend, apply

the facts and check their knowledge. More attention was paid to systematic learning than to memorizing facts. Various electronic tests added to the package provide teachers with necessary feedback of students' knowledge and abilities.

Teaching Method and Supplementary Materials

It is impossible to create the computerized tasks satisfying all the teachers' aims and to adapt them to each theme in curriculum. Therefore, we have also compiled supplementary printed worksheets for students. Worksheets can be used without any changes or might serve as examples for teachers to work out theirs own ones.

According to the teaching method developed in our department (Adojaan & Sarapuu, 1997), at the beginning of a 45-minute lesson the first ten minutes have to be spent on becoming acquainted with the program. It is essential for both beginners and advanced users of computers, as the pupils can get a survey of the structure of the pages and to satisfy their curiosity. A special introductory printed worksheet for students has been compiled for both "Estonian Vertebrates" and "Estonian Plants". It introduces the aim, scope, structure and the ways of application of certain Web site.

Next, after the introductory part of the lesson students get separate printed worksheets with various educational tasks. Students have to work independently solving the tasks for 35 minutes. Each worksheet consists of 3-4 units related to each other (Fig. 2.).

Our previous studies suggest that computers are not effective tools for only acquiring knowledge, comprehending and memorizing facts (Arro & Sarapuu, 1996). Therefore, it is essential to compile the worksheets not only for finding and memorizing facts, but also for developing students' higher order thinking skills. Every unit begins with a question or description of task, next, students have to find required information on different Web pages and fill it in the table or blanks. After that they have to analyze, synthesize and evaluate the found information according to next question or task. Solving the task is connected with all the categories of cognitive domain: knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom et al., 1956).

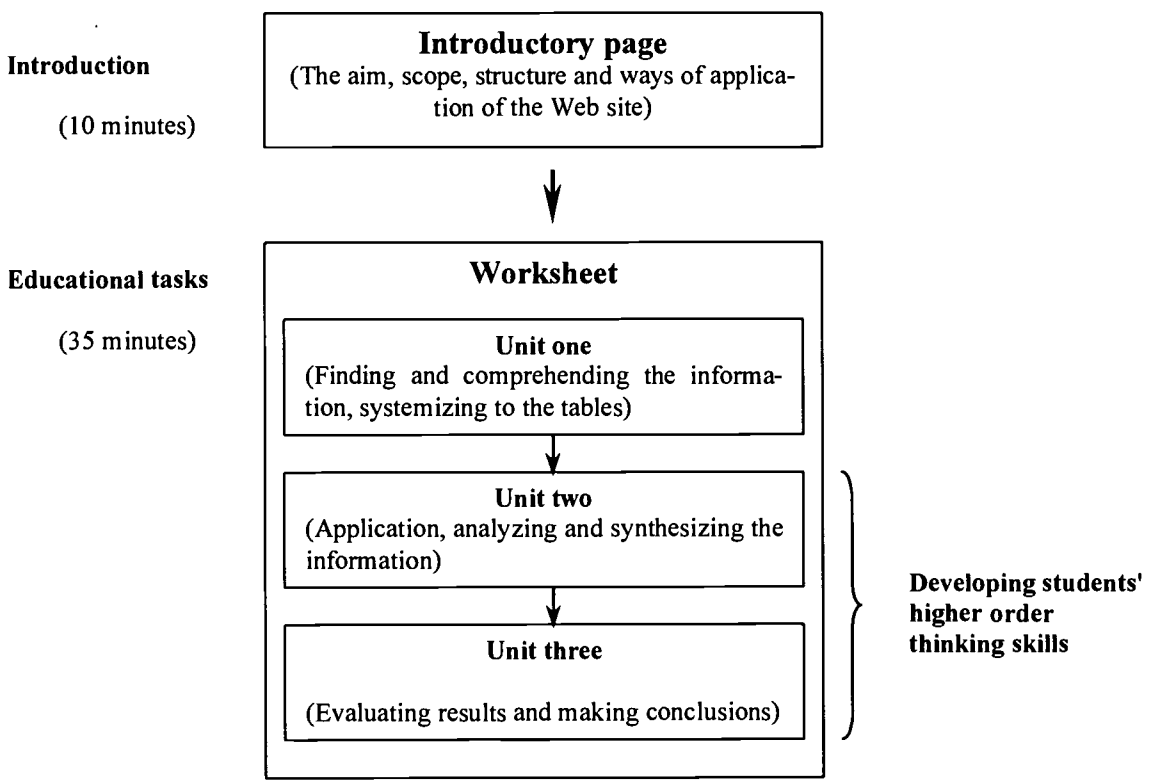

Fig. 2: Teaching method based on supplementary printed students' worksheets together with educational Web sites.

An Expert Group of Biology Teachers

27 biology teachers form an expert group. They had previously passed an advanced in-service course in usage of computers in school biology. An introductory lecture about the objectives and contents of appropriate teaching methods was conducted. Next the teachers participated in hands-on workshop. They used both "Estonian Vertebrates" and "Estonian Plants" together with supplementary printed student worksheets. Soon after the workshop the teachers were asked to fill in a questionnaire about the teaching method and the contents of student worksheets.

Some weeks later teachers conducted computerized science lessons in theirs own schools. They composed also new worksheets and students had to solve the educational tasks based on the materials either "Estonian Vertebrates" or "Estonian Plants" Web site. Subsequently teachers evaluated both educational Web sites and the teaching method (Sarapuu et al, 1998; Sarapuu & Adojaan, 1998).

Case Study

The main goal of the present case study was to try out the teaching method described above. Three teachers used "Estonian Vertebrates" and conducted 9 pilot lessons in computerized biology classes of different schools. 27 basic school students (age of 14-15) and 59 of them (age of 16-17) in secondary school solved educational tasks on two different types of worksheets. A group of 10-15 students solved one task during one 45-minute lesson. A control group of 10 basic school students worked independently with "Estonian Plant" and solved the educational tasks on worksheets.

Immediately after the lesson students had to fill in the questionnaire. They were asked to evaluate the Web site together with the worksheets and to express their opinion of possible application of the Web site in biology lessons and its relevance to everyday life. In addition, some questions were connected with students' previous experiences and their relations to computers.

We examined also students' supplementary worksheets and analyzed their answers. Different units solved by students were used to make conclusions about the finding information, comprehension the contents of topics, but also about their abilities to analyze, synthesize or evaluate (Fig. 2.).

Results and Discussion

The most important prerequisite in usage of educational Web sites is finding and comprehension of information. Pilot lessons indicated that both basic and secondary school students could successfully apply the "Estonian Vertebrates" and "Estonian Plants" as a source of information. The conclusion was based on filled worksheets and students' opinions revealed in questionnaires. All 59 secondary school students and 37 from basic school found the necessary information on Web pages. Only 2 % of basic school students had a few problems. Almost all the students who worked with "Estonian Vertebrates" or "Estonian Plants" gave positive response to the question - "Was the program convenient to use in solving the tasks?" 92 % of students answered that it was easy to find the information or they had only few problems. Approximately 8 % of students confessed to have found the information with much trouble. Only one student from 10 who examined "Estonian Plants" declared to have had much trouble in finding information. The comprehension of the texts did not cause any difficulties to students, as they did not ask the teacher to explain them terms or the contents of certain topics. Consequently we suggested that there were not any considerable obstacles for the application of "Estonian Vertebrates" or "Estonian Plants".

Some difficulties in pilot lessons were caused by students' lack of experiences in using computers. Approximately one third of the students had not had beginners' course in computing and obviously they had not had any other possibility to use a computer. However, Estonian students are interested and willing to use computers in learning any subjects. There was a question - "How big is your interest in computers?" - in the questionnaire. 68 % of students wrote that "computers are of some interest" and 19 % of them claimed that "they spend every free minute on computers". Merely 5 % of students gave a negative response to the question - "Did you like the lesson today?" 78 % chose one of the positive responses ("I liked it very much" or "I liked it") and 17 % of students was indifferent towards the lesson.

Students had to solve different educational tasks on two types of worksheets in computerized biology lessons where "Estonian Vertebrates" Web site was applied. Students' answers to the questions provided us with the material, on the basis of which we could draw conclusions about their abilities to analyze, synthesize and evaluate. One can examine this on the basis of worksheet titled as "The development of birds after hatching." The objective of this lesson was to study differences in birds' development in the period after hatching. The worksheet consisted of the following three units:

1. Students had to find Web pages with six particular species of birds and look for the information about their nesting, hatching and development of the young. Next, students had to find the common features of young and divide these species into two groups. The answer had to be presented in the form of table.

This unit of the worksheet enabled us to make conclusions about students' abilities to find the appropriate information, to comprehend and analyze it. The results of solving this task suggested that the ability to analyze of the students who participated in pilot lessons was rather poor. There was a considerable difference between the basic and secondary school students - only 31% of basic school students and 79% of secondary students did well in this part.

2. Next, students analyzed the contents of the table and made conclusions about the development of two types of young - precocial and altricial.

The second unit gave us information about students' abilities to analyze and synthesize. The analysis of worksheets gave us information about students' abilities: 49% of secondary school students did it well whereas only 15% of basic school students could make a correct generalization.

3. Finally students had to evaluate possible reasons for different types of development.

This unit enabled us to draw conclusions about students' abilities to evaluate. Only 8% of basic school students did it correctly and 85% of them did not do it at all. The results were comparatively better among the secondary school students – 33% did well and 49% could not find possible reasons. Thus the students who took part in pilot lessons showed the worst results in evaluating.

Conclusions

According to the principle that everyone should be able to read natural scientific and technological texts there is information concerning daily life and themes of general interest both in "Estonian Vertebrates" and "Estonian Plants". Students' answers in the questionnaire suggested that this approach was justified. For example, 46 % of students who worked with "Estonian Vertebrates" said that they had got to know something useful for everyday life. The themes of Estonian nature and environment protection are central themes in the new Estonian State Curriculum. This area of study brings teaching natural sciences closer to everyday life and society. Another aim of both educational Web sites is to motivate students to become more interested in these areas. 35 % of students answered that the lesson with "Estonian Vertebrates" made them be more interested in Estonian nature and the problems of environment protection. 25 % of students claimed that it made them be more interested in school biology.

Students' answers allowed us to conclude that their abilities to analyze, synthesize and evaluate were rather poor. The results reflected better ability to analyze and synthesize by secondary school students compared with basic school students. The difference did not significantly depend on whether "Estonian Vertebrates" or "Estonian Plants" was used. Consequently we suggest that solving similar tasks enhance students abilities to analyze and synthesize.

A group of experts approved the proposed teaching method and considered it to be applicable both in basic and secondary school. They only mentioned that provided educational tasks for "Estonian Vertebrates" were more interesting and applicable in basic school (Sarapuu & Adojaan, 1998).

Finally we can conclude that "Estonian Vertebrates" and "Estonian Plants" together with supplementary materials and appropriate teaching method can be effectively applied in developing students' higher order thinking skills and enhancing learning motivation. The proposed teaching method is not only applicable with "Estonian Vertebrates" and "Estonian Plants" but with any educational Web site consisting of appropriate information.

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