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(Simulating Project Auditing and Controlling Excellence)

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Abstract

This report presents the evaluation of the computer-based simulation SPACE – Simulating Project Auditing & Controlling Excellence – which is an interactive multiedia business simulation developed in partnership by Andersen Consulting and Siemens AG. The aims of SPACE are fostering self-directed learning and the acquisition of applicable knowledge in the economic domain regarding construction and solution projects of US GAAP. The evaluation was conducted in cooperation with the Institute of Educational Psychology at the Ludwig-Maximilians-University in Munich. The aim of the evaluation was to compare the effectiveness of SPACE with a traditional classroom instruction. Therefore, a problem-based transfer task was designed which assessed learning gains with respect to applicable knowledge in the following areas: (1) strategic knowledge and problem-solving skills, that means selection of appropriate information and strategies to solve a realistic business problem, (2) basic skills to calculate POC and (3) conceptual knowledge, i.e. an understanding of principles and interconnections of concepts in the domain. 38 students of business administration participated in the evaluation. 19 students learned eight hours with SPACE, the other 19 students received a traditional classroom instruction lasting also eight hours in the same subject area of US GAAP. Results show that SPACE was significantly better with regard to strategic knowledge and applying problem solving skills. In other words, the study showed that SPACE is superior to classroom instruction in this area of knowledge acquisition and application. In the other areas of basic skills to calculate POC and conceptional knowledge, differences were not significant between the classroom instruction and SPACE. When SPACE is employed under realistic conditions, i.e. in business, it can be assumed that SPACE is even more superior to classroom instruction.

Zusammenfassung

Das computerbasierte Lernprogramm SPACE (Simulating Project Auditing & Controlling Excellence), eine interaktive, multimediale Simulationssoftware, wurde von Anderson Consulting und der Siemens AG entwickelt. SPACE zielt auf die Förderung selbstgesteuerten Lernens und die Vermittlung anwendbaren Wissens. Das Simulationsprogramm behandelt inhaltlich die Kalkulation von Projektdaten auf Basis von US GAAP. Die hier berichtete Evaluationsstudie hatte zum Ziel, die Effektivität von SPACE im Vergleich zu einem traditionellen Klassenzimmerunterricht festzustellen. Mit einer problemorientierten Transferaufgabe wurden folgende Dimensionen erfasst: (1) Strategisches Wissen und Problemlösefertigkeiten (hierbei ging es um die Selektion relevanter Informationen und Strategien in Bezug auf eine realistische Problemstellung), (2) Basisfertigkeiten zur Berechnung von POC und (3) konzeptionelles Wissen im Sinne eines Verständnisses von Prinzipien und Zusammenhängen innerhalb des behandelten Inhaltsgebietes. An der Studie nahmen 38 Studenten der Betriebswirtschaftslehre teil. 19 Studenten lernten in einem Zeitraum von acht Stunden mit SPACE, die anderen 19 Teilnehmer nahmen an einem achtstündigen Klassenzimmerunterricht zum selben Inhaltsbereich teil. Hinsichtlich der Dimension "Strategiewissen und Problemlösefertigkeiten" schnitten diejenigen Studenten signifikant besser ab, die mit SPACE lernten. Das Simulationsprogramm zeigte sich somit in Bezug auf diese Dimension der Wissensanwendung dem traditionellen Klassenzimmerunterricht überlegen. In den Dimensionen "Berechnung von POC" und "Konzeptionelles Wissen" ergaben sich keine signifikanten Unterschiede zwischen den beiden Untersuchungsgruppen. Es ist anzunehmen, dass SPACE dem traditionellem Unterricht deutlicher überlegen ist, wenn das Lernprogramm unter realistischeren Bedingungen, d.h. in Betrieben, eingesetzt wird.

Aim of the evaluation

The study focuses on the evaluation of the computer-based simulation SPACE – Simulating Project Auditing & Controlling Excellence – which is an interactive multimedia business simulation. SPACE was developed by Andersen Consulting and Siemens AG. The goals of SPACE are the acquisition of applicable knowledge in the economic domain of US GAAP and projects controlling.

The simulation program was designed for Siemens ltd. to make the employees acquainted with the affordances of the US accounting principles world wide. SPACE shows the complex connection of project-management and controlling with regard to the US accounting principles.

In order to evaluate SPACE, Andersen Consulting commissioned the Institute of Educational Psychology at the Ludwig-Maximilians-University in Munich to conduct a scientific study regarding the effectiveness of SPACE.

The aim of the evaluation was to compare the effectiveness of SPACE with a traditional classroom instruction. If the learning gains of SPACE are equal to or even better than the learning gains achieved by a traditional classroom instruction, it would be a major advantage to use SPACE in the training of employees with regard to flexibility, self-directed learning and cost effectiveness.

To reach this aim of evaluating SPACE and comparing it to traditional classroom instruction, the issue of problem-based testing of transfer (Cox, 1997; Fischer et al., 1998) is taken into account. Due to the affordances and the demands in the workplace, the acquisition of applicable, transferable knowledge is of major importance in the training of employees (Gerstenmaier & Mandl, 1999; Greeno & The Middle School Mathematics Through Applications Project Group, 1998). The goal of SPACE is to generate applicable knowledge. Thus, this kind of knowledge has to be tested in the evaluation.

Therefore, a problem-based transfer task was designed which is capable of assessing transfer of learning. In this transfer task the problem-solving abilities of learners in a rich and authentic work context is a major evaluation criteria. In the evaluation study, it was to be clarified to what extent the learners were able to apply the knowledge they had acquired during training in business situations. The problem-based testing methods of transfer refer to the theories of situated learning (Collins, Brown & Newman, 1989; Greeno & The Middle School Mathematics Through Applications Project Group, 1998; Greeno, Collins & Resnick, 1996; Gruber, Law, Mandl & Renkl, 1996).

Research questions

In order to evaluate the learning gains, three major areas have been defined to specify applicable knowledge with regard to the goals of SPACE and the domain US GAAP: (1) strategic knowledge and problem-solving skills, (2) basic skills to calculate POC and (3) conceptual knowledge. Thus, the research questions are the following:

(1) Do learners using SPACE apply more strategic knowledge and problem-solving skills compared to the classroom group?

(2) Do learners using SPACE apply more basic skills to calculate POC compared to the classroom group?

(3) Do learners using SPACE apply more conceptual knowledge compared to the classroom group?

Description of SPACE

SPACE has been designed to provide Siemens professionals with hands-on practical experience in auditing and analyzing projects within a fictitious business unit that produces waste recovery systems, called Siemens Integrated Pollution Systems (SIPS).

SPACE enables the learner to learn self-directedly. The learner plays different roles within the simulation. This means that he has to carry out realistic tasks and experiences the outcome of his decisions. The learner is coached throughout the simulation by receiving continuous feedback and guidance on the work he has done so far. This feedback and guidance is provided in video- as well as text-based format. In this process of learning-by-doing, the learner can improve his performance in a risk free environment.

The simulation starts with an introductory video which is followed by the on-line-introduction explaining the technology and the navigation of the simulation. SPACE consists of three modules with various specific tasks. While solving the tasks, the learner can make use of different sources of information. The main sources are:

- *"David":* He plays the role of a coach and gives detailed feedback on the work in progress.
- *"Expert Panel":* This is an area containing real world examples delivered by videos with war stories from experienced colleagues.

- *"Content Information":* The content information gives comprehensive explanations to solve the task, supported by graphics to assist understanding. This information can be directly applied to business cases.
- *"Dictionary":* The dictionary is a glossary of terms, containing about 400 definitions in total.

Methods

Sample and assessment of pre-knowledge

The sample consisted of 38 students of business administration (third to 12th semester) at the Ludwig-Maximilians-University in Munich. In order to form two equivalent groups, all students had to undergo a pretest to determine their individual pre-knowledge that might be of relevance. In this pretest, the following dimensions were assessed: “computer skills”, “English skills” and “economic knowledge”. These dimensions take into consideration that the training is in English, on an economic subject and that the simulation group has to work with computers.

To get two groups which are comparable regarding these aspects of pre-knowledge, an individual median split was performed on each scale resulting in 2^3, i.e. 8 subgroups that then were divided evenly into simulation group and classroom group. Thus it could be assured that both test groups showed equal mean values, median values and standard deviations on each of the three scales.

Design of the evaluation

The basic design of the evaluation was the comparison of SPACE with conventional classroom instruction. On the first day, the participants received a training described in more detail below (see section "Description of the learning environments"). The next day the problem-based transfer task was conducted, which is described in the following section.

Table 1: Evaluation design (*N* = 38 students of business administration)

Simulation group	**Classroom group**
n = 19	n = 19

Problem-based test

After the training, the students had to leave back all materials. This was done in order to prevent additional learning on their own, which could otherwise not have been controlled and would produce differences not attributable to the training. The next day, each student was tested individually. The students could use their materials of the training, including the simulation program for those students who had learned with SPACE. Experimenters gave the problem-based transfer task described below to the students and controlled the time on task. After the completion of the task, the students were given a questionnaire which assessed their self-ratings on interest, comprehension and ability to apply the acquired knowledge in the task.

Design of the problem-based transfer task. According to the aims of the evaluation, a problem-based transfer task was designed to test the application of the knowledge which the participants had acquired during the training. The design of the task was conducted in close cooperation between domain experts of Andersen Consulting and experts of the Institute of Educational Psychology in order to get a realistic task.

The problem-based task referred to the three main areas which specify applicable knowledge according to the goals of SPACE and the domain US GAAP: (1) strategic knowledge and problem-solving skills, (2) basic skills to calculate POC and (3) conceptual knowledge. The problem-based task is divided into several subtasks which sequence the overall task. This allowed the participants to get the necessary information to solve the following subtasks, even if their solution of the preceding subtask was not correct.

To create a problem-based transfer task, these subtasks were embedded in a rich and authentic work context in order to come as close as possible to the application of knowledge in a real-world work project. This means that the participants took the role of the project controller who was given a specific problem to solve.

The degree to which the students attained an expert solution was judged with a standardized measurement system. To control the time on task, the participants had a maximum time available to solve each subtask. All in all, the participants had 80 minutes for the entire task. The experimenters checked the time the participants needed to work on each subtask. The subtasks and time provided are described in the following in more detail.

Strategic knowledge and problem-solving skills

- Calculation of POC – subtask 1.1: *"Selection of information source"*. The students chose from several project reports – even irrelevant reports – the information they thought to be necessary to calculate POC and POC gross margin. They were asked to explain their choice in a few words. They had ten minutes to complete this subtask.
- Root Cause Analysis – subtask 1.2*: "Choose right strategy".* The students got the problem that POC is probably highly overstated. They had to choose the most effective strategy to find the root cause of the deviation from several possible strategies. Again, they were asked to give a short explanation of their choice. Ten minutes were provided to solve this subtask.

Basic skills to calculate POC

- Calculation of POC – subtask 2.1: *"Determine POC cost"*. The students got information regarding costs which were incurred up to a specific time in the project. They were asked to decide and calculate which costs were correctly included to determine POC cost. They had 15 minutes to complete the subtask.
- Calculation of POC – subtask 2.2: *"Calculate POC and POC gross margin".* The students got a work package information of the project and were asked to calculate POC and POC gross margin. The time available was 15 minutes.

Conceptual knowledge

- Root Cause Analysis – subtask 3.1*: "Find Root Cause".* The participants got the relevant work package for the overstatement of POC and received the status report as well as events which had happened and how these events were accounted for. They were asked to relate those concepts and apply them by determining possible root causes for the overstatement and consider the direction of impact on POC. For every issue they included as having an impact, they were asked to give an explanation. They had 20 minutes to complete the task.
- Subtask 3.2: *"Determine Impact".* The participants had to determine, what impact two issues in the project controlling of different work packages had on POC and the financial statements. They had to understand those different concepts in their interconnections and effects by indicating the direction of the impact. They were asked to state if POC and financial statements were too high, too low or not affected. The time available was ten minutes.

Questionnaires

In order to get information about subjective self-ratings two questionnaires had been constructed, which were issued after the training (questionnaire 1) and after the test (questionnaire 2). Both questionnaires were designed similarly. They both covered three scales concerning (a) the interest in the domain, (b) the comprehension of the learning material and (c) the ability to apply the new knowledge in authentic situations. In both questionnaires all three scales proved to be sufficiently reliable (Cronbach's Alpha > .73).

Description of the learning environments

In this section, the learning environments are described in more detail. Both groups had been observed by experts. These observations are the basis for the following sections. The first section is concerned with the setting of learning with SPACE. In the second section, the classroom setting is described.

Description of the simulation setting. The simulation group of 19 students was working eight hours with SPACE, intermitted by a lunch break and two coffee breaks of one and a half hour altogether. Each test person was given a personal computer running the simulation program and the supporting materials of the SPACE program. Besides, the students were allowed to carry with them a personal German-English dictionary. Moreover, there were two telephones installed in the study room and the test persons were given the chance to call a hotline and get support from a tutor over the phone in case they had any problems with the program. It was up to the students to work alone or to ask their neighbours in case they had any questions. This is supposed to represent the situation at the workplace, where employees can learn individually as well as partly cooperatively with SPACE. The students were told that they could use the simulation program and all written materials in the test.

The observation shows that the students learned alone most of the time. Some students discussed shortly with their neighbours in the room concerning the tasks. The students did not make frequent use of the hotline: only three phone calls were placed during the learning period. At the end of the training session, the students received a questionnaire which was described above.

Description of the classroom-setting. Corresponding to the simulation-setting, the classroom instruction was limited to eight hours, only intermitted by two coffee breaks of 15 minutes each and a lunch break of one hour. 19 students of business administration took part in the training which was held by a senior manager at Andersen Consulting who is an expert in the domain and certified in US GAAP.

The observation shows that the trainer mainly used presentations as instructional methods with additional, example-based explanations. He regularly set little problems and asked the students to generate solutions. From the very beginning a student binder was given to the participants which they could also use to make notes. It consisted of the transparencies the trainer was using during classroom instruction. The students were told that they were allowed to use the student binder in the test. The atmosphere during instruction can be described as very concentrated and motivated. At the end of the classroom instruction the students were given the same questionnaire as the simulation group.

Comparability of the learning environments regarding the students' self ratings

In order to compare the effects of the learning environments in the test, the student ratings in both groups were controlled regarding the three dimensions which were surveyed in the two questionnaires described above. This means that students' subjective judgements of their interest, comprehension and knowledge application were assessed.

Results of the self-ratings after the training session showed that on all three dimensions the mean value differences between the two groups were not significant. In both groups the interest in the domain was rather high. Subjects of both groups stated that they comprehended the learning material quite satisfyingly. Both groups rated their abilities to apply the new knowledge in authentic situations at a medium level. The self-ratings after the test did not significantly differ from the ratings after the training.

Results

Are learners using SPACE able to apply more strategic knowledge and problem-solving skills compared to the classroom group?

Figure 1 compares the results of the simulation group and classroom group concerning task 1.1 and task 1.2 which were designed to measure strategic knowledge. The bars represent the average percentages which subjects of each group attained in relation to the maximum score.

In task 1.1, the simulation group scored 53.80% of the maximum score (*SD* = 23.79). The mean value reached by the control group in this task was 43.27% (*SD* = 13.81). The results of a t-test for independent samples show that the difference of 10.53% between simulation group and classroom group is significant (t = 1.67, p = 0.5). The effect size of the group difference in task 1.1 was .54. Thus the results show a medium effect.

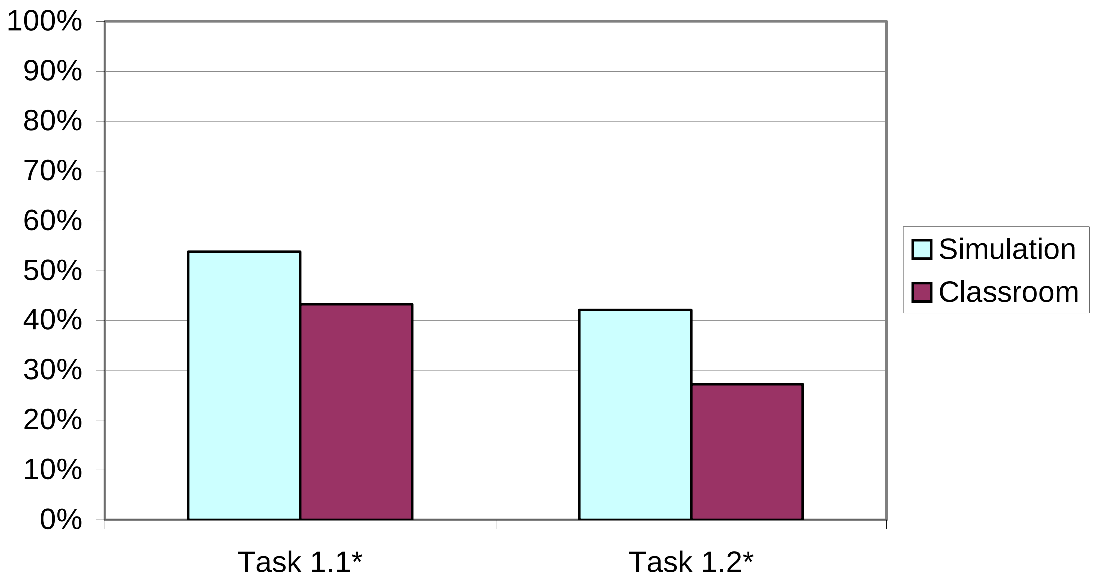

Figure 1: Mean percentages scored in relation to the maximum score of simulation group (n = 19) and classroom group (n = 19) concerning task 1.1 and task 1.2. (*differences of mean values are significant, p < .05)

The simulation group outperformed the classroom group in task 1.2 as well. The former reached a mean value of 42.11% (*SD* = 31.67). On average, subjects of the classroom group attained 27% (*SD* = 21.21) of the maximum score. Again the group differences had been checked with a t-test for independent samples. The difference of the mean value was significant again (t = 1.69, p < .05). In task 1.2 the effect size of the group difference was .51. This value also indicates a medium effect.

To sum up the results concerning the application of strategic knowledge: In both subtasks the simulation group outperformed the classroom group significantly. The medium values scored by both groups indicate a relatively high degree of difficulty concerning task 1.1 and task 1.2.

Are learners using SPACE able to apply more <u>basic skills to calculate POC</u> compared to the classroom group?

Figure 2 summarizes the results both groups attained in task 2.1 and task 2.2. Both tasks demanded basic skills to calculate POC.

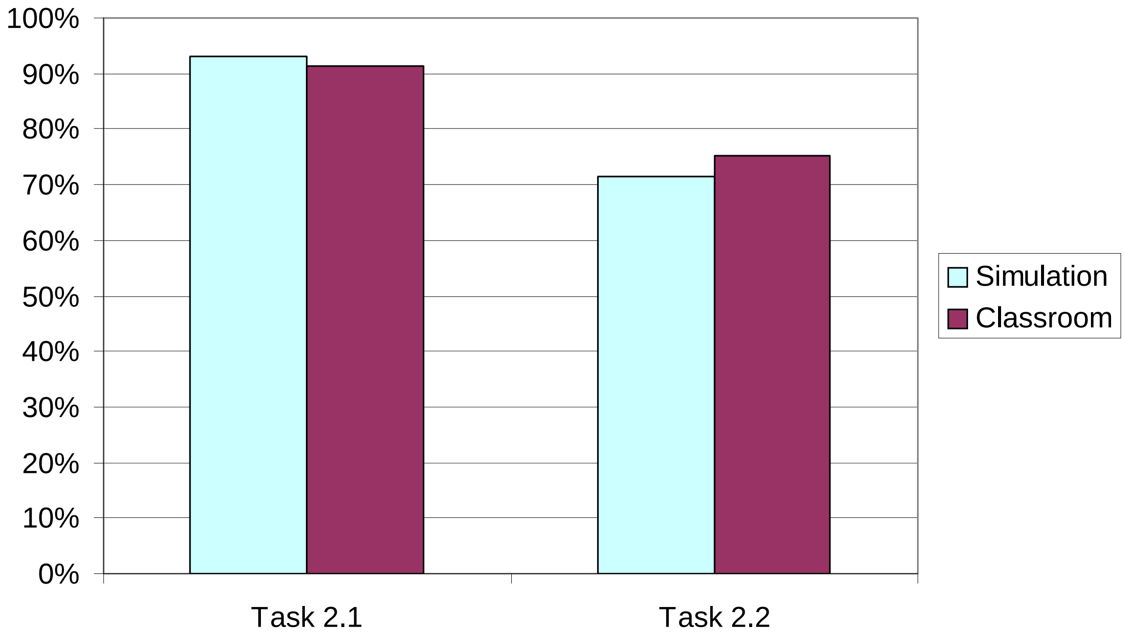

Figure 2: Mean percentages scored in relation to the maximum score of simulation group (n = 19) and classroom group (n = 19) concerning task 2.1 and task 2.2

In task 2.1 the simulation group attained 92.98% (*SD* = 10.92) of the maximum score. The mean value reached by the control group in this task was 91.23% (*SD* = 11.03). A test of significance showed that the difference of the mean values between both groups was not significant.

Results show that in task 2.2 the classroom group scored a slightly better mean value (71.43%, *SD* = 22.43) than the simulation group (75.19%, *SD* = 29.68). This group difference of the mean values was not significant either.

All in all, there were no significant differences between both groups regarding the application of basic skills to calculate POC. Both, simulation group and classroom group performed scores at a very high level in task 2.1 and at a high level in task 2.2. This shows, that both groups reached the learning target of basic skills to calculate POC.

Are learners using SPACE able to apply more conceptual knowledge compared to the classroom group?

Figure 3 shows the results of both groups regarding task 3.1 and task 3.2. Both tasks demanded the application of conceptual knowledge.

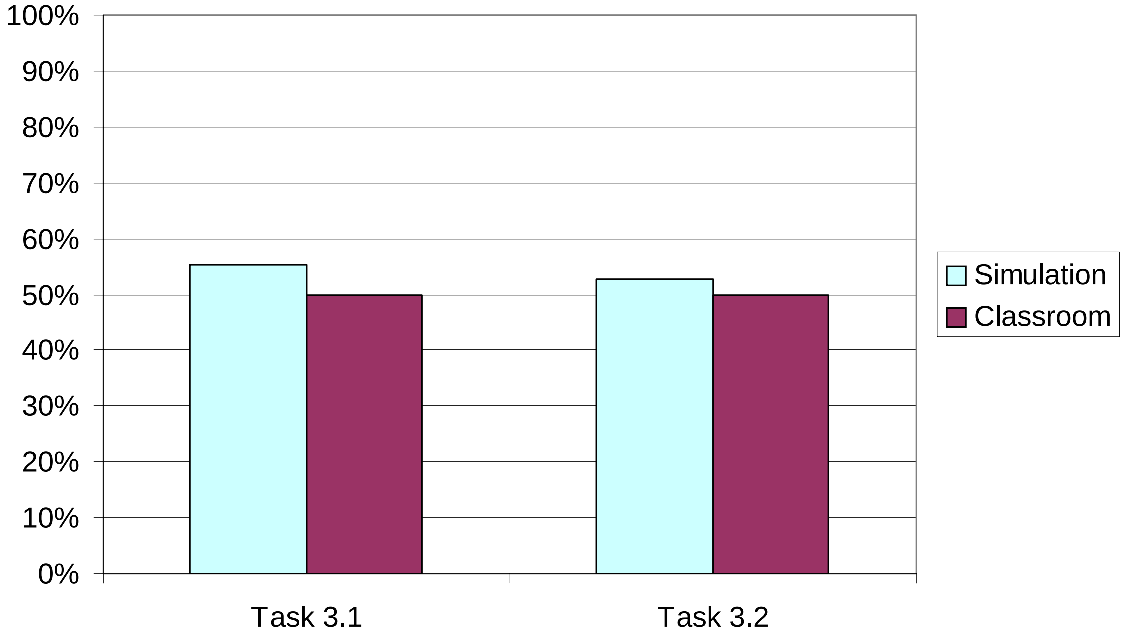

Figure 3: Mean percentages scored in relation to the maximum score of simulation group (n = 19) and classroom group (n = 19) concerning task 3.1 and task 3.2

In task 3.1 subjects of the simulation group on average reached 55.26% (*SD* = 24.18) of the maximum score. In this task the classroom group scored a mean value of 49.74% (*SD* = 22.94). The difference between both groups was not significant.

Differences between both groups concerning task 3.2 were even less than in task 3.1. In this task the simulation group scored a mean value of 52.63% (*SD* = 23.72), the classroom group attained a score of 49.82% (*SD* = 23.03). Again, a test of significance showed that the difference between both groups was not significant.

To sum up: The results concerning the application of conceptual knowledge show no significant differences between simulation group and classroom group. In both tasks the two groups scored results at a medium level.

Conclusion

All in all, the comparison between SPACE and traditional classroom instruction shows positive effects of SPACE. In more detail, the following conclusions can be drawn:

- With regard to the aim of SPACE to transmit strategic knowledge and problem-solving skills in occupational application situations, the performance simulation is superior to classroom instruction.
- With regard to the basic skills to calculate POC and conceptual knowledge, SPACE achieved equal results in comparison to classroom instruction. All in all, the learning gains of both groups are on a high level. It is well known, that these types of knowledge can be fostered in traditional classroom instruction. The comparable scores of simulation and classroom group, prove the usability of SPACE also for the teaching of these types of knowledge.
- When the SPACE knowledge and skills are employed under realistic conditions, i.e. in business, it can be assumed that SPACE is even more superior to classroom instruction. Users in organizations have more prior knowledge which is tied to practical experience and a higher level of motivation for learning. They would profit from SPACE to a higher degree than the student group in this study, when they have the opportunity to learn with realistic tasks as provided by SPACE.

- Even higher results for SPACE can be expected, if the resources in the program like the help functions or the helpline are accessed more frequently than the students in this study did. Self-directed learning with a computer simulation is a new learning situation for students, whereas they are very used to the classroom situation.
- Despite the unfavourable conditions of this study – as described above – the results point to the conclusion that the employment of SPACE in central areas of knowledge application on realistic tasks makes it superior to classroom instruction.

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