LEARNING ABOUT OWLS AND THEIR CONSERVATION – A COMPARISON OF MEDIA-ASSISTED INSTRUCTIONAL METHODS

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Abstract

In this study, two short-term educational treatments for secondary school dealing with ecology and conservation of European owl species were compared under realistic field-conditions. Both motivating learning environments, a play-like activity (quartet) and a hypermedia website tool for two lessons (90 min), are known to provide a strong "Hawthorne effect", which might useful for achievement in a short-term learning unit in Science Education. Information units were similar, only the structure of presentation differed within both treatments. Objectives of the study were (i) a comparison of both teaching methods concerning the cognitive learning outcome and (ii) motivational variables in a pre-/post- and retention-test design with control group. Pupils were randomly assigned one treatment (Hypermedia: N = 34, quartet: N = 30, control: N = 28). As result of multivariate statistics, a significant higher achievement in the computer-aided group was assessed immediately after the lesson, while the retention test did not produce significant differences between the treatments. Pupils performed significantly better in the retention-test compared to the post-test, which might be due to a short teaching sequence of ten minutes after the post-test. The motivational variables measured with the Intrinsic Motivation Inventory (Ryan, Connell & Plant, 1990) didn't show any difference between the two treatments, suggesting that both treatments are motivating and that the Hawthorne effect might be similar. Pooling both experimental groups, a significant positive relationship between interest/enjoyment and post-test scores and between effort and retention and a negative correlation between retention test and the perceived pressure can be reported.
A consequence for Science Education practice is the usefulness of both treatments for successful and motivating achievement as well as the fact, that the hypermedia approach can be used for self-determined learning as out-of-school-preparation. Furthermore, research concerning the short concluding teaching sequences is necessary.
Key words: *computer-supported learning; ecology education; hypermedia; intrinsic motivation.*

Introduction

Teaching and learning in biodiversity is an educational challenge (van Weelie and Wals, 2002; Gaston and Spicer, 2004) because biodiversity itself is an abstract and rather complex construct – called 'ill-defined' in terms of van Weelie and Wals (2002). Such a complex construct has to be split up into smaller bits to aid sustainable learning and comprehension. This is true especially in younger pupils. As the species level is the most common taxonomic unit used by conservation groups (van Weelie and Wals, 2002), knowledge about species and their life histories might provide the most fundamental aspect for teaching biodiversity (Lindemann-

Mathies, 2002; Randler and Bogner, 2002; Gaston and Spicer, 2004). In conservation practice most organisations (NGOs) stress the importance of so-called 'flagship species' for funding (Czeck et al., 1998; Dalton 2005). Further, animals provide fascinating objects for children and adolescents (Bjerke et al., 2001) and among the different classes of vertebrates, the special popularity of birds is known from many studies (Czeck et al., 1998; Bjerke et al., 2001; Randler and Bogner, 2002).

Environmental Education is usually concerned with teaching and learning within outdoor ecological settings (Killermann, 1998; Lock, 1998; Tilling, 2004). Outdoor education seems superior to classroom instruction because it may include encountering living animals (Sherwood et al., 1989) and experiencing emotional factors (Bogner, 1999, 2002). The benefits of outdoor ecological educational have been summarised, for example by Bogner and Wiseman (2004). However, during most of the time teaching and learning at school takes place within typical everyday classroom settings. Therefore, conservation and ecology education should make use of such everyday classroom teaching.

Within the context of outdoor ecological education, many researchers looked at psychological constructs such as attitude, environmental perception and other personality factors while knowledge was often neglected (overview: Bogner, 2002; Bogner and Wiseman, 2004; Randler and Bogner, 2002). Focusing on cognitive learning outcome is therefore also a worthwhile task. However, learning could be barely defined as 'cold cognition' (Pintrich et al., 1993) and other factors, such as social or emotional ones, should also be taken into account. Although our main focus was on the learning and retention effects of the conservation unit dealing with native owl species, we additionally applied five out of six motivational scales – the Intrinsic Motivation Inventory – based on Deci and Ryan's Self-determination Theory (1990). Self-determination Theory suggests that pupils have an intrinsic motivation to autonomously explore new fields of knowledge, to perceive competence and to be socially related. Within this theoretical framework the questionnaire is a useful tool to compare different instructional or educational treatments with regard to motivational apsects. Because treatments were randomly assigned, we omitted the scale dealing with perceived choice.

We used owls (Order Strigiformes, Families Strigidae and Tytonidae) as species group for our teaching approach, because animals rank high in the favourite interest of children (Morgan 1992; Bjerke et al. 2001) and owls represent a group of endangered species in Europe (Hagemeijer and Blair, 1997). To teach these aspects we developed two different instructional strategies to aid self-determined learning and to enhance motivational variables (see e.g. Gläser-Zikuda et al., 2005 for an overview). One approach used a play-like activity (a traditional quartet card play) and the other approach was a computer based hypermedia learning environment. In general, the effectiveness of games and simulation games in education has been questioned by Randel et al. (1992). Of 67 studies reviewed by Randel et al. (1992), 38 showed no differences between games and conventional instruction, 22 favour games, 5 favour games but the control groups seem questionable and only 3 favour conventional instruction. Nevertheless, there is encouraging support for using play-like activities such as role-play or games in biology teaching (Duveen and Solomon, 1994; Bailey and Watson, 1998) and such games seem to foster motivation (Bailey and Watson, 1998).

The effectiveness of hypermedia software has been shown in many studies in Science education, often revealing better results compared to either computer-aided but linear (e-books) or more traditional learning environments, such as books (Yildirim et al., 2001; Rehbein et al., 2002). Hypermedia learning environments are networks of information nodes and ordered relations (links) which allow learner-controlled and self-directed access to multiple information units. Learners can determine their own learning paths and the learning time according to their individual needs. Hypermedia learning environments offer information in multiple representations like images, texts, sounds, animations and films under multiple perspectives. Several studies have shown, that this can positively influence a variety of affective aspects (e.g. motivation, increased level of engagement or decreased anxiety) which, in turn, might enhance learning success (e.g. Friedrich, 1999; Unz and Hesse, 1999; Unz, 2000; Yildirim et al., 2001; Girwidz et al., 2006). Spiro and colleagues (1992), for instance, suggested hypermedia learning environments as appropriate tools for learning within complex domains. But there is still little empirical evidence about an enhancement of learning success using hypermedia learning instead of traditional educational methods (e.g. Tergan, 2002; Chen and McGrath, 2003).

Both approaches (quartet and computer aided learning) are known to include a strong

Hawthorne-effect: Explanations of improved student performance are based on the novelty of the technology in the classroom, peer collaboration, increased student motivation, having new and motivating instructional materials and others. Thus, our study focuses on the instructional potential of both methods aiming for an effective aid in environmental education in everyday classrooms. Further, we controlled for differences in motivation by using the Intrinsic Motivation Inventory.

One of the main problems of evaluating different teaching approaches lies in the design and planning of educational experiments. For example, one can compare a group that received a thoroughly developed treatment with a real control group that did not receive any educational treatment (Bogner, 1999), but usually most control groups performed significantly worse (Leeming et al., 1997). On the contrary, many studies based on a comparison of two different treatments revealed no significant effects and some even found the opposite (see Fraser et al., 1987 for a thorough discussion). Here, we aimed for an educational setting that compared both, two different teaching methods (computer based versus quartet), but also used a real control group. Further, we aimed for an entirely randomised procedure (Keeves, 1998).

Methodology of Research

Educational Programs

Scientific contents of the quartet and the website were i) morphological adaptations of owls towards their ecological environment such as eyes, ears, beaks and talons, the production of pellets, plumage and specialised feather structure, ii) life history, communication, reproduction, ii) ecological needs such as a food, habitat requirements and predators, iii) preservation of owls (and aspects of persecution), and iv) information about eight different European species.

The single information units of the quartet and of the website provided identical information using text in combination with images. The presentation of learning materials followed a theoretical framework of media design principles (see detailed in Girwidz, Bogner, Rubitzko and Schaal, 2006): Both materials were adapted to learners' literacy and prior knowledge according to the Cognitive Load Theory of Chandler and Sweller (1991). For instance, information units are designed to reduce extraneous cognitive load by avoiding the presentation of irrelevant information or unnecessary decoration. In addition, the amount of information units takes into account learners' abilities in processing new knowledge entities. Therefore, information was provided in segmented portions: For instance, single sub-themes in the website were presented without scroll-bars or long texts to allow the learner a fast access to the content. After each segment, the learner could start a further information unit by clicking on a continue-button. This so-called segmentation effect (Mayer and Moreno, 2003) showed evidence, that learners understand such a multimedia information better "when it is presented in learner-controlled segments rather than as continuous presentation" (p.47). The information units on the quartet card present information in the same way, but learners' control is substituted by coincidence while playing.

Both materials followed the design principles of R. E. Mayer's *Generative Theory of Multimedia Learning* (1997, 2001): The adequate media presentation by a coherent combination of visual and verbal information facilitates mental processing (e.g. selection, organisation and integration processes), active knowledge construction and, therefore, the probability of sustainable mental representations.

The difference between both materials was the segmentation and the pacing of information units. While learners using the quartet weren't able to influence the sequence of information units, the 'website learners' determined themselves their learning-path and the time spending on a single information unit. However, the segmentation of information may be helpful for knowledge acquisition in both cases, especially for learners with lower domain specific expertise.

Both materials provided the possibility of interactive learning. The quartet allowed personal interaction between the game participants while the website allowed individual information access and the discovery of interactive learning materials, such as discovery images or an owl quiz.

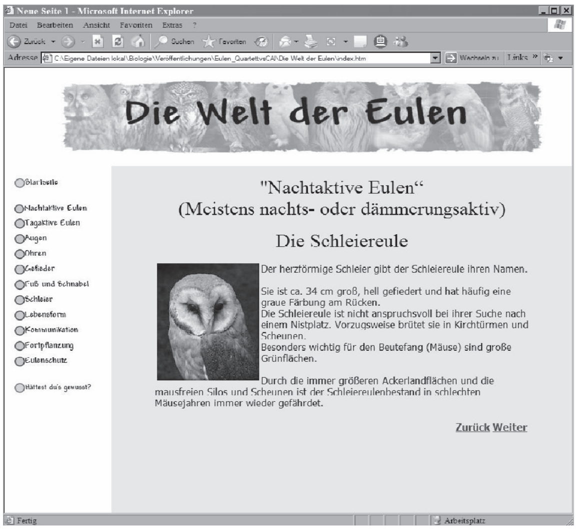

Figure 1. Hypermedia website about “The World of Owls“.

Within self-directed learning materials, structural support is an important aspect for successful knowledge construction: Several empirical studies revealed the need for hierarchical structures of information, especially for novices in new knowledge domains (e.g. Pazzani, 1991; Shin et. al., 1994; McDonald and Stevenson, 1998; Calisir and Gurel, 2003). Therefore, the information on the website was structured in a clear, hierarchical way and the navigation provided an adequate structure. The information was divided in sub-themes mentioned above. Learners had the possibility to ‘jump’ from one chapter of the menu to another, but each single chapter like, for example, the conservation of owls, had to be worked through sequentially. Thus, on the one hand, learners profited of the segmentation effect, while they could on the other hand influence their learning paths individually. In the quartet, again, coincidence conducts the pupils’ learning paths.

Design and testing procedure

In total 98 pupils (56 boys, 42 girls; all 6th graders) participated in the study (aged between 11 and 12 years). However, only 30 pupils (quartet) and 34 (computer) participated in all three tests and could be used for calculating a multivariate GLM. All instruction and testing was carried out by S. Krall. As the person of the teacher often has a significant effect on learning and retention (Gläser-Zikuda et al., 2005), it is important to control for this variable (see also Randler and Bogner, 2004). In our treatment-control-design we have accounted for this possible bias. We formed two treatment groups that were tested prior (pretest), immediately after (posttest) and with a delay of four to six weeks (retention test) to assess learning and retention effects (Randler and Bogner, 2002). An additional experimental group served as a control (28 pupils of similar age and grade). These pupils did not receive any teaching in biology during the two lessons (Physics and German language) but were tested prior and afterwards to assess the influence provided by repeated testing (Keeves, 1998). We did not use these tests for grading to exclude extrinsic motivation as a confounding factor. Also, students never were aware of any further testing.

Motivational variables

Additionally, we measured motivational variables derived from the Intrinsic Motivation Inventory (IMI; see Plant and Ryan, 1985; McAuley et al., 1987; Ryan et al., 1990). The IMI is a multidimensional measurement device intended to assess participants’ subjective experience related to a target activity (Plant and Ryan, 1985; Ryan et al., 1990). The constructs comprise six dimensions: interest/enjoyment, perceived competence, effort, choice, value/ usefulness, felt pressure and tension. As the pupils were given no choice because of the randomisation procedure we did not use the specific sub-scale ‘choice’.

Randomisation of the treatment groups

To avoid any bias in our experimental design we applied a randomised class division with a rigorous separation of pupils into new clusters. Within each class, every pupil randomly received one of the treatments. This was assured by using skat cards. Every pupil had to draw one card from a set of cards facing downwards on the table. The number of red and black cards was adjusted to the number of pupils to achieve an equal division of the class. However, within their respective treatment group pupils were entirely free to choose their partner. Pupils at the computer worked in dyads while the quartet had to be played in groups of three to four.

Although didactical field studies are never completely consistent with regard to experimental variables (as it might be achieved under strict laboratory conditions) we feel that our study provides a very high ecological validity in terms of experimental design (Keeves, 1998).

Statistics

Achievement and motivational data were normally distributed (Kolmogorov-Smirnov-Test; P always > 0.1). Therefore, parametric testing procedures were applied, using univariate and multivariate general linear modelling with type III sum of squares for unbalanced data. Achievement tests were carried out two-tailed, using SPSS version 13.0. Correlational analyses between achievement and motivational variables were carried out using one-tailed tests. We chose this procedure because there is strong empirical and theoretical evidence for one-directional hypotheses, i.e. that motivation and perceived competence positively influences achievement (see, for example Plant and Ryan, 1985; Ryan et al., 1990; Randler and Bogner, 2004; Randler et al., 2005). The results presented here are means ± standard errors (s.e.).

Results of Research

Pupils of both treatment groups significantly increased their knowledge between pretest and posttest: i) in the quartet-group from (mean ± s.e.) 8.5 ± 0.5 to 10.1 ± 0.5 (T=3.716; P=0.001; N=33), and ii) in the computer-group from 8.2 ± 0.5 to 11.2 ± 0.6 (T=6.324; P<0.001; N=35; see Figure 2). However, a less pronounced but also significant increase was found in the control group which scored 9.2 ± 0.5 prior and 10.1 ± 0.5 after the lessons (T=2.553; P=0.017; N=28). Knowledge about owls and their conservation further increased significantly between posttest and retention test from 10.0 ±0.5 to 13.3± 0.7 (T=4.647; P<0.001; N=30) in the quartet playing group and from 11.3 ± 0.6 to 12.7 ± 0.6 (T=2.470; P=0.019 N=34). This substantial increase seems a result of a short teaching sequence where the correct answers of the respective questions of the posttest were discussed.

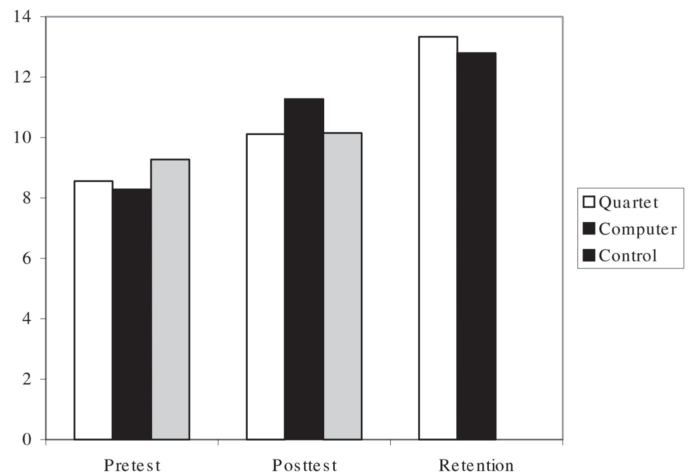

Figure 2. Achievement scores of all three groups in pretest, posttest and retention.

	Wilks-Lambda	F	Significance	Eta²
Constant	0.479	32.595	<0.001	0.521
Prestest	0.467	34.207	<0.001	0.533
Medium	0.899	3.387	0.040	0.101

Table 1. Multivariate general linear model with posttest and retention test as dependent variables, pretest as covariate, gender and educational treatment as factor. Final model after a stepwise backward procedure.

Prior knowledge was a significant predictor of both subsequent knowledge measurements (posttest: $r=0.695$, $P < 0.001$, $N=98$; retention test: $r=0.478$; $P < 0.001$; $N = 66$). Therefore, we applied a multivariate general linear model and used both posttest and retention test as dependent variables, gender and treatment as fixed factors and pretest as covariate. After deleting all non significant two-way interactions ($p>0.05$), and all non-significant factors ($p>0.05$) in a stepwise backward procedure our final model contained treatment as factor and pretest as covariate (Table 1). In the immediate posttest pupils participating in the computer program scored significantly higher compared to pupils that played the quartet ($F_1=5.762$; $P=0.019$; $eta^2=0.086$). However, no differences existed in retention ($F_1=0.226$; $P=0.636$ $eta^2=0.004$). Pretest scores also showed a significant influence (posttest: $F_1=63.6$; $P<0.001$; $eta^2=0.511$; retention: $F_1=17.728$; $P<0.001$; $eta^2=0.225$). We further examined the differences between both treatment groups and the control group in a univariate GLM using posttest as dependent variable, gender and treatment as factors and pretest as covariate.

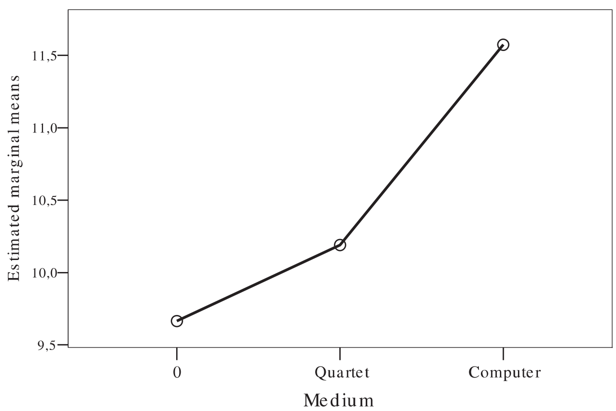

Figure 3. Estimated marginal means from a general linear model (GLM) based on treatment (factor) and prestest scores (covariate) using posttest as dependent variable.

This model revealed similar results (Figure 3) suggesting that both methods increased knowledge compared to the control group, but again, that the computer group scored significantly higher (Medium: $F=5.710$; $P=0.005$; $eta^2=0.110$; Pretest: $F=101.4$; $P<0.001$; $eta^2=0.525$). As there were no significant differences between both treatment groups in the motivational variables data were pooled (Figure 4).

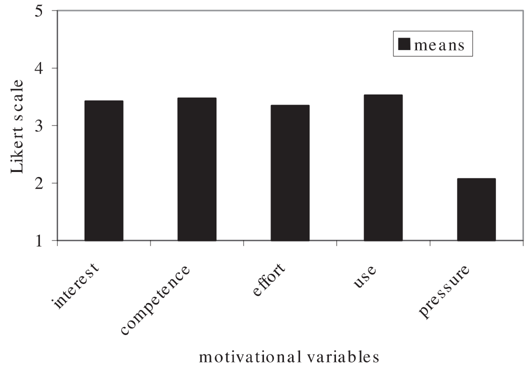

Figure 4. Mean scores of motivational variables (data form both groups pooled).

Further, we calculated the residuals of knowledge from the minimum linear model after accounting for medium and prior knowledge. These residuals were subsequently correlated with the five motivational scales (Table 2). We found a weak positive correlation between interest/enjoyment and posttest scores and between effort and retention. Pupils with a subjective higher interest during the educational treatment scored better in the posttest and pupils that experienced a higher effort scored better in retention. However, a strong negative correlation existed between retention test and pressure, suggesting that pupils which felt under pressure during the activity scored significantly worse in the retention test.

Conclusion and Discussion

Pupils benefited from both educational approaches, however, immediately after the educational treatment, the 'website learners' performed better. This result seems valid because our rigorous experimental design controlled for many extraneous variables. Similar results were found, e.g. by Yildirim et al. (2001), Rehbein et al. (2002). Nevertheless, research on multimedia and related instructional strategies has been characterised by inconsistent findings about their effects on learning (Hede, 2002). However, it is virtually impossible to integrate all factors identified by Hede (2002) into a practical didactical field study. The results presented here are interesting because they show a superiority of a hypermedia learning environment compared to another motivating instructional tool, a play-like activity based on a quartet. One reason for the different results may be found in the structure of the information units: The hypermedia owl website provided a clear content structure and the pupils had – in contrast to the quartet players – a self-directed access to the information units. As consequence, pupils had further support to structure their individual knowledge acquisition and construction, which seems to be important for younger pupils. In addition, a number of empirical studies revealed the potential of individualised information access: The individual segmentation of learning materials' presentation and the possibility to follow an individual learning pace showed positive influence on learning success (e.g. Sweller et al., 1998; Moreno and Mayer, 2000; Paas et al., 2004,). However, the website provided more customised learning than the quartet and thus, the cognitive load (Sweller et al., 1998) might be easier adapted to individual preconditions than the play-like activity. Nevertheless, even the quartet playing groups significantly increased their knowledge despite the more play-like activity. As such quartets are easily to produce by teachers themselves, this might provide a useful educational tool (Randel et al., 1992).

Prior knowledge nearly always shows a significant influence on subsequent learning and it often explains the highest amount of variance (Einsiedler and Treinies, 1997, Schiefele and Rheinberg, 1997). However, we controlled for prior knowledge by using linear models and residual techniques. Afterwards, pupils that received the computer program scored significantly higher during the immediate posttest compared to quartet group. However, this difference merged to non-significance in the retention test. This is an interesting fact because other studies failed to show such marked and significant differences regarding cognitive abilities between treatments, especially when different treatments were compared (e.g. Armstrong and Impara, 1991; Bowler et al., 1999).

More interesting, knowledge increased after the posttest. We suppose that the clearly visible learning effect from posttest to retention is mainly due to some teaching activity. After the posttest, pupils asked the teacher questions about the different items of the test and a short discussion within the respective classes arose. This short teaching and learning sequence lasted approximately ten minutes involving discussions within the respective classes. Moreover, these findings have educational implications, namely, that self-determined and learner-centred activities could be improved by a subsequent discussion with the whole class where pupils can discuss their findings. Interestingly, pupils from the control group showed a significant positive shift in their knowledge from pretest to posttest. Such a phenomenon was also reported from other testing situations (see especially Keeves, 1998 for repeated testing procedures).

Concerning the motivational variables we found no superiority of the computer-based activity. However, as the other educational treatment also comprised an interesting and motivating activity, namely the play-like activity using the quartet (see also Bailey and Watson, 1998), we propose that both treatments provided an interesting tool for learning about owls and their ecology. In consequence, both instructional methods seem to provide the same interest/enjoyment, and pupils felt competent and put the same effort into the activities, valued both equally and felt not differently under pressure. Therefore, we could rule out the possibility of a Hawthorn effect (e.g. Schulmeister, 2002; Gerdes, 1997) because i) we found no difference in motivational and emotional variables which may have caused the achievement differences, and ii) both instructional strategies include novel settings. The 'novelty effect' (Falk et al. 1978) which was previously found in outdoor education may detract pupils from learning and may explain the small learning effects in both approaches. We expected similar results for the play-like activity and for the hypermedia website, because both instructional strategies include a strong Hawthorne effect. In fact, the motivational dimensions didn't differ in both treatments, even though the learning success was better for the hypermedia learners. This stresses the rigour of our study since we did not compare a multimedia learning environment with traditional teaching but rather two instructional methods that may produce a similar amount of Hawthorne effect. In contrast, comparing traditional teaching and instruction with computer-supported work cannot easily exclude this effect.

The correlations of interest/enjoyment and effort with achievement were significant as was proposed by theory. Nevertheless, these correlations were weak. Usually, such correlations between achievement and, for example, interest become stronger parallel to the age of the pupils (Schiefele and Rheinberg, 1997; Schiefele and Csikszentmihalyi, 1998). Therefore, the low age of the pupils (6th graders) might explain the missing correlation. Pressure and tension as experienced by the pupils correlated negatively with retention suggesting that achievement might be significantly influenced by negative emotional and motivational variables. This again emphasises the need for pressure free instruction and phases where pupils are able to work on their own (Gläser-Zikuda et al., 2005).

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