Empirical evaluation of a dichotomous key for amphibian identification in pupils and students

Evaluación empírica de identificación dicótoma para anfibios con escolares y estudiantes universitarios

CHRISTOPH RANDLER

University of Education, PH Ludwigsburg, Institute for Natural Sciences and Technology, Reuteallee 46, D-71634 Ludwigsburg, Germany
Randler@ph-ludwigsburg.de

Abstract

The aim of this study was to enhance learning of pupils working together in groups of 3-4 in an identification unit using plastic models and a dichotomous key. Treatment pupils and treatment students performed better compared to a control group. Concerning gender, there was no difference between boys and girls. Further, a strong correlation between pupils and students in their percentages of correct identification existed.

***Key words**: amphibian species identification, model specimens, self-regulated learning, within-class grouping*

Resumen

El objetivo de esta investigación es mejorar el aprendizaje de escolares y estudiantes de la universidad, trabajando en grupos de 3-4 personas en una unidad de identificación, usando modelos de plástico y una clave dicótoma. Los resultados de los escolares y estudiantes que estudiaron con nuevo método, fueron mejores que los de un grupo de control. No se detectaron diferencias entre niños y niñas. Además, hubo una correlación marcada entre escolares y estudiantes universitarios en sus porcentajes de identificación correcta.

***Palabras clave**: identificación de anfibios, modelos de animales, aprendizaje autorregularizado, trabajo en grupo.*

Identification tasks have been targeted as a fundamental aspect for an understanding of ecosystems and biodiversity (LINDEMANN-MATHIES, 1999; RANDLER & BOGNER, 2002). Experiencing biodiversity always means encountering species since species assemblages in turn provide biodiversity. Using identification books or keys in combination with educational units focusing on identification represent favorite educational and instructional methods rather than simply teaching factual knowledge (RANDLER & BOGNER, 2002). Such educational settings should make use of self-regulated, group-based and hands-on learning (e.g. RANDLER & BOGNER, 2002). Usually, outdoor educational settings are considered to be superior over indoor settings (KILLERMANN, 1998), but nevertheless, such educational settings commonly focus on plant species or invertebrates (KILLERMANN, 1998) since amphibians are difficult to observe in nature (with, for example, the exception of toad migration during spring).

RANDLER & BOGNER, (2002) compared a traditional, rather teacher-centered educational unit dealing with bird species identification with another one highlighting self-determination, hands-on and group-based learning. In short, the modern approach was more successful, but only, when the number of species to be learnt was reduced from the former 14 down to six. This emphasizes the need for a reduction of syllabus contents in general (RANDLER & BOGNER, 2004) and the problems in learning about species.

The aim of this present study was to enhance learning and retention effects when pupils in small groups of 3-4 were working together in an identification skill training using plastic models together with a dichotomous identification key. As in previous studies, group-based learning (Lou et al. 1996) and hands-on science (e.g. STOHR-HUNT, 1996) was preferred. However, original objects (e.g. BERCK, 1999) could not be used and, therefore, plastic models were given preference, since these models closely resembled natural specimens. Further, these models were scientifically sound. Usually knowledge and identification skills of pupils are rather underdeveloped (see KLEE & WEIß, 1985 for an overview). For an example in birds, RANDLER (2003), found untrained pupils able to identify birds on a higher taxonomic level (the respective avian family or order), but merely none was able to report the correct species names. Hence, pupils have developed some kind of identification skill, but rather on an unspecified level.

In this present study another approach was used. Usually, identification tasks are based on pictures, models or taxidermies (stuffed specimens) and on identification books based on visual entities (drawings or photographs). However, pupils mainly focus on the pictures in these books and "avoid" reading the specific text which usually supports identification features and is helpful for memorizing. Therefore, an identification key based on dichotomy and language was used. Such a dichotomous key is based always on two alternatives (decisions) which were subsequently followed by another pair of alternatives unless the final species name is reached. Such dichotomous keys were previously used, e.g. in human biology (BAVIS *et al*. 2000), plant identification (OHKAWA, 2000), fruits, nuts and cones of trees (COLLINS, 1991) or timber (THOMAS, 1991). This comparative approach rather request a closer look compared to using a picture-based identification book since the identification key provided no figures (but only text-based information). Further, the plastic models are quite practical and therefore, the pupils were asked to touch them. This combination of an identification key based on language (without any pictures), natural models of amphibians, and the possibility to touch these models, is considered to evoke a better retention rate since learning in such ways links both hemispheres of the human brain. Such linkings are considered to enhance learning and retention. Apart from learning and teaching biodiversity, the results of this study could be generalized since these methods could be transferred into other subjects.

Figure 1
Examples of the models

SPECIES SELECTION FOR THE IDENTIFICATION TASK

About 20 species of amphibians regular occur in Germany, with 18 out of them breeding in Baden-Württemberg, SW-Germany (BAUER, 1987), the district where schooling took place. In order to present a useful task, species were chosen according to their abundance in the specific region. As outlined previously, the number of species to be learnt should not be too high. Therefore, a selection of eight species was chosen for pupils (6th graders), while students at the University had to learn 20 species in a similar manner. RANDLER & BOGNER (2002), present criteria for species selections in identification tasks. These criteria were applied (e.g. distribution, abundance). The species are presented using their scientific name in Figure 2.

EDUCATIONAL PROGRAM

Plastic models of eight different amphibian species were used for training pupils on an identification task and twenty models were chosen for students. These models were obtained from a commercial producer (Schlüter-Biologie) and closely resembled original animals. Learning was organized in the following way: Each model was assigned a number from 1-8 and was presented two times in the classroom to avoid any crowding of the pupils during the lesson. Pupils were working together in groups from 3-4, since this is considered an optimal group size (Lou *et al.* 1996). Every pupil received an identification key (dichotomous) where they always had to decide which alternative was correct. After a correct identification of the species, pupils moved to another desk with another model. After completing the cycle, all species were discussed in the classroom and pupils were asked for the identification features of the respective species. Afterwards, pupils received a colored sheet where all species were depicted and they had to label each of them with the correct name. Students at the university (freshmen) received a slightly different treatment. As in pupils, students were working together using a similar –but more difficult– key and further, had to learn more species (20). Instead of receiving a working sheet, students made their own notices and afterwards received a teacher-centered Power Point presentation to further support their learning. Nevertheless, hands-on and self-regulated learning was the main aspect of the training session, too.

DESIGN AND TESTING PROCEDURE

30 pupils (16 boys, 14 girls) and 56 university students from different courses (>90% females) took place in the study. The students came from three parallel identification courses focusing on morphology, taxonomy, systematics and identification of animals. This course is an integral part of the pre-service teachers' training at the University of Education. For testing, again, colored pictures were used, but they differed from those presented previously to pupils and students. Using the same pictures could lead to other learning effects, e.g. pupils sometimes remember to which site an animals turned or whether it is depicted from a frontal view. I did not apply a pretest since repeated testing can lead to a better performance without any learning (Keeves, 1998). Pupils were tested one week and students ten weeks later without using these tests for grading.

30 other pupils (15 boys, 15 girls) served as a control group. These pupils were drawn from the same school during the same term. This was to ensure an ecological validity (Keeves, 1998) since they experience the same hometown and the same school environment.

To account for possible differences between the two classes a within-group testing procedure was used: Both classes received the same questionnaire where they had to label eight species correctly. On a second sheet, pupils only had to assign the higher order taxonomic group (lizard, toad [2x], newt, snake, frog). This selection comprised two reptiles additionally. Further, the species used in this second sheet were unknown to both groups. Major purpose of this test was to assess differences in prior knowledge and concepts about amphibians and reptiles. Previous studies in bird species identification found, that most pupils are able to label species on a higher taxonomic order, such as genus, family or order (e.g. owl, gull, woodpecker; Randler & Bogner, 2002), thus suggesting that prior concepts exist. One hypothesis was that pupils should not differ in their general concepts as measured with sheet two, and thus have the same prior knowledge. Therefore, no differences between both classes in this second part of the test should occur.

STATISTICS

As data were not normally distributed non-parametric tests were applied. All tests were carried out two-tailed using SPSS 11.0. Data from the three different courses at the university were pooled since there were no differences in achievement (Kruskal-Wallis-Test: : x^2_2=1.340; p=0.512; N=56). The results present means ± standard errors.

RESULTS AND DISCUSSION

Treatment-pupils were able to identify 4.0 ± 0.4 (50%) species one week after the educational lesson, while university students were able to recognize 2.9 ± 0.2 (37%) after more than ten weeks (out of the eight species used for testing). In the control group only 1.3 ± 0.09 species (16%) were known.

(Figure 2). This was mainly based on the correct identification of the Fire salamander (*Salamandra salamandra*). The difference between the three groups was significant (Kruskal-Wallis-test: x^2_2=34.686; p<0.001; n=116). In subsequent pair-wise comparisons, the difference between treatment-pupils and the control group was significant (Mann-Whitney-U-Test: Z=-5.089; p<0.001; N=60), as was the difference between treatment-students and the control group (Mann-Whitney-U-Test: Z=-5.068; p<0.001). Also, differences could be found between treatment-pupils and university students (Mann-Whitney-U-Test: Z=-2.068; p=0.039; n.s. after Bonferroni-correction). As expected, differences in concepts between treatment and control pupils did not exist (Mann-Whitney-U-Test: Z=-1.580; p=0.114; N=60; Figure 3). This suggests that both classes (pupils) had the same prior knowledge in concepts but treatment pupils acquired species knowledge during the training lesson.

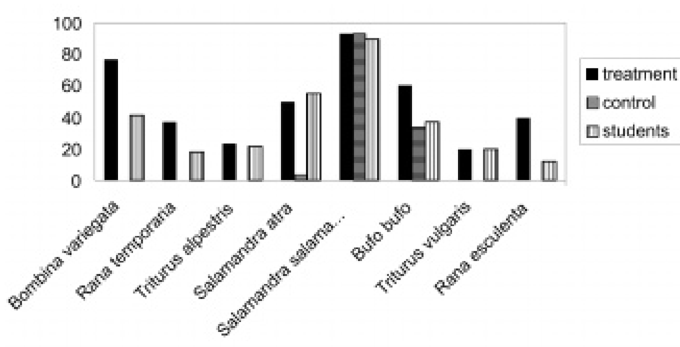

Figure 2
Percentages of correct answers for each species after the educational unit. Pupils were tested one week later, students after a time gap of ten weeks. The control group did not receive any training

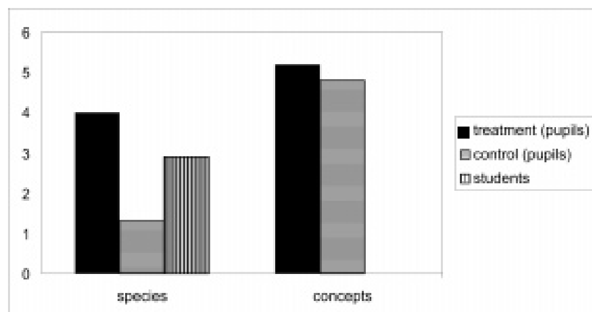

Figure 3
Differences between the three groups in number of correct identification and in concepts of pupils

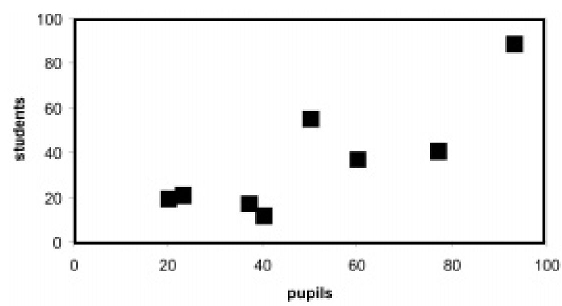

Figure 4
Correlation between the percentage of pupils (and students) that labeled the respective species correctly

Concerning gender, no difference between boys and girls in 6th graders existed, neither in the treatment (boys: 4.0±0.5; girls: 3.9±0.6; Mann-Whitney-U-Test: Z=-0.147; p=886; n=30) nor in the control group (Mann-Whitney-U-Test: Z=-0.468; p= 0.713; N=30). To compare learning and retention between pupils and students in the treatment group, the species were ranked according to their percentage of correct identification in each group (see Figure 4). The species that received the highest percentage of correct answers was assigned rank 1, the species with the second highest percentage of correct answers rank 2. This was done both for the pupil sample and the students, using treatment participants only. There was a strong correlation between pupils and students in the percentages of correct identification (r_s=0.714; p=0.047*; N=8 (species); see Figure 4). This suggests that both pupils and students memorize the same species in a similar percentage. Species that were easier to be memorized by pupils were also easier identified by students. The difference in treatment between pupils and students may prevail because the time gap between treatment and testing differed (pupils: one week, students: >ten weeks).

CONCLUSIONS

Prior knowledge has an enormous influence on subsequent learning and instruction. However, the comparison of the existing concepts in pupils showed no difference between treatment and control pupils, and therefore, learning effects could be assigned to the educational program. In general, remembering just fifty percent of the eight species one week later in pupils (6th graders) seems a poor result. However, other studies also stressed the difficulties in acquiring species identification skills and knowledge (see, e.g. overview in RANDLER & BOGNER, 2002).

From a psychological point of view, different treatments should be compared, e.g. using picture-based identification books instead of the dichotomous key or using teacher-centered lessons. However, major aim of this present study was to evaluate a useful and consistent approach as an example of 'best-practice' in science education and add knowledge to the studies examining such learner-centered and group-based identification tasks in teaching biodiversity. Apart from knowledge, this approach provides a useful tool for a further training in methodological skills (e.g. using identification keys) and of social skills (working in groups). These aspects are emphasized in modern science instruction. Further, this approach can be easily transferred into other subjects or topics. Again, species identification knowledge is difficult to obtain and lists of species to be learnt should be reduced.

ACKNOWLEDGEMENTS

This study was partly funded by the University of Education, PH Ludwigsburg and by the Bundesministerium für Bildung und Forschung (JP RANDLER). I am grateful to my colleagues to be able to use the model specimens from our collection. Further, the lesson was carried out by U. LANG, and B. ALLMENDINGER carried out the tests in the control group. The dichotomous key for the University students was developed and improved by Dr. W. KIENZLE. Thanks go to them all.

BIBLIOGRAPHY

BAUER, S., Verbreitung und Situation der Amphibien und Reptilien in Baden-Württemberg. *Beihefte Veröffentlichungen Naturschutz Landschaftspflege Baden-Württemberg,* 41, 71-155, 1987.

BAVIS, R.W., SEVEYKA, J. & SHIGEOKA, C.A., Another strategy for teaching histology to A&P studenst: classification versus memorization, *American Biology Teacher,* 62, 365-369, 2000.

BERCK, K.-H., *Biologiedidaktik*, Quelle & Meyer, Heidelberg, 1999.

COLLINS, L.T., A dichotomous key to tree cones and fruits of the eastern United States, *American Biology Teacher,* 53, 29-30, 1991.

KEEVES, J.P., "Methods and Processes in Research in Science Education", in: FRASER, B.J. & TOBIN, K.G. (ed.), *International Handbook of Science Education*, Part Two, 1127-1153), Kluwer Academic Publishers, Dordrecht, 1998.

KILLERMANN, W., Research into biology teaching methods, *Journal of Biological Education*, 33, 4-9, 1998.

KLEE, R. & WEIß, J., Beschäftigung mit Arten sowie Handeln im Natur - und Umweltschutz– Ergebnisse einer empirischen Untersuchung, *Mathematisch-Naturwissenschaftlicher Unterricht*, 48, 298-304, 1985.

LINDEMANN-MATTHIES, P., *Children's perception of biodiversity in everyday life and their preferences for species,* Dissertation. University of Zürich, Zürich, 1999.

LOU, V.; ABRAMI, P.C.; SPENCE, J.C.; POULSEN, C.; CHAMBERS, B. & D'APOLLONIA, S., Within-class grouping: a meta-analysis, *Review of Educational Research*, 66, 423-458, 1996.

OHKAWA, C., Development of teaching materials for field identification of plants and analysis of their effectiveness in Science education, *American Biology Teacher*, 62, 113-123, 2000.

RANDLER, C., Amsel, Drossel, Fink und Star ... Welche Vogelarten kennen Schülerinnen und Schüler?, *Praxis der Naturwissenschaften – Biologie in der Schule*, 52 [1], 44-45, 2003.

RANDLER, C. & BOGNER, F., Comparing methods of instruction using bird species identification skills as indicators, *Journal of Biological Education,* 36, 181-188, 2002.

RANDLER, C. & BOGNER, F., Emotional and cognitive aspects of learning: The ecological unit "Lake", in: EILKS, I. & RALLE, B. (ed), *Quality in practice-oriented research in science education*, Shaker, Aachen. (in press), 2004.

STOHR-HUNT, P.M., An analysis of frequency of hands-on experience and science achievement, *Journal of Research in Science Teaching*, 33, 101-109, 1996.

THOMAS, P.A., A key for the identification of eighteen common timbers, *Journal of Biological Education,* 25, 15-19, 1991.

Received: 22.02.2005 / Approved: 2.09.2005