Interactivity and e-Learning – An experimental study

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Abstract

Interactive features play an important role in e-learning. In this paper we report an experimental pilot study which tested e-learning units with different degrees of interactivity. A specific experimental design adapted to a blended-learning scenario was developed. Participants learned with e-learning units, dealing with different movement analysis concepts (MACs), which differ only in interactive features (different degrees of interactivity). Pretest and posttest measured participants' basic knowledge and knowledge transfer of the MACs. A further measurement of participants' basic knowledge was performed immediately after learning. Moreover participants' experience of activation and interactivity was assessed by a questionnaire. The results show that students could improve their knowledge. However we did not find any significant impact of different degrees of interactivity. This result may be due to confounding problems or a small sample size. In some items the groups who learned interactively or actively rated activation and interactivity higher than the non-active or non-interactive groups. Open-ended questions showed, that when being exposed to non-interactive or non-active e-learning units students complained about the absence of interactive features.

KEYWORDS: E-LEARNING, DEGREES OF INTERACTIVITY, EXPERIMENTAL STUDY

Introduction

Interactivity and interactions are important aspects in e-learning (Sims, 1997). According to Wiemeyer (2008) within an e-learning system complex interactions can be distinguished (interactions between learners, teachers, learning content and learning system). The importance of interactions for the learning process is described by Wagner (1997) who focused on interaction outcomes. According to Wagner (1997, p. 22-23) interactions facilitate active engagement of learners, support individualized learning experiences, enhance understanding, support knowledge transfer and increase motivation. Interactions and interactivity in e-learning can enhance the learning process and have an additional benefit to students only if they are well designed and integrated into a didactical design. In the literature different classifications, concepts, categories and ideas exist how to design interactive e-learning (Chou, 2003; Kettanurak, Ramamurthy & Haseman, 2001; Roblyer & Ekhaml, 2000; Sims, 1997; Wagner, 1997). Different technologies like synchronous communication tools (online-chats, video-conferencing) or asynchronous communication tools (discussion forum, e-mailing, mailing-lists, wikis) as well as specifically designed learning objects

(tasks/questions with feedback, simulations, animations and interactive videos) enable interactions. Several studies examined the effects of different degrees of interactivity and interactions on learning outcome in multimedia learning (Evans & Gibbons, 2007; Gao & Lehmann, 2003; Haseman, Polatoglu & Ramamurthy, 2002; Ritter & Wallach, 2006). The studies of Ritter and Wallach (2006) and Gao and Lehmann (2003) showed that students who learned interactively improved their learning outcome significantly more compared to non interactive conditions. The study of Evans and Gibbons (2007) showed an interactivity effect only for an immediate transfer test. No significant impact of interactivity on learning outcome was found by the study of Haseman, Polatoglu and Ramamurthy (2002). These inconsistent results may be due to different implementation of interactivity (different kinds of tasks) and methodological shortcomings (e.g., missing or mismatching pretest, confounding of time on task and interactivity, short retention interval).

In the subproject "Functional movement analysis" of the HeLPS project, a cooperative project of the five Hessian Institutes of Sport Science, interactive e-learning units were designed. The aim was to teach knowledge concerning three different movement analysis concepts (Göhner, 1979; Kassat, 1995; Meinel & Schnabel, 1998) in an interactive way and moreover to practice the application of these concepts. Formative evaluations of the developed e-learning units performed in the winter term 2007/08 and in the summer term 2008 showed, that students liked and appreciated the interactive features and wished more interactive support (Roznawski & Wiemeyer, 2008). To analyze the effects of interactive features within e-learning units on students' knowledge and motivation, a specific experimental design was developed and tested in a pilot study in the winter term 2008/09.

Hypotheses

The primary aim of the experimental field study was to gain detailed knowledge about learning with interactive e-learning units within a blended-learning scenario. The study focused on two main aspects: first students' learning outcome (achievement) and second students' experience of activation and interactivity when learning with interactive e-learning units. The following hypotheses were tested.

Hypothesis 1: Students who learn with the interactive or the active versions of the e-learning units achieve better learning outcomes in the knowledge tests than students who learn with the non-interactive or the non-active version of the e-learning units.

Hypothesis 2: Students who learn with the interactive or active version of the e-learning units experience higher activation and interactivity than students who learn with the non-interactive or non-active versions of the e-learning units.

Methods

The pilot study was performed in the course "How do movements work?". A sample of 12 students (9 males, 3 females, mean age: 24.4 years) participated and completed the course. This course was organized based on a blended-learning concept with alternating online working phases and phases of physical presence. The online working phases were supported by ILIAS, a web-based open-source learning management system. We used ILIAS for providing the online learning units, communication with the students (chat and discussion forum) and online-tests. Altogether three online phases took place. During these phases

participants worked on e-learning units for one week, dealing with the movement analysis concepts (MACs) of Meinel and Schnabel (1998; MAC-MS), Göhner (1979; MAC-G) and Kassat (1995; MAC-K). In the following two phases of physical presence students applied these concepts to selected sport movements. In the first lesson students discussed how to apply the concepts in small groups. Discussions were moderated by experts and supported by prepared checklists which illustrated the procedure of the MACs. In the second lesson the results of the teamwork were presented and discussed in a plenary session.

The experimental design and tests

The experimental design was adapted to the course structure. For testing the differences between varying levels of interactivity we used an experimental pre-post design with two experimental groups. The participants' knowledge was assessed by five tests: a pretest, three immediate tests and a posttest. At the beginning and at the end of the experiment the participants had to answer a questionnaire to assess their motivation and attitude towards e-learning. Furthermore the participants completed a short online survey after each immediate test to evaluate their attitude towards and perception of the e-learning units (only selected results will be reported).

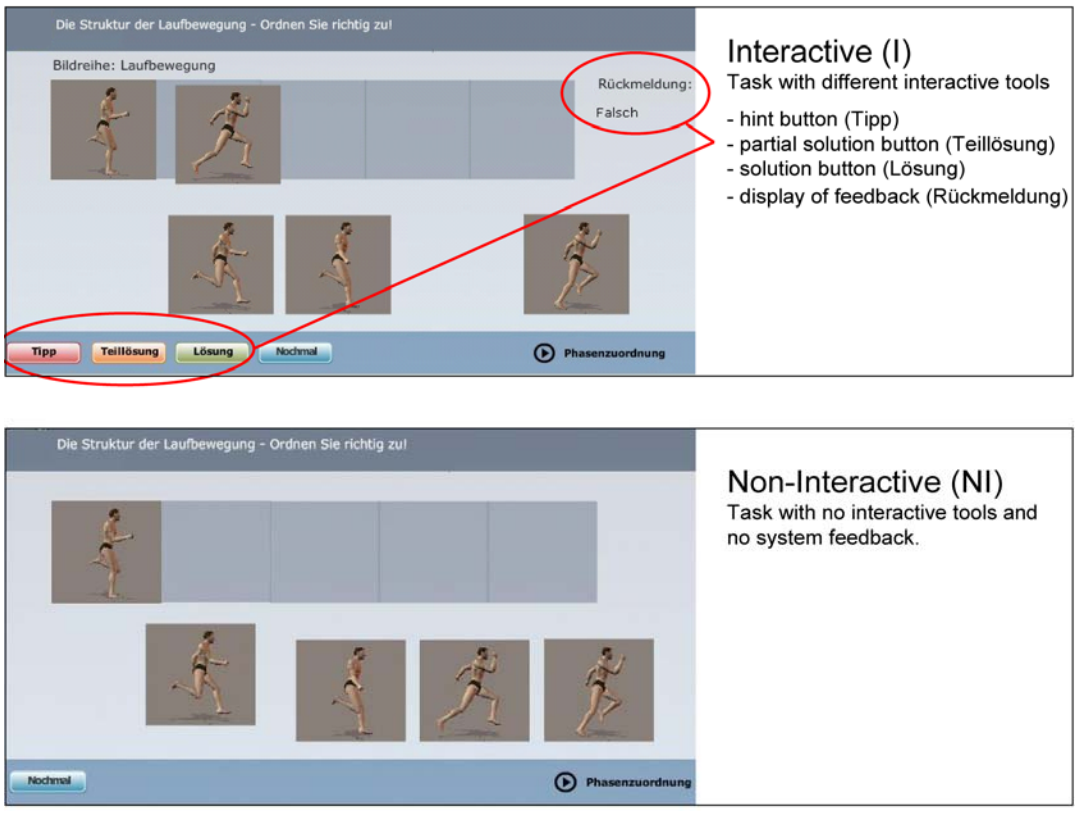

Figure 1. Interactive task (I) for Meinel and Schnabel (1998) with system feedback and non-interactive task (NI) without system feedback

Experimental treatment

Based on pretest performance participants were assigned to the experimental groups (matching method). During each online working phase the experimental groups worked on an e-learning unit with identical content. The e-learning units only differed in interactive features or the active engagement. Interactive units (I) consisted of tasks and questions including system feedback, whereas non-interactive units (NI) did not deliver any system feedback. Figure 1 shows an example of an interactive and non-interactive task in the e-learning unit dealing with MAC-MS. Active units (A) required active engagement with tasks and questions, whereas non-active units (NA) did not contain tasks and questions. Figure 2 shows an example of an active task (drag and drop) which supported active engagement with the learning content and the same learning content which is represented as tabular form and supported less active engagement.

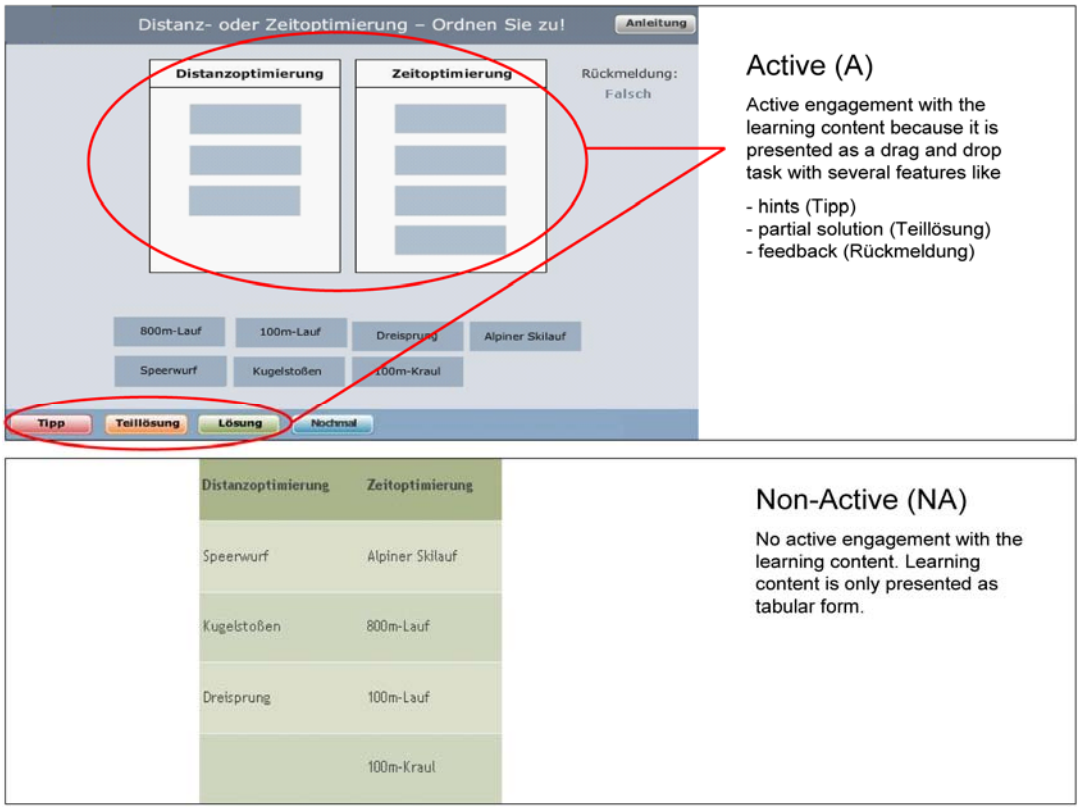

Figure 2. Active unit (A) for Göhner (1979) with active engagement and non-active unit (NA) without active engagement

The following table (Table 1) provides an overview and explains the experimental treatment and the differences of the treatment groups in more detail. The MAC-MS units (I/NI) only differ in the existence of interactive tools (i.e., hints and feedback) but they have an identical number of tasks and questions. The MAC-G and MAC-K units (A/NA) differ in the way they support active engagement. Active units (A) assist active engagement with the learning content because of tasks and questions, whereas non active units (NA) do not contain any tasks and questions.

Table 1: Differences of experimental conditions in the three e-learning units

Learning unit	Differences of experimental conditions	Number of Questions	Number of Tasks
MAC-MS (U1)	I (with interactive tools)	6 (hints etc.)	12 (hints etc.)
	NI (without interactive tools)	6	12
MAC-G (U2)	A (with active engagement)	3	21
	NA (without active engagement)	None	None
MAC- K (U3)	A (with active engagement)	1	10
	NA (without active engagement)	None	None

Figure 3 illustrates the treatment for the experimental groups. The groups learned with e-learning units which differ only in the degrees of interactivity. In the first online phase group 1 learned interactively about the MAC-MS (U1 I), in the second online-phase they learned non-actively about the MAC-G (U2 NA), and in the third online phase they learned actively about the MAC-K (U3 A). Conversely, group 2 first learned non-interactively in the first online phase about the MAC-MS (UI NI), actively in the second online phase about the MAC-G (U2 A) and in the last online phase non-actively about the MAC-K (U3 NA). Each online working phase was followed by an immediate knowledge test performed online. One week after the last session of the course a posttest addressing all three MACs followed. Whereas the results of the knowledge pretest and the three specific knowledge tests did not count for the course grade the results of the final knowledge test contributed 50% to the final course grade.

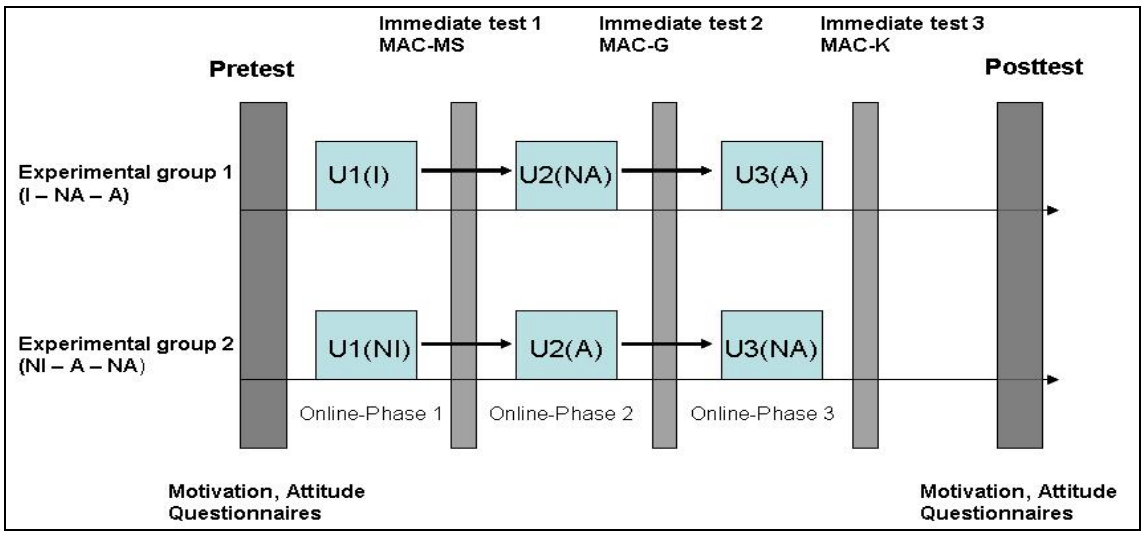

Figure 3. Experimental Design (U – Unit, I – Interactive, NI – Non-Interactive, A – Active, NA – Non-Active; MAC-MS, MAC-G, MAC-K – movement analysis concepts of Meinel & Schnabel (1998), Göhner (1979) and Kassat (1995), respectively).

Tests

Knowledge tests (Pretest and Posttest)

Pretests and posttests covered each of three MACs and were structured identically; the first part assessed basic knowledge and the second part tested knowledge transfer. Altogether both tests consisted of 30 basic knowledge questions (10 for each MAC) and 12 knowledge transfer questions for all MACs. In order to avoid recognition effects questions were different in pretest and posttest. The basic knowledge questions were selected from a pool consisting of 145 questions. Students were asked if short statements dealing with the different MACs were correct or wrong and how confident they were with their answers (five-point scale: 'highly sure, that the statement is right', 'rather sure that the statement is right', 'I don´t know', 'rather sure that the statement is wrong', 'highly sure that the statement is wrong'). The design of the knowledge transfer tests was adapted to the procedure of the different MACs and the developed checklists. Students were asked to apply the three MACs to sport movements (i.e., butterfly stroke, high jump and kip on the high bar).

Immediate tests

Each of the three immediate knowledge tests addressed basic knowledge about one of the studied MACs. These questions (short statements) were also taken from the above-mentioned question pool and the options to answer the questions were the same as in the pretest and posttest. The immediate knowledge tests were performed using the ILIAS survey tool and have been carried out after each online working phase.

Questionnaires

Altogether two different types of questionnaires were applied in the study. The first questionnaire measured students' motivation and attitude towards e-learning, e-learning experience, computer literacy and use of computers. In order to notice changes in attitude students answered this questionnaire at pretest and posttest.

The second questionnaire measured use, experience, and attitude (utilization, design and structure of tasks and questions, learning, comprehensibility, experience of activation and interactivity) towards the e-learning units with a four-point scale ('strongly agree' to 'strongly disagree'). Open-ended questions at the end gave students the opportunity to mention positive and negative aspects of the e-learning units.

Procedure

Pretest

In the second lesson of the course students performed the pretest to measure students' existing basic knowledge and knowledge transfer concerning the three MACs (MAC-MS, MAC-G, MAC-K). The test was performed as a paper-and-pencil test in the classroom at usual course time and took 45 minutes. Students were informed that pretest results did not count for the course grade. Furthermore they were instructed to answer the test to the best of their knowledge. Based on pretest performance students were assigned to the experimental groups. Furthermore students answered the questionnaire which measured students' motivation and attitude towards e-learning, e-learning experience, computer literacy and use of computers which took about 15 minutes.

Online phases - learning the MACs

After a further lesson held by the teacher three online learning phases followed. The same procedure was applied at all online phases. First the groups learned with the e-learning units concerning the different concepts (first phase: MAC-MS, second phase: MAC-G, third phase: MAC-K) which only differed in the degrees of interactivity at the learning management system ILIAS. The phase of online self-study ended with an online session where all students met at the learning management system to perform the immediate online knowledge tests dealing with the different MACs (first phase: MAC-MS, second phase: MAC-G, third phase: MAC-K). Additionally the groups answered questionnaires about the learning units. Altogether students had 20 minutes time to complete the test and the questionnaire. Students were instructed to answer the test to the best of their knowledge and without any help (e.g., consult a book, look up the e-learning units) in order to measure the learning achievement. Furthermore students were informed that the results did not count for their final grade. Immediately after passing the test and questionnaire an online chat lesson followed. In the chat lesson students applied the concepts to selected sport movements with the assistance of the lecturer.

Phases of physical presence – applying the concepts

At the end of each online phase, two phases of physical presence followed. In the first lesson students applied the concepts in small groups to selected sport movements using checklists and in the following lesson their results were discussed in a plenary session.

Posttest

One week after finishing the last MAC the posttest was performed as a paper-and-pencil test in the classroom at the usual course time. Similar to pretest procedure students had 45 minutes to answer the questions for each concept. This time the results counted for the final grade. Again students answered the questionnaire which measured motivation and attitude towards e-learning, e-learning experience, computer literacy, and use of computers.

Results

Statistical data analysis was performed using SPSS Statistics version 17.0.0. The applied statistical tests are specified in the respective sections.

Knowledge tests

The total scores of the pretest and posttest were analyzed using a 2 (groups) × 2 (tests) ANOVA with repeated measures on the factor tests. ANOVA yielded a significant main effect of knowledge test (F (1,10) = 124.14, $p < .001$) indicating a gain from pretest to posttest (see Figure 4). The analysis yielded no significant main effect of experimental groups (F (1,10) = .001, $p = .975$) and no groups × tests interaction (F (1,10) = .002, $p = .965$).

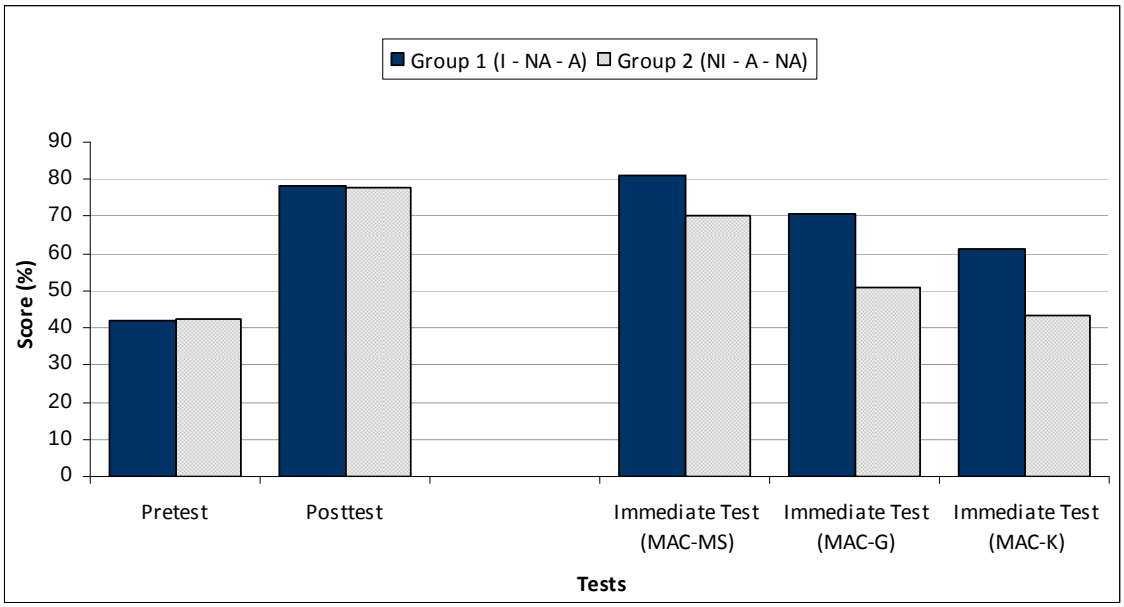

Figure 4. Means of total knowledge score (%) of the two experimental groups in different tests

Furthermore participants' *basic knowledge* at pretest, immediate test and posttest was analyzed (Table 2). The 3 (MACs) × 2 (groups) × 3 (tests) ANOVA with repeated measures on the factor tests yielded a significant main effect of MACs (F (1, 13) = 65.70, p <. 001). There was also a significant main effect of tests (F (2, 18) = 6.26, p < .01). The MACs × tests interaction was also significant (F (3,25) = 3.51, p < .05).

Table 2. Results of 3 (MACs) × 2 (groups) × 3 (tests) ANOVA for differences in basic knowledge

Effects	***df***	***F***	***p***
Main Effects			
MACs	1,13 $^{\varepsilon_1}$	65.70	< .001
Tests	2,18	6.26	< .01
Groups	1,9	.56	.48
Two-way interaction			
MACs × Groups	2,18	1.72	.21
Tests × Groups	2,18	.86	.44
MACs × Tests	3,25 $^{\varepsilon_2}$	3.51	< .05
Three-way interaction			
MACs × Tests × Groups	4,36	.22	.92

$^{\varepsilon_1}$, $^{\varepsilon_2}$ Adjusted with Greenhouse-Geisser: $\varepsilon 1$ = .696, $\varepsilon 2$ =.686

Figure 5 shows the relative basic knowledge scores of the two experimental groups in the different tests. Wilcoxon tests revealed that participants continuously increased performance at each test for each MAC. Comparing the MACs Wilcoxon tests showed, that the concept of MAC-MS was significantly easier than the concepts of MC-G and MC-K at the immediate

tests. Furthermore there was a significant difference between the concepts of MC-MS and MC-K at posttest indicating greater difficulty of MAC-K.

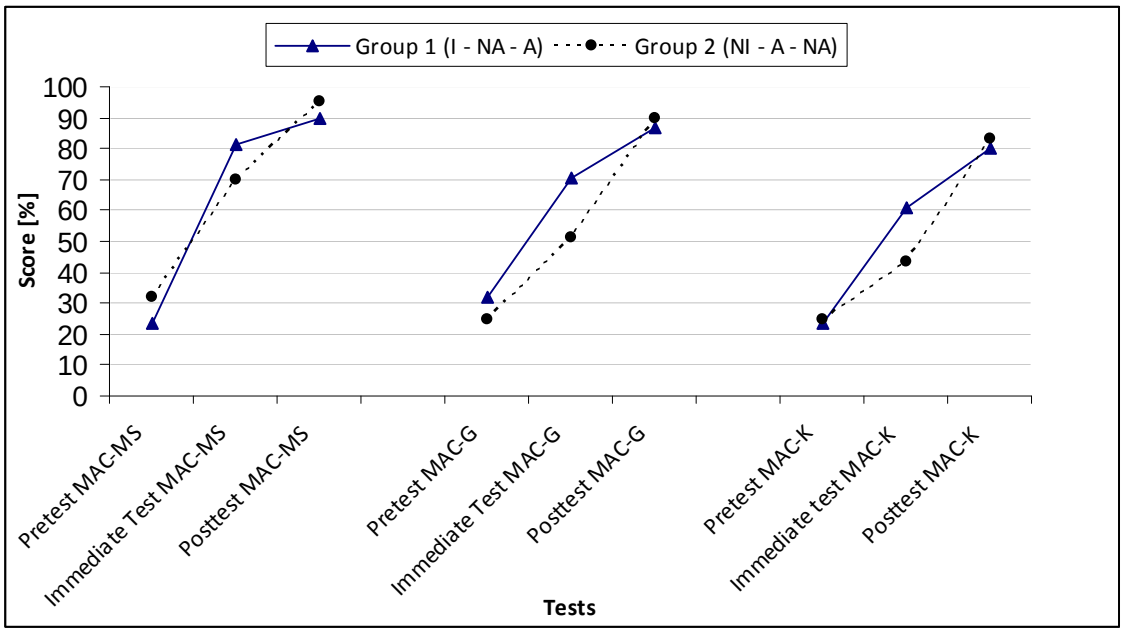

Figure 5. Basic knowledge scores (%) of the two experimental groups at different tests

The participants' *knowledge transfer* of each MAC at pretest and posttest was analyzed using a 3 (MACs) × 2 (groups) × 2 (tests) ANOVA with repeated measures on the factor tests (Table 3). We found a significant main effect of MACs (F (2, 20) = 17.09, $p < .001$). Furthermore ANOVA yielded a significant main effect of tests (F (1, 10) = 8.67, $p < .001$) indicating knowledge gain from pretest to posttest. Wilcoxon tests revealed significant differences between all MACs at posttest. At pretest there was only a significant difference between MAC-MS and MAC-K. Furthermore Wilcoxon tests showed that from pretest to posttest students significantly improved their knowledge transfer of MAC-MS and MAC-K but not for MAC-G.

Table 3. Results of 3 (MACs) × 2 (groups) × 2 (tests) ANOVA for differences in knowledge transfer

Effects	***df***	***F***	***p***
Main Effects			
MACs	2,20	17.09	< .001
Tests	1,10	8.67	< .05
Groups	1,10	.38	.55
Two-way interaction			
MACs × Groups	2,20	.48	.63
Tests × Groups	1,10	.20	.66
MACs × Tests	2,20	.34	.72
Three-way interaction			

MACs × Tests × Groups	2,20	.13	.88

Figure 6 shows the relative knowledge transfer scores for each MAC at pretest and posttest. Hypothesis 1 was not supported. Students learning with the interactive or active e-learning units did not achieve better learning outcomes.

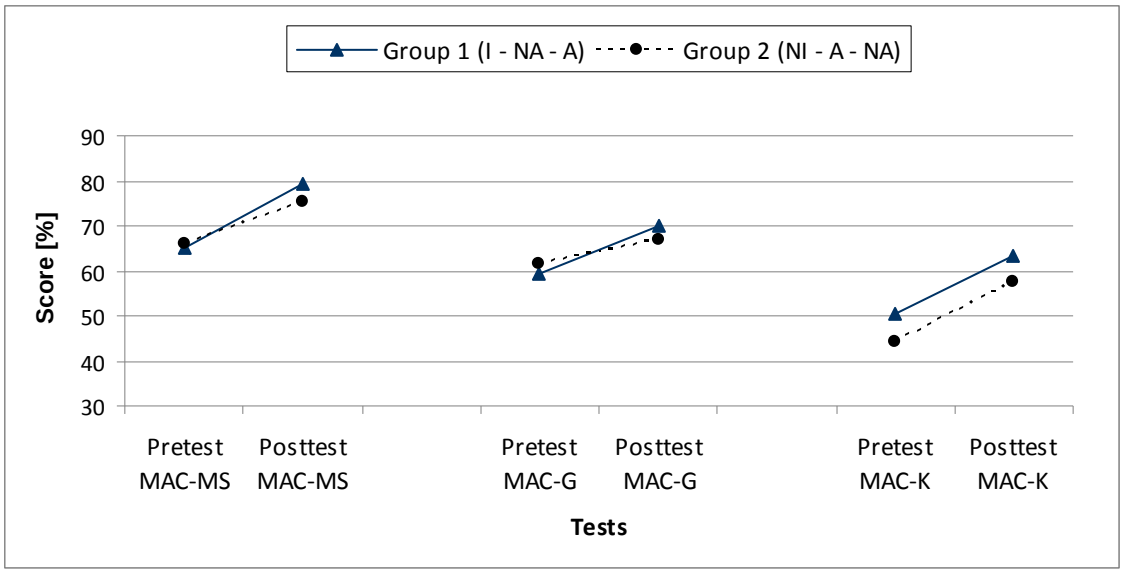

Figure 6. Knowledge transfer scores (%) of the two experimental groups at pretest and posttest

Confidence in answering questions

The originally used five-point scale was transformed to a three-point scale. This transformed confidence score reflects how sure students were with their answers ('I don´t know', 'rather sure' and 'highly sure'). If they selected 'highly sure' in all questions they gained 30 points at pretest and posttest for each MAC and 20 points at each immediate test. The confidence in answering questions at pretest and posttest was analyzed using a 2 (groups) × 2 (tests) ANOVA with repeated measures on the factor tests. There was a significant main effect of tests at MAC-MS (F (1,10) = 162.89, p < .001), MAC-G (F (1,10) = 232.68, p < .001) and MAC-K (F (1,10) = 129.48, p < .001) indicating an increase of confidence in answering the questions (Figure 7) from pretest to posttest. No significant group effects were found for MAC-MS (F (1,10) = .88, p = .37), MAC-G (F (1,10) = .24, p = .63) and MAC-K (F (1,10) = .26, p = .62). The groups × test interactions were also not significant for MAC-MS (F (1,10) = .69, p = .43), MAC-G (F (1,10) = 1.09, p = .32) and MAC-K (F (1,10) = .60, p = .46).

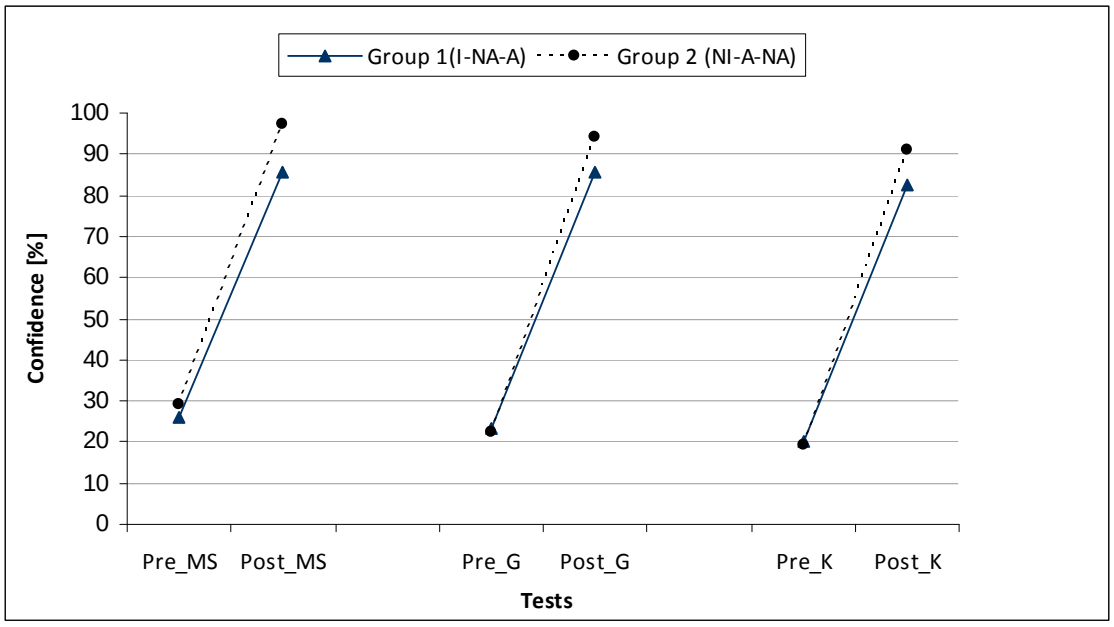

Figure 7. Relative mean confidence scores at pretest (Pre_) and posttest (Post_) for all concepts (MS – Meinel & Schnabel, G – Göhner, K – Kassat)

Confidence scores of immediate tests were analyzed using a 2 (groups) × 3 (MACs) ANOVA with repeated measures on MACs. ANOVA yielded no main effect of groups (F (1,9) = 1.05, p = .33). The main effect of MACs was significant (F (2,18) = 8.31, p < .01). The interaction groups × MACs was not significant (F (2,18) = .29, p = .75). Wilcoxon tests revealed that the MAC-MS was significantly easier than the MAC-G and MAC-K.

Again, hypothesis 1 was not supported.

Questionnaire (Activation and Interactivity)

The experience of activation and interactivity was measured with a four-point scale (4 – 'strongly agree', 1 – 'strongly disagree'). Activation and interactivity of the MAC-MS, MAC-G and MAC-K questionnaire were analyzed using a 3 (MACs) × 2 (groups) × 9 (items) ANOVA with repeated measures on the factor items (Table 4). The analysis yielded a significant main effect of groups (F (1,9) = 9.69, p < .05). There was also a significant interaction of MACs × groups × items (F (16,144) = 2.26, p < .01). Because we were interested in group differences, U-test follow up analyses were calculated.

Table 4. Results of 3 (MACs) × 2 (groups) × 9 (items) ANOVA for differences in perception of activation and interactivity

Effects	***df***	***F***	***p***
Main Effects			
MACs	2,18	2.19	.14
Groups	1,9	9.69	<.05
Items	3,24 [ε]	1.55	.23
Two-way interaction			
MACs × Groups	2,18	2.10	.15
MACs × Items	16,144	1.30	.21
Groups × Items	8,72	1.22	.30
Three-way interaction			
MACs × Items × Groups	16,144	2.26	<.01

[ε] Adjusted with Greenhouse-Geisser ε = .336

U-tests for MAC-MS (Figure 8) confirmed significant group differences concerning the variables ‘respond to actions’, ‘deep learning’ and ‘self determined learning’.

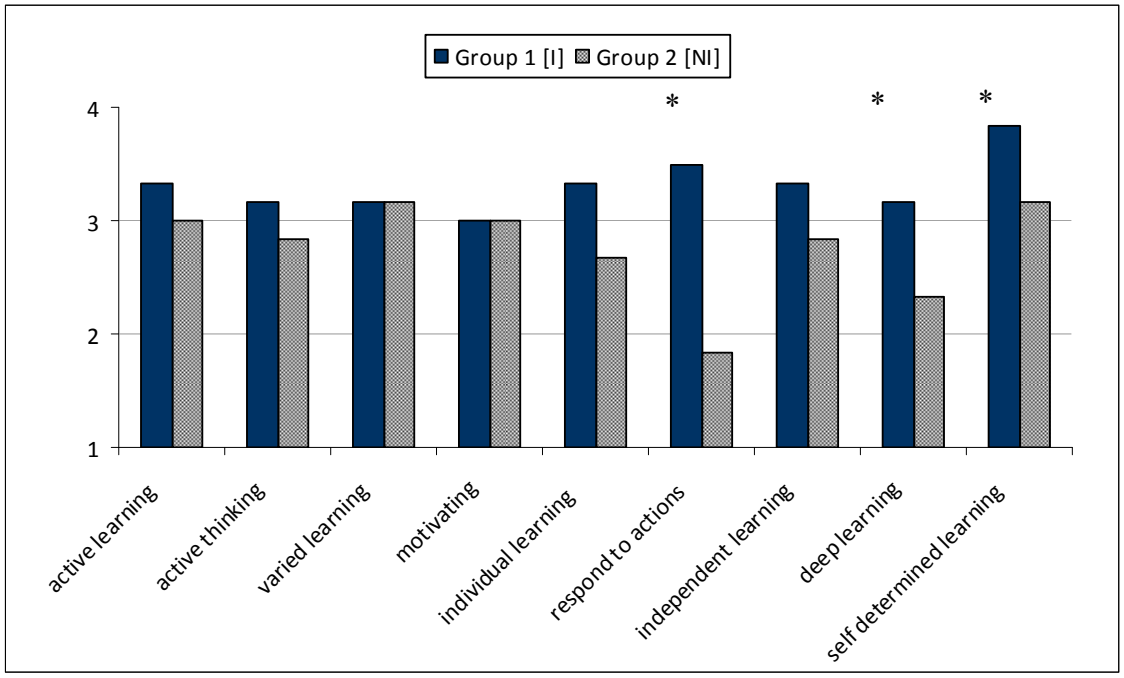

Figure 8. Experienced activation and interactivity of the e-learning unit dealing with the MAC of Meinel & Schnabel (1998) (4 – ‘strongly agree’ , 1 – ‘strongly disagree’)

U-tests for MAC-G confirmed significant group differences concerning the variables ‘individual learning’ and ‘self determined learning’. U-test for MAC-K did not show any significant group differences. Hypothesis 2 was supported only for selected variables. Students learning with the interactive or active e-learning units experienced higher activation

and interactivity concerning response to actions, deep learning, self-determined learning and individual learning.

Results of open-ended questions

Open-ended questions at the end of the questionnaires showed that participants clearly recognized the differences between the different degrees of interactivity of the e-learning units. Students who learned with the interactive e-learning unit for example mentioned that 'the tasks and questions demonstrated what I have learned' and that they liked the combination of text, video and pictures. Students who learned with the non-interactive e-learning unit complained about 'the lack of direct feedback' or the 'lack of solutions'. Students who learned actively appreciated the interactivity of the units, 'the tasks, which demonstrated what I have learned' and 'the questions which introduced a new topic'. Conversely when learning with the non-active e-learning units they complained about the lack of tasks and questions and that they had 'no opportunity to test what I have learned with the e-learning unit'.

Discussion and Conclusions

The reported pilot study served to test an experimental design for examining different degrees of interactivity and to measure knowledge achievement, motivation, and attitude towards e-learning.

The results reveal various learning effects. A total effect refers to the whole course and a specific effect to the e-learning units. Both experimental groups could improve their knowledge of the three different MACs during the course. Compared to pretest results the results of the immediate tests showed that both experimental groups improved their basic knowledge of each concept after learning with the e-learning units. Altogether students could improve their knowledge continuously until the posttest (no ceiling effect).

Comparing the immediate knowledge test scores of all MACs, these scores showed, that both groups scored best at MAC-MS, second best at MAC-G and worst at MAC-K. This is probably caused by the degree of difficulty of the three concepts, because difficulty and complexity of the concepts are increasing from MAC-MS to MAC-K. Furthermore it is noticeable that group 2 received lower scores than group1 in all immediate tests and that they only performed comparably well in the posttest. A reason for this can not easily be identified. Presumably the students of group 2 were not motivated at the immediate tests.

The students also improved their knowledge transfer concerning MAC-MS and MAC-K from pretest to posttest but there was no effect for MAC-G. A reason for this could be, that the criteria for analysis proposed by Göhner (1979) are comparably abstract. This is consistent with the criticism by Kassat (1995) who states that Göhner (1979) does not deliver clear criteria for analysis.

Contrary to our expectations we did not find any significant differences between the groups who learned with different degrees of interactivity. This could be due to the fact that we only tested small groups (6 participants per group). Furthermore we may not find an interactivity effect because there is a confounding problem. This study tested different degrees of interactivity within a real blended-learning scenario and students are possibly influenced by different factors like chat session, group discussions and team-work after they had learned

with the e-learning units. Moreover we could not eliminate or control the impact of potential external factors like using additional support during the online tests. A further reason could be, that despite differences between the interactive and non-interactive version and the active and non-active version of the e-learning units both groups experienced a comparatively enriched learning environment. This may be confirmed by the fact that both groups doubled their knowledge. Maybe more pronounced interactive features within the active and interactive versions of the e-learning units are necessary to show an interactivity effect.

The confidence in answering questions at pretest and posttest shows a similar and even more distinct development as the knowledge test results at pretest and posttest. There is a great increase in confidence from pretest to posttest but no significant differences between the groups. There were also no group differences at the immediate tests for confidence in answering questions. The development of the confidence scores at the immediate tests is also comparable with the immediate knowledge test results. MAC-MS was the easiest concept showing the best knowledge test results and the highest confidence scores, followed by MAC-G and MAC-K.

The variables which measured students' experienced activation and interactivity showed no clear results. The three-way interaction MACs × groups × items indicates that only few variables show differences between groups. The item 'self-determined learning' seems to be particularly sensible, whereas the items 'response to actions', 'individualized learning' and 'deep learning' differentiate only between selected MAC-related e-learning units. An unexpected result occurred with MAC-G. Here group 1 rated the e-learning units as more activating and interactive than group 2, although group 2 received the more activating e-learning unit. Obviously the perception of activation and interactivity of group 1 is generally higher regardless of the real degree of interactivity of the respective e-learning unit. This may be due to a different concept of activation and interactivity.

As a consequence of the inconsistent results the following improvements will be implemented in follow-up research and especially in the next term: First this experiment will be repeated with a larger number of participants to improve validity. A power analysis will be done to determine the sample size needed. To control the impact of potential external factors during the online tests, like using additional support, a time limit will be introduced. The time limit forces students to answer the tests immediately without leaving time to look up solutions or communicate to other persons. Furthermore all test results (except pretest results) will contribute to the final grade. In future research transfer of knowledge should be tested in a broader way using a greater variety of sport movements. Moreover long term retention tests are planned to test whether different degrees of interactivity generate delayed learning effects.

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