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Research article

Effectiveness of multimedia-supported education in practical sports courses

Roland Leser ✉, Arnold Baca and Johannes Uhlig
University of Vienna, Centre for Sport Science, Vienna, Austria

Abstract
Multimedia-assisted teaching and learning have become standard forms of education. In sports, multimedia material has been used to teach practical aspects of courses, such as motor skills. The main goal of this study is to examine if multimedia technology impacts learning in the field of sport motor skill acquisition. This question was investigated during a practical sports education course involving 35 students who participated in a university soccer class. The whole course was split into two groups: Group A was taught traditionally with no assistance of multimedia and Group B was prepared with multimedia-assisted instructional units. To quantify selected skills of soccer technique and tactic, the test subjects performed a specific passing test and a tactical assessment. Furthermore, a questionnaire was used to assess the subjective impressions of the test subjects. All testing instruments were applied before and after a six-week-long teaching period. A comparison of the gathered data between the two groups resulted in no significant differences, neither concerning the results of the technique test nor concerning the tactic test. However, the results of the questionnaire showed a positive agreement among the participants in the usability and assistance of multimedia for the sports practical course. Considering the reviewed conditions, it can be concluded that the use of multimedia content doesn't affect the learning effects.

Key words: Multimedia, soccer, e-learning.

Introduction

Due to advances in computers and electronic media, the potential for quality education has been elevated with the appearance of innovative instructional methods employing multimedia equipment and resources. E-learning materials have been developed for a variety of disciplines. In the area of sport and physical education, which focuses on human motion, media for picturing this motion, such as video and animations, are particularly useful. They allow presenting how to perform certain motions and to illustrate sports techniques. Variations in speed (e.g. slow motion), viewpoint or degree of abstraction (e.g. stick figure animation) provide various modes of presentation.

Throughout the last years increasing efforts in developing and using multimedia based courses and materials to be used for teaching sport in theory and practice can be observed (Sorrentino, 2001; Wiksten et al., 2002; Katz, 2003; Igel and Daugs, 2005). Multimedia e-learning systems have been developed for sports or disciplines of sport science such as sports biomechanics (Tavi et al., 1992; Baltzopoulos and Papadopoulos, 2001; Schleihauf, 2001; Kibele, 2005). In addition, interdisciplinary solutions have been strived for. Baca et al. (2005) have designed and implemented a comprehensive modular system falling into this category. Their starting points are sports. Questions related to these sports are answered from the perspective of sport scientific disciplines in a highly interdisciplinary way. Modules are organized in the form of a matrix of sports and sport scientific disciplines.

Multimedia materials and learning environments have also been developed for technical and tactical education. The system mentioned above (Baca et al., 2005), for example, includes manifold animations and video sequences to assist instructors and students to comprehend sports motions and technical/tactical actions as applied in game sports. One specific emphasis lies in the methodical organization of the learning process of sports techniques. Leser et al. (2009a; 2009b) present an application for learning tactics in soccer. They presume that dynamical visualisations are advantageous when communicating tactical behaviour. This assumption is supported by the meta analysis performed by Hoffler and Leutner (2007), which confirms the effectiveness of such instruction materials for comprehending dynamic phenomenological and real situations.

There are some studies, which examine, how multimedia technology impacts learning in the area of sport and sport science in the cognitive domain (Wiemeyer, 2008). Little is, however, known, how such intervention impacts student outcomes in the motor domain. Only some studies on motor skill learning were published so far. Vernadakis et al. (2002, 2004) did not find significant differences in learning the setting skill in volleyball or the shooting in basketball. In a more recent study Vernadakis et al. (2006) investigated the effect of multimedia computer assisted instruction, traditional instruction and combined instruction methods on learning the long jump event. The combined method tended to be the most effective for cognitive learning and skill development, whereas pure multimedia computer assisted instruction resulted in significantly lower skill test scores than the other groups.

To our knowledge, there are no studies investigating how multimedia materials affect learning of tactical behaviour.

It is therefore of interest to get more insight, if and how technical and tactical education in sport may benefit from multimedia assisted instruction. The effectiveness of such educational material was therefore investigated when utilised in a sports practice course. Special emphasis was put on investigating the impacts of animations in order to find out, if this form of dynamical visualisation is particularly beneficial in tactical education.

The rest of the paper describes the application scenario, presents results, draws conclusions and gives a short outlook.

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Table 1. Biographical variables of the two groups and sports background

	Group A	Group B	Total
Men	15	13	28
Women	3	4	7
Mean age (SD)	23.54 (2.73)	23.36 (2.61)	23.44 (2.67
Mean number of semester	5.54	4.43	4.96
Number of soccer players	3	3	6
Number of other sports game players	4	2	6
Number of participants with other sports activities	11	12	23

Methods

Design and procedure

The study compared two different teaching methods in a soccer practical sports course at the Centre for Sport Science, University of Vienna (CSU) during the 2009 summer term. Due to the high number of participants who registered for the course, the class was split into two groups. The students were allocated to one of the two groups by the CSU teaching institution's registration system and were, therefore, more or less chosen at random (If the number of student registrations for a CSU course is higher than 30, the course is split into several subgroups/sections. The allocation to the parallel sections is done automatically.). Throughout the semester both groups attended the course 90 minutes per week. The same teacher instructed both groups, and the aims and content of the courses were the same. The content relevant to the study was concentrated within a block of six consecutive units during the first third of the semester. In one case, traditional instruction was provided (Group A), characterised by the fact that at the beginning of the units, short theory blocks (i.e., soccer technique, tactics etc.) were given, before the subsequent practical forms of exercise and teaching. In the other case, the students attended the practical units already armed with theoretical preparation (Group B). The test subjects went to a computer-equipped lecture hall twice a week, where they received brief instructions on the operation of an information platform (as described later) and they worked through the information via independent study. Each unit was designed to take between 15 and 25 minutes. There was always an investigator on site to deal with any questions that arose during the learning process and the frequency and duration of the participants' self studies were noted. The multimedia-teaching units were taught before and at the beginning of the teaching activities. Due to organisational constraints it was not possible to carry out the multimedia units at fixed intervals before the corresponding practical education. Nevertheless, much importance was attached to the factor that the time between learning and practising was adequate and an information transfer was possible. This second teaching method corresponded with the blended learning approach, being used at CSU with the platform "Sport multimedial" (Baca et al., 2009; Leser et al., 2009a; 2009b). Both units were, in fact, pursuing the same goals of the improvement of soccer-specifical play: technical, tactical, physical and mental skills and knowledge.

The study followed a classic pre-test/post-test design. The instructional content of technical and tactical aspects of soccer performance was examined by means of two tests: one test before the six-week instruction block, and one after the six-week instruction block. In addition, subjective assessments of the instruction and of the participants' own performance were gathered from the test subjects by means of a questionnaire. The following working hypotheses were formulated:

1. Group B improves more in the area of the technical soccer performance aspects tested than Group A.
2. Group B improves more in the area of the tactical soccer performance aspects tested than Group A.
3. Both groups assess their ability after the specific instruction block as higher than before the instruction. Group B also attributes its higher ability to the multimedia-supported instruction.

Participants

In total, 35 students (7 women and 28 men) from the Sport Science undergraduate course of CSU took part in the study. All the test subjects were active in sports: six were active soccer players for amateur clubs, another six came from other sports game disciplines and the rest were involved in other types of activities (Table 1).

Multimedia-lectures

The multimedia-teaching units were based on the soccer module of "Sport multimedial", an online platform used to convey theoretical and practical aspects of sports to students (Baca, 2005). The same fundamental scheme was used for each element including core areas of soccer technique and tactics. The participants were first given the content in the form of short texts that were supported by static images. In some cases, this first step in conveying the content was further supported by animations. For example, these animations showed the ideal form of technique or tactic in an abstract yet dynamic manner (cf. Leser et al., 2009a; 2009b). This was followed by video presentations of the ideal execution of the technique or tactic, and lastly, by variations of these. These demonstrations of technical and tactical motions provided insight as to the importance of different viewpoints and levels of detail (cf. Figure 1). Herewith, the learners should obtain comprehensive information of the multimedia element, which in turn induces more authenticity for the learners.

To demonstrate one concrete example of the e-learning course, the content and elements used to convey defensive tactics are detailed below.

The self-study course was structured sequentially. It began with written cues containing the most important rules for the defensive behaviour in one-versus-one situations:

1. Always concentrate on the ball!
2. The primary objective is to avoid the break-

Figure 1. Four screenshots of a slow-motion video presenting a soccer-specific shooting technique from two different viewpoints and with varying levels of detail.

through of the opponent by proper positioning – the direct way to the own goal should always be covered.

3. Run towards the player in possession of the ball and adjust your motion to his/her speed!

4. Take position to that side where your opponent obviously tries to pass you and adapt this position continuously to the movements of your opponent ("defender dance")!

5. Feint your opponent by minimising and enlarging the distance to him/her!

6. Attack your opponent when the ball is "free" (as in, the moment when the ball is not absolutely under control)!

These basic tactical rules were then illustrated by static graphics (Figure 2).

In addition to the static illustrations, animations were provided which focused on the crucial factor of "timing" (e.g., appropriate moment of attack). These animations were not only restricted to isolated one-versus-one situations but also showed adequate individual behaviour in the defence in more complex situations. Figure 3 gives an example of ideal-typical behaviour of two defenders versus two attackers. The learning element also included the tactical advice for the defenders. Implementing the one-versus-one situation in a more complex setting should assure that the learners also become aware of the relevance of this tactical element in real game play respectively in training.

Six multimedia units were prepared: three on the subject of soccer technique and three on soccer tactics. The units built on each other within the technical and tactical content. Table 2 reflects the structure and content of the multimedia course by the single units.

Instruments

For the purposes of the study, three analysis instruments were used: a performance diagnosis test to check soccer technique (LSPTm), an expert rating to classify soccer tactics and the use of a questionnaire to assess the subjective impressions of the test subjects.

LSPTm

There are numerous testing procedures within the area of soccer technique. However, only a few of these meet scientific quality criteria. The Loughborough Soccer Passing Test (LSPT, Figure 4) is a valid and reliable test that evaluates some component parts of soccer techniques, such as pass precision, ball control and dribbling (Ali et al., 2007). The test person starts with the ball in the central zone and has to perform 16 passes from the passing area. The direction of each pass is announced through an investigator immediately after the previous pass. The subject tries to hit the coloured marks mounted on the benches. After the ball rebounds he/she receives the ball and executes the next pass. The testing criterion is the amount of time it takes to perform the test plus a penalty time when errors occur (e.g., to miss the mark). The amount of the penalty time depends on the kind of error (for the detailed test description, see Ali et al., 2007).

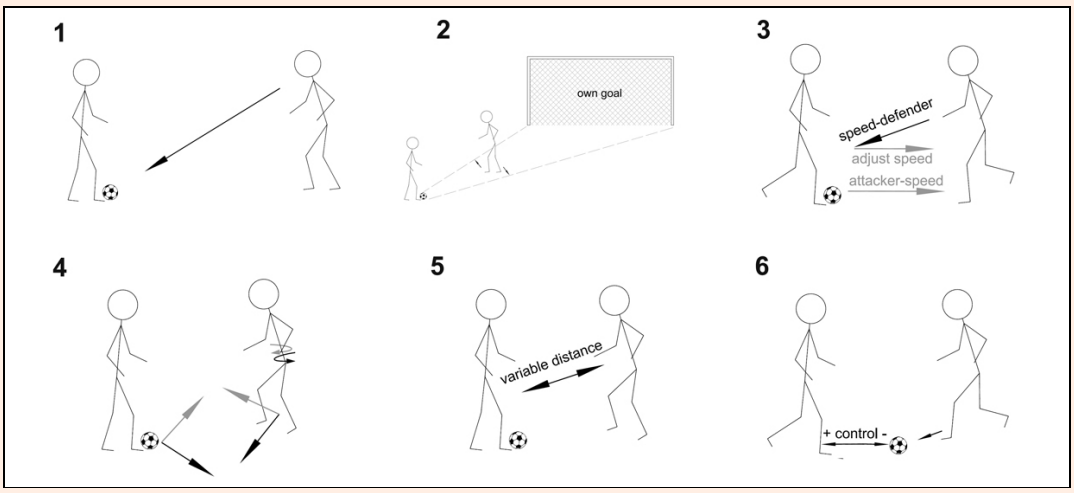

Figure 2. Illustration of the most important basic rules for the defensive behaviour in one-versus-one situations.

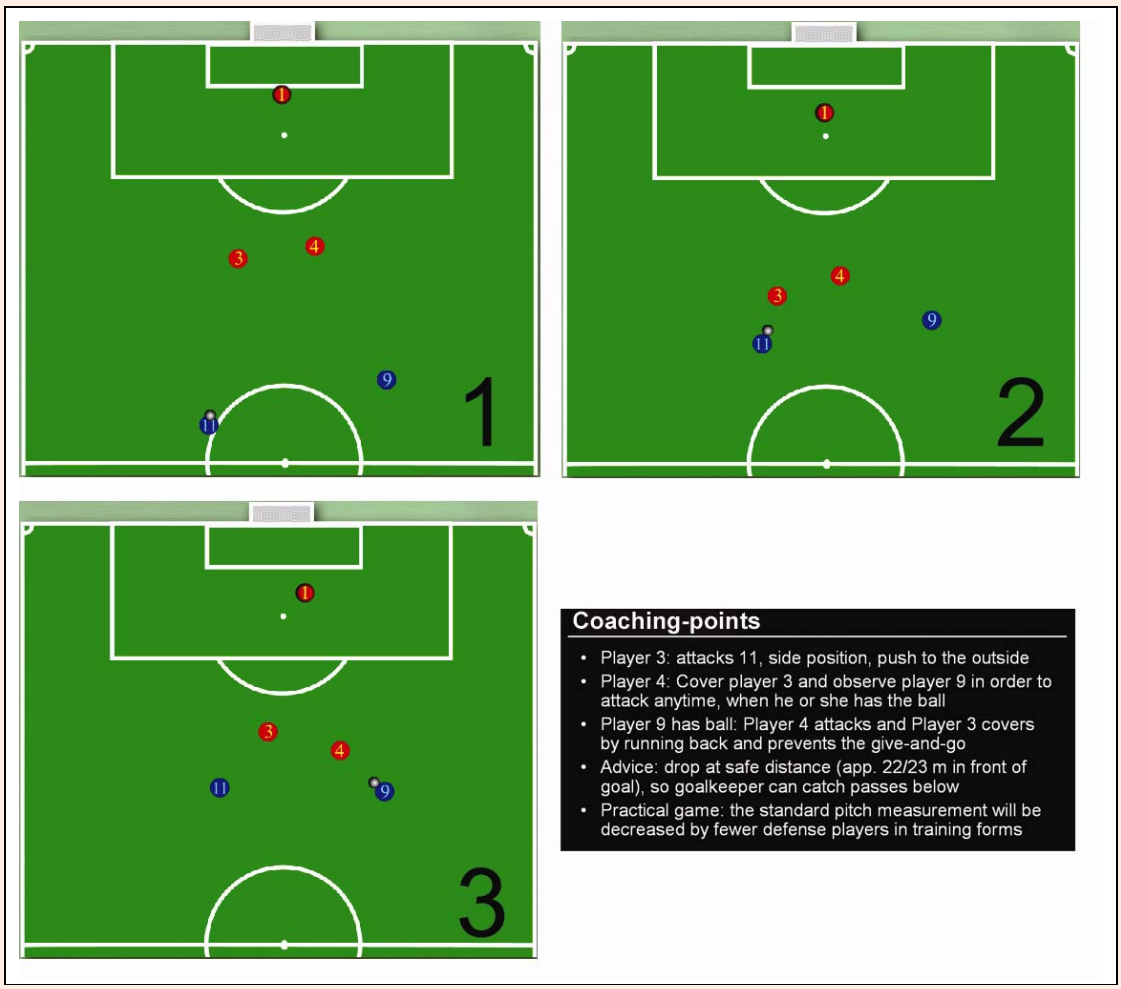

Figure 3. Three screenshots of an animation illustrating a two-versus-two situation with advice for the defenders ("Coaching-points").

Originally, the LSPT was constructed and applied for testing skilled soccer players. In case the LSPT was used for the investigation, the original test was too difficult for many participants and therefore the tests often couldn't be completed. The new objective was to find an alternative solution to the already proven LSPT. This alternative method should, on the one hand, challenge the target group adequately, and on the other hand, it should be of high validity just like the original test. For this purpose, the LSPT was simplified by a couple of modifications. In comparison to the original test, the inner rectangle (1 x 2.5 m), originally used for the return of the ball in control after each pass, was removed and the passing zone was increased to cover the entire exterior rectangle (2.5 x 4 m). The assignment of points (time calculation) as a testing criterion was adapted accordingly. The validity of the LSPTm was checked and assessed as sufficient.

Expert ranking

There are only a small number of valid and reliable test procedures for the direct assessment of tactical abilities and skills in sports. Some approaches try to assess these procedures through the reactions to computer simulations or video scenes (e.g., French and Thomas, 1987). However, the aim of the present study was to assess tactical abilities and skills directly in a practical application. For this reason, an expert rating was performed via a video study and an aspect of content selected from the soccer units. The selected content involved the individual tactical behaviour in a one-versus-one (duel) situation. The video sequences, upon which the assessment was based, were recorded during a standardised exercise. Here, the attacking test subject, who had the ball, ran towards the defender with the aims of passing him within a restricted area and then scoring a goal (Figure 5).

Table 2. Structure and content of the multimedia course.

	Tactics	Technique
Content	offensive and defensive behaviour in one-versus-one situations (duels)…..	Shooting, passing, ball control
Unit 1	written basic information, static illustrations, few ideal-typical video presentations, isolated viewpoint	
Unit 2	repetition/summary of unit 1, animations, videos containing variable realisations, reflection in more complex situations	
Unit 3	repetition/summary of unit 1 and 2, various videos representing different skill levels and also containing deficient realisations	

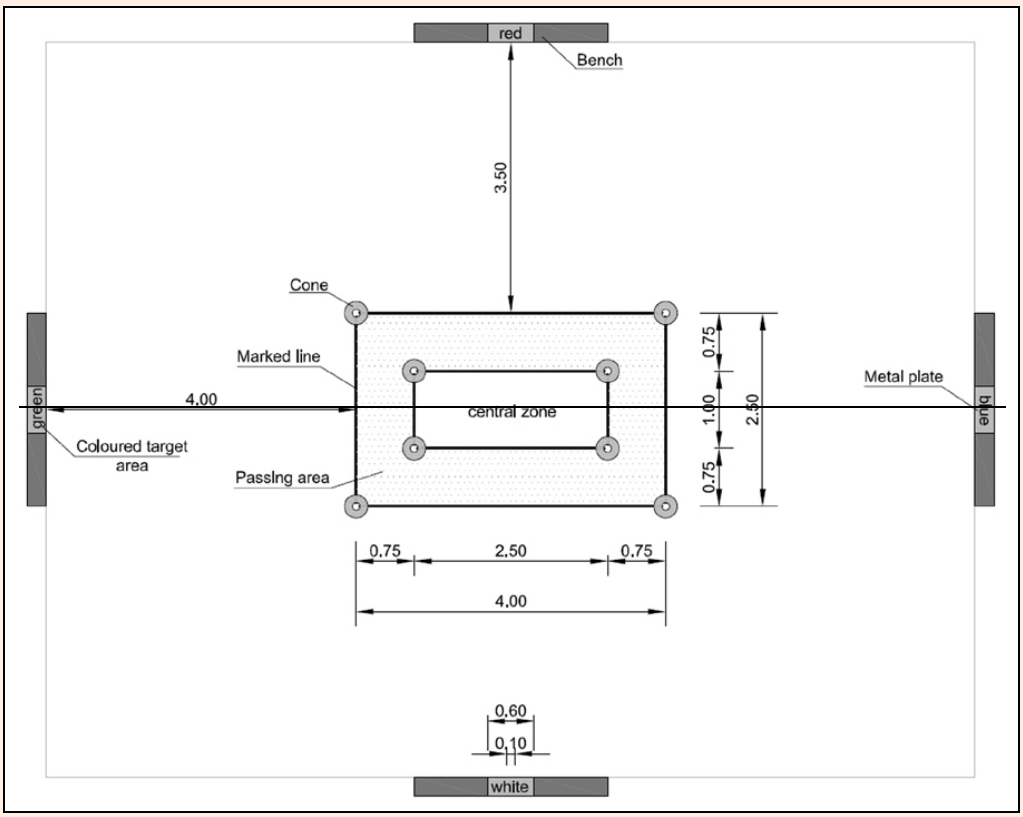

Figure 4. Schematic representation of the Loughborough Soccer Passing Test (Ali et al., 2007, 1463).

Four soccer coaches with the highest or second-highest level Austrian coaches' licences, who could also contribute sufficient experience with studying videos and with rating procedures, conducted the assessment of the tactical performance. Each individual performed exercise was stored as a digital video sequence for the expert rating. Then, four video packages were put together for each test subject. There was one package for each of the following before and after the teaching activity: attacking behaviour (player with the ball) and defensive behaviour

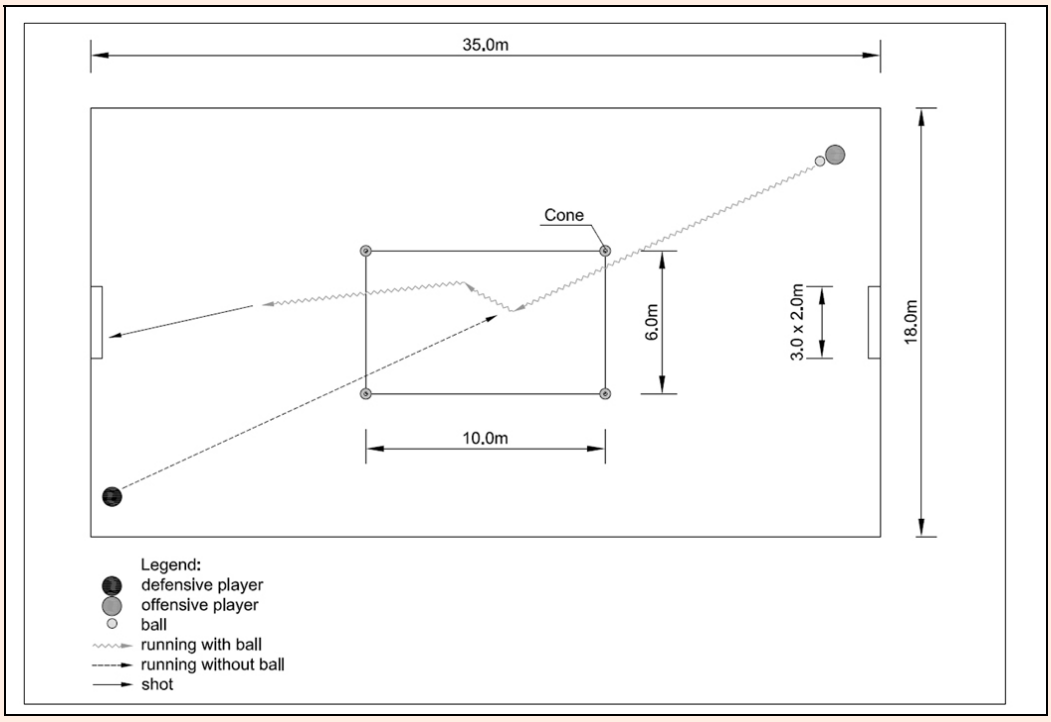

Figure 5. Progress of the exercise for the assessment of the individual tactical performance in a one-versus-one situation.

(player without a ball). Each package contained five to ten video scenes. These video sequences were played to the assessors as many times as they wished. The video functions of slow motion and freeze were available. After looking at a complete video package, the assessors evaluated the performance on a five-point scale (1 = very good, 2 = good, 3 = satisfactory, 4 = adequate, 5 = unsatisfactory). To assist the assessment, the assessors were provided with a criteria catalogue as a guideline for the grading. The experts did not know whether the particular video package contained recordings from before or after the teaching activity.

The validity of the test procedure was assured by the high level of the trainers' expertise while conducting the assessment. Their reliability was checked by presenting the same video package for assessment to two different and independent experts. The resulting correlation coefficient, Spearman's Rho of 0.506 ($p = 0.016$), demonstrated sufficient consensus.

Query

To evaluate the opinions and assessments of the testing as well as the effects of the teaching activity as anticipated by the participants, two questionnaires were developed. One questionnaire was presented to the treatment group, and one was given to the control group.

The first part of the questionnaire presented to the treatment group contained biographical questions about the person's age and sex, the number of terms and his/her main sports activity. If the main sports activity was soccer, there were further questions related to membership of a club, performance level, position played and frequency of training.

The second part of the treatment group's questionnaire contained questions on the testing itself. The test subjects could state on a five-point scale (i.e., applies, more or less applies, perhaps, does not really apply, does not apply), to what extent they found the testing difficult and to what extent they believed that they had improved between the first and the second measurement.

The final part of the questionnaire contained questions on the multimedia-teaching units. The participants assessed, on a five-point scale (see above), questions regarding to the following: to what extent the teaching units were helpful, to what extent their content was well prepared, to what extent the increase in complexity was appropriate in the sequence of the units and to what extent they expected having improved as a result of the teaching units.

The questionnaire presented to the control group was the same as described for the treatment group with the exception that the questions on the multimedia units were omitted. In the multimedia section of the questionnaire, the participants were asked whether they would have preferred the use of multimedia content to assist with practical performance improvement.

Data analysis

The data analysis was carried out by using SPSS® version 13.0 for Windows. Allocated by sex and active soccer players, the Chi-Square Test for Independence and the Fishers's Exact Test were used, respectively, to detect any possible differences between Group A and Group B in their biographical details. An independent Student's T-Test was then used to check for any difference in age and number-of-terms variables.

For comparison with the results of the LSPTm test, an independent T-Test was also employed to detect any difference between the initial values of the two groups. A comparison between the two group's pre-test and post-test results was performed using a dependent Student's T-Test.

Because all of the variables of the expert ranking and the questionnaire results – that were checked for significance – were ordinally scaled, they were analysed with parameter-free procedures. The Wilcoxon Test was used for the comparison of the pre-test results and the post-test results. For all other analyses, an independent U-Test was used.

Results

Comparison of the results of the LSPTm

Table 3 contains the results of the LSPTm between the pre-test and post-test for the control and treatment groups. The values correspond to the real performance criterion of the test; namely, the execution time plus all penalty times. Lower values indicate better performance.

Table 3. Results of the LSPTm (mean seconds, SD)

	Pre-Test	Post-Test	Shift	Significance
Group A	61.6 (14.2)	67.8 (19.7)	6.2	.156
Group B	68.5 (22.2)	71.5 (27.8)	3.0	.545

A comparison between the two groups of the initial values (pre-test Group A versus pre-test Group B), as well as a detection of a change in both groups between the pre-test and post-test, consistently failed to generate any significant results (Table 3).

Comparison of the results of the expert ranking

In the assessment of tactical skills, a distinction was made between attacking and defensive behaviour. Table 4 summarizes the results for both aspects. The differences between the pre-test of Group A and Group B were not significant ($p = 0.525$ (defensive); $p = 0.608$ (offensive)). Table 4 shows that the group without multimedia units between the pre-test and post-test deteriorated by half a rank for both the attacking and defensive behaviour. The group that received the multimedia activity exhibited a tendency toward slight improvement but none of these results were significant.

Results of the questionnaire

No difference was found between the two groups ($p = 0.797$) for the question regarding the subjective assessment of the testing difficulty (in particular the execution of the LSPTm). The testing was perceived as difficult but not too demanding. Furthermore, there was no significant difference in the results for the subjective assessment of whether the test result had improved between the pre-test and post-test ($p = 0.458$). Neither group believed that there had been any improvement or deterioration. How-

ever, there was a difference in the assessment of whether the quality of the soccer skills had improved between the tests ($p = 0.043$). Whereas Group A evaluated this as neutral, Group B thought to have improved.

Table 4. Medians for expert ranking by tactical abilities for offensive and defensive behaviour.

	Def.-Pre	Def.-Post	Off.-Pre	Off.-Post
Group A	3	3.5	3.5	4
Significance	.398		.793	
Group B	3.5	3	4	3
Significance	.903		.167	

The questions regarding the multimedia units' structure design and content were assessed as good and very good, respectively. The majority of the control group participants would have, in principle, also liked to have received support by means of multimedia materials.

Discussion

The study investigated the effects and effectiveness of multimedia-supported instruction, as compared with traditional instruction, in practical sports education. Specifically, two soccer courses held at a university training institution were compared with each other. Traditional instruction methods were used in one course and the other course was supported with multimedia units. To compare the two groups with regard to their progress in practical soccer skills, a soccer-related passing test and an expert rating were used. The applied passing test is accepted as a valid and reliable assessment instrument (Ali et al., 2007). The applied passing test pre-test values differed relatively high between the investigated treatment and control groups (Table 3). However, an independent T-Test resulted in no significant differences between the two groups; therefore, homogeneity of the investigated collective was assumed. A reason for the observed differences was presumably the high variance of the data, which may be a limitation of the study.

Another methodical problem was that the expert ranking used to rate the performance of individual tactical behaviour had only a medium correlation between the several evaluators (Spearman's Rho = 0.506). Despite that, this instrument was nonetheless used in the investigation because the correlation was statistically significant and there are no other methods known which give reason to expect more validity than a correctly conducted expert assessment. However, the results of the expert ranking should be considered with respect to this.

The overall outcome of this empirical investigation produced a uniform picture of results. No differences could be detected between the control and treatment groups for either of the areas of selected soccer technique or soccer tactics. In this setting, multimedia-supported instruction led to no improvement in performance in the specific soccer components tested. Interestingly, the results tended to decline when comparing the pre-test with the post-test. Though no significance was observed, the authors found no explanation for this decline but consider randomness as a main factor. If there would have been an additional factor that negatively influenced the results' change from the pre-test to the post-test, then it could be assumed that the decline in performance may be lower in the treatment group than in the control group. However, here also, the independent tests (T-Test for the passing test and Mann-Whitney U-Test for the expert ranking) showed no significant results.

The main outcome of this investigation corresponds with the conclusions of the Russel (1999) metastudy for media-supported instruction. Russel (1999) reported his findings as the "No Significant Difference Phenomenon." In a summary of 355 studies, he concluded that there was no difference in the instruction associated with the media used. On the other hand, some studies have been found that emphatically demonstrate the effectiveness of multimedia-supported instruction (e.g., Leser, 2005; Lewalter, 2003). Regarding to these findings Hoogeveen (1995) points out that positive-learning effects only occur "…if an adequate level of man-machine interactivity, a high level of congruence of used media, an adequate use of reference models, and a sufficient quality of information representation is implemented in multimedia assisted instruction."

Nevertheless, it must be said that the studies that confirmed the effectiveness of multimedia in sports generally appear to be in the minority. This is also confirmed by a recent review of the literature by Wiemeyer (2008), who points out that most of the investigations studying multimedia-supported learning in sport and sport science do not find significant differences between traditional and multimedia learning. Unfortunately, there exist no reviews for the specific task of sport motor skill learning, as investigated in this article. Only a few studies (Vernadakis et al., 2002; 2004; 2006) could be found concerning this topic. None of these studies show clear evidence that multimedia learning is more effective than traditional learning.

A crucial factor in whether media-supported instruction can be beneficial may reside in the complexity of the setting analysed. The study investigated a very specific situation involving a learning setting in practical sports skill acquisition. This focus, within a very homogenous constellation of learners' interactions with a special task and a given environment, seems to be necessary due to the numerous interacting factors that influence multimedia learning. Therefore, the results are only valid for the described setting, and generalisations would only be possible in very similar learning situations.

One very important aspect in considering the effectiveness of e-learning environments could not be investigated in this study: long-term learning effects. The authors found similarities between their approach and a blended learning paradigm called "Person-Centered e-Learning – PCeL" (Motschnig and Mallich, 2004). The participants of studies investigating this concept consider much higher long-term learning effects in PCeL conferred to conventional learning (Motschnig and Derntl, 2003; Motschnig and Mallich, 2004). This is an indication that there may be also positive long-term effects in using multimedia-supported blended learning approaches for practical sports education.

Future directions

Multimedia education not only assists students in learning

and improving sports motions or tactical behaviour or helps teachers and coaches to better guide exercises. The emphasis in future will probably shift to a development of intelligent systems that not only present multimedia information, but, moreover, account for individual performance data in generating this multimedia feedback. Pervasive computing technology will capture relevant motion data during exercising and give personalised feedback in almost real time. It may be expected that systems of that kind may be more effective when learning or improving sports motions or tactics than traditional systems.

Conclusion

The current study analyses the effectiveness of multimedia-supported teaching in motor skill learning. The survey has resulted in one main finding: no significant positive effects could be found for students using digital learning materials compared to students taught traditionally. Although this outcome goes hand in hand with other empirical research on multimedia learning it should not be generalized because the analysed learning situation was embedded in a very specific context. Long-term learning effects might, however, be expected as a consequence of positive motivational experiences made by many participants of the treatment group.

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Key points

- Multimedia-assisted learning showed no positive learning effects on technical skills in soccer.
- Multimedia-assisted learning showed no positive learning effects on tactical skills in soccer.
- Students participating in practical sports courses have very good attitudes towards the use of multimedia learning material. This may be considered for motivational effects.

AUTHORS BIOGRAPHY

Roland LESER
Employment
Research Assistant, University of Vienna, Centre for Sport Science, Auf der Schmelz 6A, 1150 Vienna, Austria
Degree
Mag. Dr.
Research interests
Game analysis, e-learning.
E-mail: roland.leser@univie.ac.at

Arnold BACA
Employment
Full Professor and Head of Centre, University of Vienna, Centre for Sport Science, Auf der Schmelz 6A, 1150 Vienna, Austria
Degree
Dipl.-Ing. Dr.
Research interests
Game analysis, e-learning, motion analysis, mobile coaching.
E-mail: arnold.baca@univie.ac.at

Johannes UHLIG
Employment
Teacher and Senior Lecturer, University of Vienna, Centre for Sport Science, Auf der Schmelz 6A, 1150 Vienna, Austria
Degree
Mag. Dr.
Research interests
Coaching.
E-mail: johannes.uhlig@univie.ac.at

✉ **Roland Leser**
Research Assistant, University of Vienna, Centre for Sport Science, Auf der Schmelz 6A, 1150 Vienna, Austria