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# INCREASING THE EFFECTIVENESS OF ECOLOGICAL EDUCATION THROUGH INTERACTIVE TASKS

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**Abstract.** *Ecology, environmental protection, and education leading to sustainable development are at present one of the dominant educational topics at primary and secondary schools. Though a great deal of attention is paid to teaching of these topics in educational systems of most countries, it is mostly only in terms of theory with a little emphasis on comprehension. One of the ways of how to change this situation is the use of appropriate learning tasks that would make the lessons more interesting, would show a link between these lessons and the practice and would lead to the acquisition of skills, competences and approaches of sustainable character. Therefore our focus was to develop a method of how to create interesting interactive learning tasks and the ways of their application in educational practice. Our research has designed a set of such tasks and verified their effectiveness in practice.*

**Key words:** *sustainable development, ecological education, interactive tasks, assessment of educational effectiveness.*

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## Introduction

At present, in most European countries, changes of their educational systems are taking place. A main emphasis is laid on the development of key competences and acquisition of attitudes and values. One of the important goals of this reconstruction is to create a balanced structure of basic concepts and relationships that would enable us to classify the information within a meaningful context of both the knowledge and real life. Students should master the methods of how to learn, how to use modern communication tools and information technologies, how to process this information, transform them into knowledge, apply them, be able to think critically and assess, work both independently and in a team.

Taking into account an ever - increasing importance of issues related to the environment and the emphasis laid on the acquisition of key competences, our research has been focused on the development of interesting interactive learning tasks dealing with these issues and on the methods of their application in educational practice.

### *Theoretical Solutions*

Ecology and environmental protection are multidisciplinary fields linking biotic and abiotic world. This is the reason why they are often included into different teaching subjects (Zuil, 1998). Though a great deal of attention is paid to teaching of ecological topics in educational systems of most countries, it is mostly only

in terms of theory with a little emphasis on comprehension. This is also confirmed by the research which shows that most ecology and biology courses are not primarily based upon the assumption of how the pupils can acquire the curriculum in the most effective way. The largest part of teaching (90%) is based on a passive transfer of knowledge, laboratory practice is very rare (10%), and many students have never studied ecology in nature (D'Avanzo, 2003). An application of cognitive research to teaching is far less common in ecology teaching than in other subjects. This is also confirmed by the results of an extensive research that describe incomprehension of basic ecological findings by the pupils – food pyramids, population dynamics of animals, climatic effects, and environmental pollution on the animals, etc. (Munson, 1994; Hogan, Fisherkeller, 1996; Eyster, Tashiro,1997; Jewel, 2002; Carlsson 2002; Stamp, Armstrong, 2005). If we really intend to improve ecology education, ecology sections of the faculties and specialists involved in didactics should cooperate more on the projects related to ecological thinking and teaching of ecology (D'Avanzo, 2003). In the forthcoming decades, a survival of mankind will depend on our ability to understand the basic principles of ecology and to learn how to live in accordance with them (Capra, 2004). Therefore it is important to teach the students not only the basic facts about life, but first of all a full understanding of principles of ecological needs, a new vision of the world, and a new way of thinking in terms of relationships and links. To reach a full understanding of ecological principles, it is necessary to teach the students how to think within the framework of links and relationships. It is therefore teaching of this ecological knowledge that can play the most crucial role in the education of 21st century (Capra, 2004). Therefore the focus on teaching of the proper understanding of ecological concepts is the basis because it enables us to better understand the environment in which the man lives along with other organisms (Munson, 1994). It is necessary to prefer critical thinking, properly asked questions, experiments, and independent acquisition of knowledge. It is important for the students to acquire, apart from knowledge, also the experience from nature – from a school garden, a forest, from a shore of the river. Otherwise they can leave school as very good ecologists who, however, do not care much about the nature and the Earth.

All these thoughts and considerations result in the necessity to deal with changes in ecology education. Teachers should take a think about what teaching of ecology means; they should also follow recent research on teaching published in journals and apply these new approaches and information to ecology education. Therefore the aim of our long – term research work is to support, both in terms of theory and practice, the process of acquisition of knowledge related to ecology and environmental protection at secondary schools.

This study informs about the stage of our research work where our focus was on the use of learning tasks of different difficulty and complexity, and on the finding of how the secondary school students (17 years old) acquired ecological knowledge, how they grasped it and how they are able to apply it.

*Aims of Research*

The aim of our research was to find out how the secondary school students (17 years old) acquired ecological knowledge, how they grasped it and how they are able to apply it.

To achieve the main aim, the following partial aims were set:

a) To analyse the main trends in teaching of ecology and environmental protection both in this country and abroad.
b) To evaluate the conception of teaching of ecology and environmental protection and perform a concept analysis in available teaching materials for secondary schools.
c) To create, on the basis of obtained findings, sets of tasks on the given topic, which could be used for teaching at secondary schools and grammar schools.
d) To verify these sets of task in practice, to statistically process these results and on the basis of statistical processing to carry out modifications of items.
e) To verify the effectiveness of sets of tasks in real teaching environment via a didactic experiment.

**Methodology of Research**

Development of sets of tasks included the following steps:

- Planning.
- Contextual analysis of curriculum.
- Development of items and construction of sets of tasks.
- Piloting verification of sets of tasks.
- Evaluation and statistic processing of sets of tasks.
- Modification of items.

**Development of items and construction of sets of tasks**

On the basis of content analysis of curriculum, 52 items were designed and divided into 11 sets of tasks entitled Influence of environment on organism, Population, Food chains, Zoogeographic regions, Biosphere, Circulation of substances in nature, Growth of human population, Worldwide network of protected areas, Endangered organisms in the Czech Republic, Ecology of landscape, and Human influence.

The items used in the individual sets of learning tasks were divided into four categories, according to the following target competences (Čížkova et al. 2000, Čtrnactova et al. 2000):

| | | |
|---|---|---|
| A | acquisition and comprehension of curriculum | 13 |
| B | application of findings and problem solving | 10 |
| C | observation and experiments | 19 |
| D | communication | 10 |

When creating the learning tasks, both verbal and non-verbal tasks were formulated, because non -verbal formulation is highly motivating and makes understanding and solving the tasks easier.

In the tasks, the following types of non-verbal instruments were used:

a) tables with missing data, which are supplied by the students solving the tasks;
b) schemes, in which the students fill in the missing elements;
c) simple graphs, on the basis of which the students solve the tasks;
d) pictures of biological objects.

A text, table, scheme, graph or pictures are either complete, then they serve for the students as further information in the task description, or incomplete, then they serve as a clue for the answer.

In the tasks, the items of the following types are included:

I. closed items
- double choice type
- multiple choice type
  - with one correct answer
  - with more correct answers
- matching type

II. open items
- fill – in type
  - with short answer
  - with long answer

Tasks of different difficulty were constructed so that the students had to use more complex thinking operations to solve them, e.g. analysis, synthesis, comparison, etc. Sets of learning tasks also included some problem tasks, where the students, while solving them, had to use the knowledge from other sciences, e.g. chemistry and geography or from everyday life. Some items lead the students to practising, assessing and deducing based on the data from graphs, maps, and comprehensive reading of scientific texts.

A great emphasis was laid on the motivating component of learning tasks. Students are primarily motivated by a different style of work with worksheets, activation in teaching, but also by the fact that they can learn a lot of interesting information. However it is necessary to suggestively formulate the tasks that should contain the information interesting for the students.

While constructing the tasks, an emphasis was laid on effective aims. The tasks should develop a positive approach of students to the nature and the environment; they should raise their interest in independent cognition of ecological principles. The tasks are often accompanied by pictures, schemes, graphs, etc., which serve as an instrument raising the interest of students to solve these tasks.

*Verification of learning tasks*

The above sets of tasks were verified in four Prague grammar schools and one grammar school outside Prague after the completion of the curriculum in ecology and environmental protection (3rd year – 17-year old students)

Our team in person gave these sets of tasks. Students filled in their solutions directly into the sets of tasks; while doing this, they were not allowed to use course books, atlases, etc. A total number of 109 students filled in the tasks.

*Evaluation and statistic processing of sets of tasks*

Closed tasks with one correct answer were rated by one point while closed items with two correct answers by two point, etc. Open items were rated in a similar way. As for filling in the concepts, then each correctly filled in concept was rated by one point; as for filling in the tables, then each correctly filled in line in the table was rated by one point, etc.

The purpose of statistic processing was to find out the index of difficulty (success rate) of individual items, a total success rate of sets of tasks, and a relative number of students in the individual point categories, Chráska (1999).

A maximum number of points, which the students could reach for a set of tasks, was divided into the equal point categories. Mostly, the maximum number of points was divided into six different categories.

On the basis of piloting and a follow - up analysis, experts' reviews of teachers and specialists in ecology and environmental protection, modifications were carried out and a final version of tasks was proposed.

An example of the task verified is to find out the level of comprehension of the term food chain and its application.

In ecosystems, a constant cycling of substances and flow of energy between biotic and abiotic component and individual groups of organisms occur. Organic matter produced by one group of organisms is consumed by other organisms. When obtaining energy needed for their living, organisms are interlinked via energy – food relations. The species, which are gradually dependent on each other via nutrition, form a food chain. At the beginning of the food chain there is a producer and further elements of the chain are always consumers of higher orders, adapted according to  legl at al. (2002).

1. Using vertical lines, divide the figure 1 into 4 parts and describe each part properly. For this description, use some of the following words: producers, decomposers, consumers of 1st order, consumers of 2nd order, consumers of 3rd order, reducers.

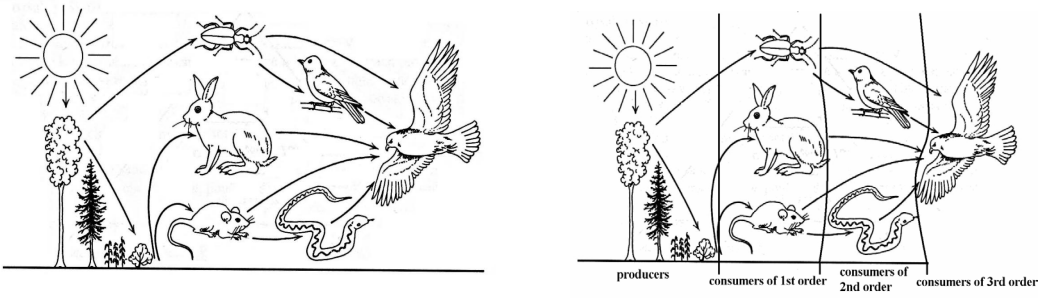


**Figure 1. Food chain in the nature (adapted according to légl et al. 2002)**

2. Choose correct statements:
   a) primary producers are autotrophic organisms
   b) primary producers are heterotrophic organisms and consumers are autotrophic organisms
   c) all consumers are also secondary producers of organic matter
   d) decomposers (reducers) are mainly fungi and micro - organisms
3. In food chains, a gradual accumulation occurs of some indecomposable toxic substances. Initially low concentrations of these substances gradually accumulate in the bodies of consumers. These substances are not excreted, but they are accumulated in tissues/plexus. In which of the following options are the organisms arranged from the highest to the lowest concentration of these toxic substances in the body?

   a) eagle – fox – rodent – plant
   b) eagle – rodent – fox – plant
   c) plant – rodent – fox – eagle
   d) plant – fox – rodent – eagle

4. Fill in the missing word in the text:
   Formers use pesticides to protect arable crops from undesirable organisms of chemical substance. In 1972 the USA followed by other states banned insecticide __**DDT**__ , used to kill insects. It is known that this substance penetrated from crops into food chains of animals and accumulated in consumers of the highest order. It mainly affected predators that laid eggs with such a thin shell that broke under the weight of the sitting female.

*Didactic experiment – to verify effectiveness of set of tasks*

On the basis of curriculum contained in worksheets, a final test was constructed with a total of 20 questions - 11 with one correct answer, 6 questions with short answer and 3 tables where the students were expected to fill up the data. The students could obtain a maximum of 43 points for correct solution of the test. Research was carried out in five grammar schools; from each grammar school two classes were selected – one experimental group and one control group (Figure 1).

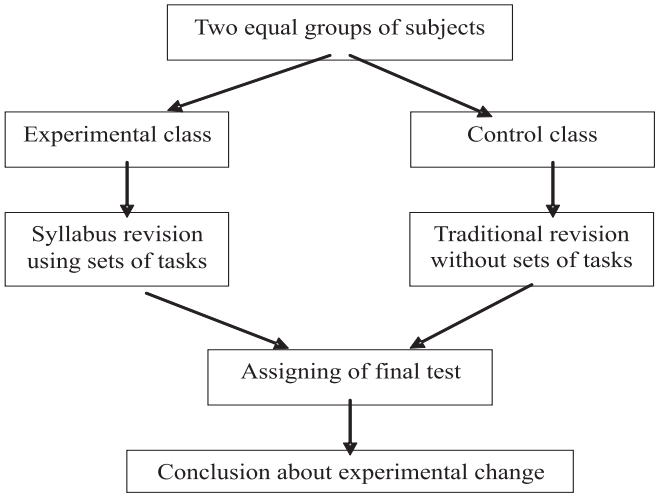


**Figure 2. Plan of research (modified according to Čížková et al. 2005).**

In total 223 students participated in the experiment. The experimental class worked with a set of tasks from ecology and environmental protection while the control group was taught without the use of a set of tasks. In each grammar school, the experiment was carried out in the classes taught by the same teacher. Therefore it is possible to assume that the classes were equal prior to the verification of effectiveness of the set of tasks. The difference between the classes was in different way of curriculum practising. In the experimental class, for revision and consolidation of curriculum, sets of tasks were used with allocation of two teaching hours to work them out. In the control class, the curriculum was revised in a traditional way using control questions. In both classes, a final test was completed a week after revision.

**Results of Research**

Table 1 and Figure 3 illustrate the success rate of the individual items of the final test in the experimental and control class.

In addition, a total success rate of the final test was computed in both experimental and control class.

- a total success rate of the final test in the experimental class: 55%
- a total success rate of the final test in the control class: 39%

**Table 1. Success rate of items in the experimental and control class.**

| Item number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Success rate in experimental class (%) | 96 | 62 | 62 | 42 | 12 | 54 | 96 | 56 | 63 | 46 |
| Success rate in control class (%) | 96 | 45 | 55 | 28 | 14 | 30 | 48 | 21 | 40 | 28 |

| Item number | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| Success rate in experimental class (%) | 63 | 67 | 50 | 46 | 43 | 77 | 54 | 19 | 27 | 81 |
| Success rate in control class (%) | 51 | 55 | 35 | 55 | 30 | 69 | 49 | 2 | 10 | 42 |

Figure 2 shows the difference between the success rate of the individual items in the experimental and control class. In most cases, the experimental class was more successful than the control class. A considerable difference between the experimental and control class can be traced in a majority of items. In some cases, the difference is in tens of percents! Only one item shows a higher success in the control class.

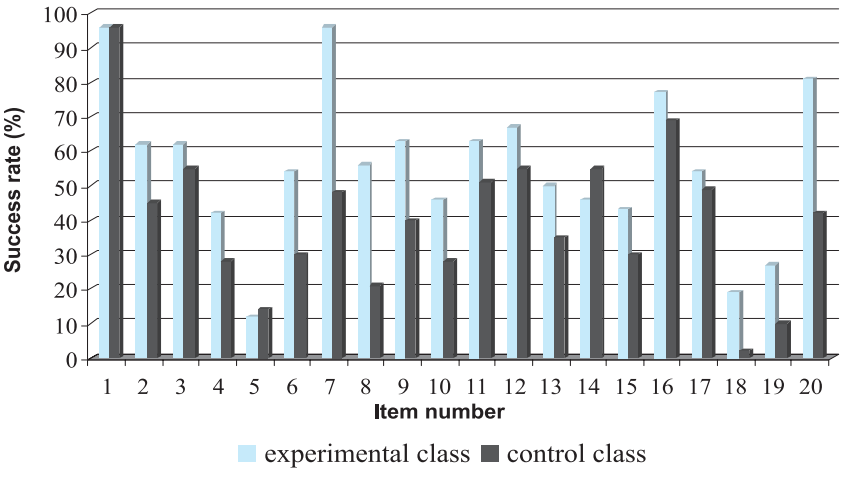


**Figure 2. Comparison of success rate of items in the experimental and control class.**

Table 2 and figure 3 show the spectrum of obtained points, both relative and absolute number of students in the experimental class.

**Table 2. Number of students in the individual point categories in the experimental and control class.**

| Point category | 0-7 | 8-13 | 14-19 | 20-25 | 26-31 | 32-37 | 38-43 |
|---|---|---|---|---|---|---|---|
| Number of students in experimental class | 0 | 1 | 7 | 7 | 8 | 3 | 0 |
| Relative number of students in experimental class | 0 | 4 | 27 | 27 | 31 | 11 | 0 |
| Number of students in control class | 0 | 8 | 13 | 7 | 1 | 0 | 0 |
| Relative number of students in control class | 0 | 28 | 45 | 24 | 3 | 0 | 0 |

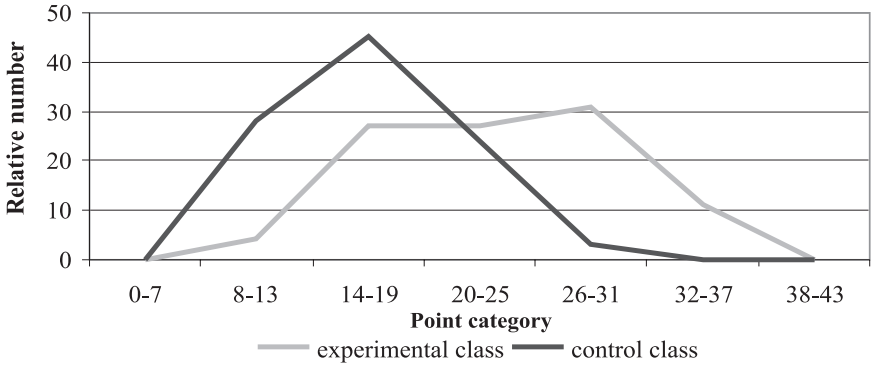


**Figure 3. Comparison of the relative number of students in the individual point categories between the experimental and control class.**

From the figure 3 it is evident that the highest relative number of students in the experimental class is in the category of 31-26 points while in the control class the highest relative number of students is in the category of 19-14 point.

**Evaluation of Research Results**

The main objective of this research was to support – both in terms of theory and practice - the teaching of ecology and environmental protection at secondary schools, in particular through the use of learning tasks. A pre-requisite for completion of this objective was to evaluate the conception of topic "ecology and environmental protection" and to carry out a concept analysis in available teaching materials for secondary schools. In this part of our research, five course books recommended for ecology teaching in the Czech Republic were evaluated.

For concept analysis of course books, frequency tables were used. On the basis of these tables five main topics were focused on: Organisms and environment, Ecology of populations, Ecology of communities and ecosystems, Biosphere and Man, and Environmental protection divided into 11 worksheets entitled Influence of environment on the organism, Population, Food chains, Zoogeographical regions, Biosphere, Substance cycling in nature, Growth of human population, World-wide network of protected territories, Endangered organisms of the Czech Republic, Landscape ecology, and Human influences.

Another objective of the research was – on the basis of findings obtained from the course books analysis – to create sets of tasks for a given topic; these could be used in teaching at secondary and grammar schools. A total of 52 tasks were created for ecology and environmental protection; these were then divided into 11 sets. The tasks were constructed with the aim to ensure – while solving them - revision and extension of the curriculum and to motivate the students for further work. An emphasis was laid upon the comprehension of the basic principles of ecology and environmental protection by the students; they should understand their importance for preservation of life on the Earth. In some tasks, in compliance with the work Capra (2004) we also attempted to strengthen interdisciplinary relations in the teaching of this topic, mainly with geography and chemistry.

Development of sets of tasks was followed by their verification in practice, statistic processing of results and tasks modifications. The aim was to verify not only the contextual, formal and stylistic quality of tasks and the approach of students to their solving but mainly their difficulty. Through the verification stage it became evident that in spite of time and contextual demandingness, the students enjoyed the work.

Evaluation of some tasks, especially the open ones, was also rather problematic. While making a score of open items, it is not always easy to set the confines between the partially correct and incorrect answer.

The results of verification of sets of tasks were statistically processed and on the basis of this processing, modifications were proposed. The most difficult for the students were the tasks where they were expected to apply the acquired knowledge to a particular example, or to use the information referred to in the text and leading to the solution of the tasks. This is probably caused by the fact that in our schools a passive transfer of knowledge still prevails and the students are not used to independent thinking, work with acquired information or search for information in the respective subject – field text. The same problem is also mentioned in the publications by D'Avanzo (2003). She carried out the research at US universities, according to which it is evident that the largest part of teaching (up to 90%) is based on only passive transfer of knowledge. This problem relates to both secondary and tertiary schools and is basically worldwide. In accordance to D'Avanzo, the solution can be seen in greater awareness of teachers about how people learn (psychology of learning) and about the results of the latest research in this area. Therefore the emphasis should be laid on further education of teachers.

A common mistake also was that in the tasks with more correct answers the students marked only one or two of them and did not expect that more answers could also be correct, or even all of them. It is probably caused by the fact that the students are not used to such tasks and they automatically assume that only one answer is correct.

Some students also had problems with tasks the solution of which depended only on reading the introductory text or understanding a graph. It is caused by the fact that the students do not read attentively and are not used to extract the information from the graph.

The tasks, where interdisciplinary relations were applied, did not cause, in most cases, problems for the students. A low success rate of some tasks was caused by the lack of time or improper orientation in the map. Mainly the localisation of places on maps was the reason why the tasks were modified. Here some



ambiguously localised countries were replaced by others that are more appropriate for the purposes of a particular task. A link between the grade from biology and geography and a rate of success while solving the task was not in principle noted. Only students with good grading were better in the tasks requiring knowledge of particular information or concepts. It is interesting that students with worse grading were often more successful while solving problem tasks where logical thinking and links between the knowledge from different subjects were needed. A possible explanation can be that worse students are ready to risk and show their creativity while good students are willing to be sure about the answer. The reason might also be the fact that students are positively evaluated at school, mostly for memorising facts without the necessity to understand relations and links. It is therefore possible that the tasks requiring the application of findings and solutions of problems revealed who actually grasped the syllabus and who only smatters.

Another objective of the research was to experimentally verify the effectiveness of sets of tasks. First a research tool was created - a final test, the content of which was based on sets of tasks. From the results it is evident that students of experimental class in all grammar schools reached better results. Sets of tasks were therefore helpful when reaching a better acquisition and grasp of findings than classical methods used in teaching – i.e. mostly by explanation. Therefore it is assumed that the hypothesis "Students achieve better results in knowledge and skills from ecology and environmental protection if they use topic-related sets of tasks for revision, consolidation and systematization of syllabus" was confirmed.

However the results of didactic experiment cannot be simply generalised for all the schools where verification of sets of tasks and assignment of final test took place. While verifying the effectiveness of sets of tasks and a follow-up generalisation of results, it is necessary to consider a lot of related problems. A teacher plays an important role. Results of didactic experiment can also be affected by a particular disposition of the individual classes because in grammar schools where the students, after admission, are divided into classes according to their placement in the entrance test, it can happen that in one class more "bright" students occur than in the parallel class. All these factors, of course, affect the results of didactic experiment.

## Conclusion

One of the ways of how to ensure implementation of environmental education into basic and grammar schools at the required level is a shift from a transmisive model of teaching towards the methods of cognitive constructivism and increased activity of students in the process of teaching. An effective tool is an up-to-date content of teaching and the use of appropriate activating methods and forms of teaching, mainly learning tasks of a problem nature, projects, excursions and fieldwork, which would make the teaching more interesting, would show its connection with practice and would lead to acquisition of sustainable skills.

This very way of increasing the effectiveness of teaching via appropriate learning tasks was the subject of the above research. This research referred to in the article is an integral part of our long-term work in the area of science education.

Realisation of research confirmed that this way of teaching is really effective and brings about the expected positive results. However, at the same time it requires a thorough preparation and considerable understanding of a given topic of the syllabus and an ability to apply contemporary pedagogic and psychological theories in practical teaching. At the same time it is necessary, within life-long learning, to acquire new methods and forms of teacher's work in science subjects at all types of schools so that the teachers could use them really effectively in their teaching.

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