Text-Based Learning vs. Learning with Computer Simulations: Does Gender Matter?

Michael D. Kickmeier-Rust[1]/Andreas Holzinger[2]/Sigi Wassertheurer[3]/Michael Hessinger[4]/Dietrich Albert[1]

[1] Department of Psychology, University of Graz (Austria)
[2] Inst. of Medical Informatics, Statistics and Documentation, Medical University Graz (Austria)
[3] ARC Seibersdorf research G.m.b.H., Vienna (Austria)
[4] Surgical Ward, Medical University Graz (Austria)

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Abstract

Investigating multimedia learning has a long tradition and we can refer to a large body of empirical results. Gender-based differences and further individual factors, however, have not been considered as moderating variables to a large extent. The current article presents some preliminary results of a large-scale study aiming at investigating the efficacy and efficiency of multimedia learning objects for the use in higher medical education. The experiment described here compared text-based learning of blood flow effects with simulation-based learning. Interestingly, the results show that males as well as females could use both types of learning objects equally well and that they did not differ in learning styles and strategies. However, the results yielded very distinct differences in the impact of different learning strategies on learning performance.

1. Introduction

Gender differences in e-learning are persistently a matter of debate among psychologists, educationalists, sociologists and of course among designers and developers. The increasing amount of web-based and technology-enhanced learning offered by schools and universities raise particular questions of gender differences or equity in the usage of multimedia learning objects, educational games, or educational computer simulations.

Investigating general gender differences in performance and learning has a long tradition [1]. In general, research did not demonstrate consistent gender differences in learning and memory [2]. Some studies yielded performance differences in specific memory tasks. For instance, Lewin, Wolgers, and Herlitz [3] or Lindholm & Christianson [4] found advantages for women in episodic memory tasks. Buckner and Fivush [5] or Friedman and Pines [6] reported women's superiority in autobiographical memory. Davis [7] or Seidlitz and Diener [8] found some evidence for higher performance of women in events associated with emotions. Lowe, Mayfield, and Reynolds [9] and Jordan, Schulz, Foster, and Matthews [10] found advantages for women in verbal memory tasks and advantages for men in spatial memory tasks.

Also, for other cognitive abilities, no large differences were found between males and females ([11], [12]), and differences within males or females are considered to be larger than differences between them. There is also research on the effects of different learning styles but the results vary widely. Studies suggest that men are generally seen to learn more abstract, intuitive, and undirected, while women are seen to be more analytical, more organized, but also more anxious about study success (cf. [13], [14]).

However, it remains unclear whether such differences (or similarities) affect learning with new technologies. In web-based learning environments, experiences and expectations based on gender have been suggested to relate to learners' attitudes and behaviours [15], [16]. Gender differences were also identified within learning from computer-based technologies, for example, in attention, cognitive processing, or learning outcomes (see the meta-analyses of Astleitner and Steinberg [17] or Withley [18] for reviews).

2. Text-Based vs. Simulation-Based Learning

The current experiment focuses on gender differences in learning performance with different types of learning objects. The experiment was conducted in the framework of a large scale study regarding efficacy and acceptance of different types of learning objects (i.e., traditional forms such as text and static images or multimedia learning objects such as simulations, animations, or video). The intention of this study is to provide a detailed empirical basis for extending and improving the learning objects used at the Medical University Graz, which are accessible online. For this purpose, it is highly important to evaluate the efficacy, acceptance, and possible individual differences (e.g., gender) of the online platform and its different types of learning objects. The current article presents the preliminary results of a comparison of text-based and simulation-based learning.

We compared two types of learning objects, a traditional textbook lesson with static images and an interactive computer simulation of the same learning contents. We measured learning performance using a typical 2x2 design (type of learning object x pre and post-test). Additionally, we assessed learning styles and strategies.

Learning contents for the current experiment was created from the field of blood vessel prosthesis; strictly speaking, the haemodialysis shunt steal-syndrome. In brief, the learning contents comprised effects of blood flow at specific blood vessel prosthesis, the so-called shunt, in dependence of various parameters, for example, shunt position, shunt diameter, or blood pressure.

The text-based learning object consisted of an introductory text explaining the haemodialysis shunt and the steal-syndrome. The text was supplemented with a static image displaying a sketch of blood vessels and shunt. Blood flow effects were displayed with arrows. The simulation-based learning object was realized using Haemosim software [19], [20], [21], which is a JAVA-based collection of simulation tools in the field of blood flow.

To assess learning styles, we used the HALB test [22], which is a short and economic questionnaire in German language including acoustic, visual, active, or reading learning styles / preferences. To assess learning strategies we used the LASSI inventory [23], which differentiates ten factors related to learning strategies (attitude and interest, motivation, usage of time management principles, anxiety, concentration, information processing, selecting of main ideas, usage of learning support techniques, self testing, and test strategies).

3. Experimental Investigation

3.1. Participants

The presented analyses are based on the results of 65 students of the Medical University Graz, thereof 26 male and 39 female students. The average age was 22.10 years (SD = 1.80), the youngest student was 20, the oldest 27 years of age. All participants were students of human medicine in the sixth semester. The experiment was conducted at the beginning of a seminar on vessel surgery, thus, all students had high level knowledge of physiology and medical terms, but were supposed not to have a high level of knowledge regarding the steal-syndrome.

3.2. Experimental Design

In the experiment reported here, we compared two types of learning objects, a traditional textbook lesson with static images and an interactive computer simulation of the same learning contents. Because the data recording phase is still in process, the current results are only of preliminary nature. We measured learning performance, using a typical pre and post-test scenario realized as a 2x2 design (type of learning object x pre and post-test). As dependent variables we recorded the students' performance in the knowledge tests and, additionally, we assessed learning styles and learning strategies.

3.3. Material

3.3.1. Text-Based Lesson

The text-based learning object consisted of an introductory text at a length of 2 A4 pages explaining the haemodialysis shunt and the steal-syndrome. The text was

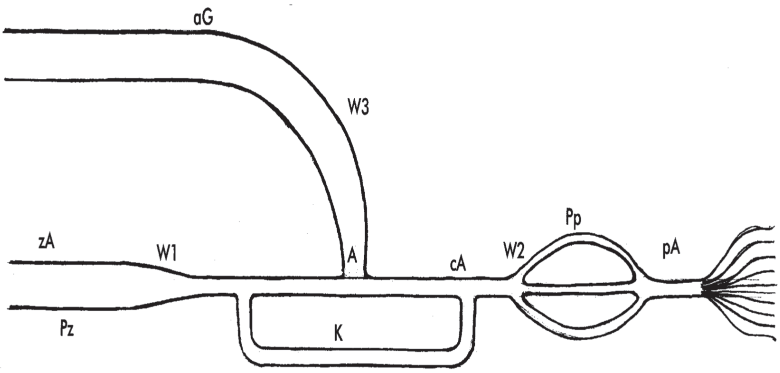

Figure 1: Static image to illustrate the contents of the text-based lesson, source: authors.

created by a head surgeon of the Medical University Graz. In the style of a typical textbook lesson, the content was suited to the prior knowledge and abilities of the students. Moreover, the text was supplemented with a static image (Figure 1) displaying a sketch of blood vessels and shunt.

3.3.2. Simulation-based Learning – Haemosim

Haemosim is a web-based educational simulation software based on several light weighted JAVA2 applets [19], [20], [21]. Each applet has been designed to interactively present certain haemodynamic learning content. The application is based on solid mathematical models [24], [25], [26], [21] and was developed under consideration of user-centered development methods [27], [28], [20]. The learning material is organized in three levels: (a) Basic laws for steady flow in tubes, (b) unsteady (pulsatile) flow in straight elastic tubes under homeostatic conditions, and (c) transient blood flow in arteries.

For the current experiment, we used the applet simulating the law of Hagen-Poiseuille (Figure 2), which provides the fact that volume flow is related to the fourth power to the radius so that, for example, a 2x increase in radius causes a 16x increase in volume flow. The flow velocity, on the other hand, is only quadratic in respect to the radius. The applet can reproduce effects on bypassed vessels or the effects of shunts. Particularly, it allows for simulating a “steal phenomenon” which is observed in vessel surgery when a shunt is dimensioned suboptimal.

The simulation comprised a short introduction and graphical simulations of blood flow. The different parameters of blood flow effects could be altered by the students using various sliders and buttons. The effects of changing parameters immediately were displayed in a graphical representation of blood flow. The simulation was designed to be as comparable to the text-based learning object in terms of terminology and contents as possible. For example, the simulation used identical words in the short introduction as used in the text-based lesson and an equal graphical representation as the static image of the text-based learning object. Instead of the single image, however, students could realize a variety of blood flow scenarios.

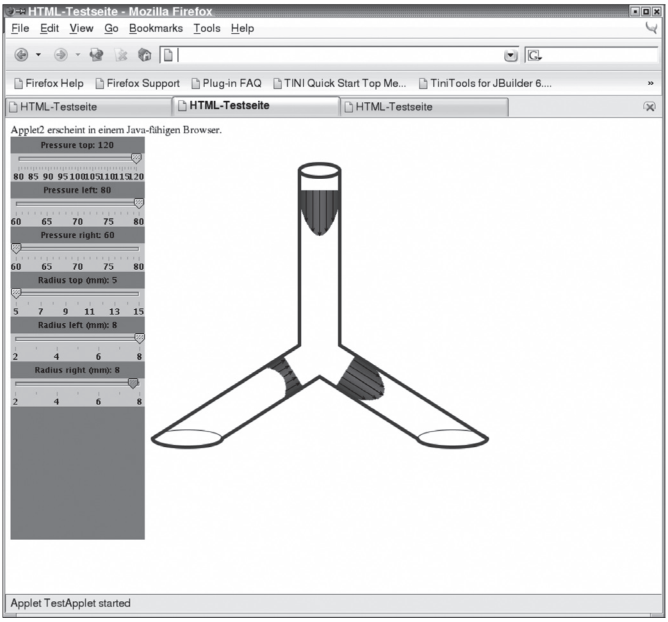

Figure 2: Haemosim applet to simulate blood flow on bypassed vessels or the effects of shunts; source: authors.

3.3.3. Additional Material

To assess the student's knowledge in pre and post-tests, we used a questionnaire asking five multiple-choice questions. Each question had four alternatives, whereat checking none, one, or more alternatives could be correct. The minimum score was 0 and the maximum score was 20 (one point for each correct response). For the pre and post-tests we used the same tests.

To assess learning styles, we used the HALB test [22], which is a short and economic questionnaire in German language. It gives indications (in form of percentages) to what extent a student is an acting, auditory, reading, or visual learner. To assess learning strategies, we used the LASSI inventory [23], which differentiates ten factors related to learning strategies (attitude and interest, motivation, usage of time management principles, anxiety, concentration, information processing, selecting of main ideas, usage of learning support techniques, self testing, and test strategies).

3.4. Procedure

Participants were recruited at the beginning of a seminar on vessel surgery at the Medical University Graz. At first, participating students were asked to fill in biographical data, to complete the learning styles and strategies tests, and to complete the pre-test on their initial knowledge in this particular field. Then students were randomly assigned to both experimental groups (text-based vs. simulation-based learning). After a break, the experimental groups were presented the related learning objects. Students of the text-based learning group were presented the two-page lesson in form of print-outs; students of the simulation-based learning group were seated in front of computer screens and presented the Haemosim simulation including a short introductory text. Students in both groups were instructed to try to learn as much as possible within a fixed time of six minutes. After another break, the students were asked to complete the post-test. The whole test procedure took about 45 minutes.

4. Results and Discussion

The results of this experiment yielded no significant gender difference in learning performance, learning styles and strategies. Both male and female students performed equally in the knowledge assessments tests with both types of learning objects (Figure 3). Only slight differences were found. In the text-based group male students achieved a score of 13.68 (SD = 2.42) in the post-test, female students achieved a score of 14.24 (SD = 2.60). In the simulation group, male students achieved a score of 14.50 (SD = 3.11) and female students of 12.43 (SD = 3.41). A Repeated Measures ANOVA, however, yielded non-significant differences ($F(1, 61) = .49$, $p = .826$). Interestingly, also no interactions, i.e. differences in learning performance were found for the types of learning objects (the text-based learning resulted in a mean score of 13.98, SD = 3.52; the simulation-based learning resulted in a mean score of 12.89, SD = 2.97).

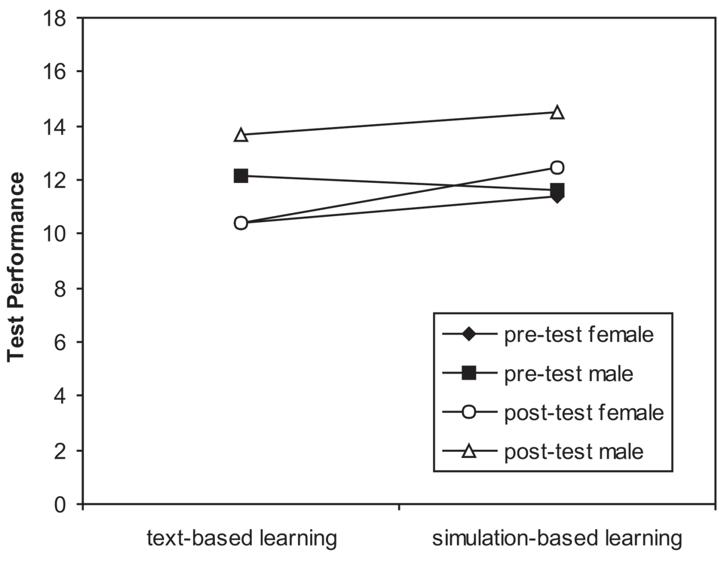

Figure 3: Performance in the post-test for gender and both learning groups; source: authors

Similarly, we did not find significant differences for learning styles and strategies. Generally, the participants of the current experiment achieved average scores for the LASSI learning strategies test (Figure 4). Between males and females, almost no differences were found. The biggest differences were found for "anxiety and worry about school performance" (ANX); females stated somewhat higher anxiety (21.39) than males (18.55). Also, the HALB learning style questionnaire showed that males and females did not differ in learning styles (Figure 5).

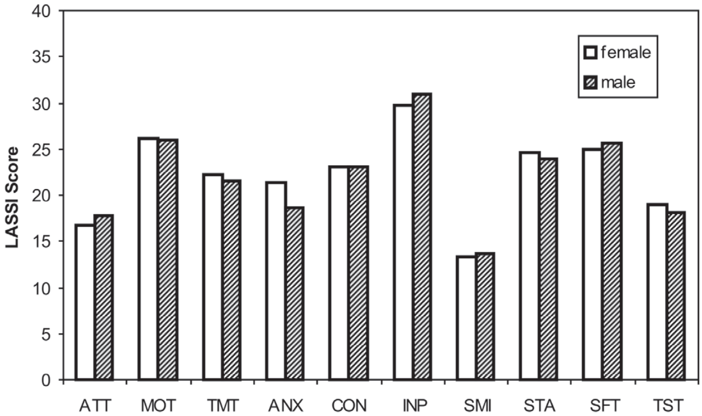

Figure 4: LASSI scores for males and females. The maximum score is 40, the minimum 0; source: authors.

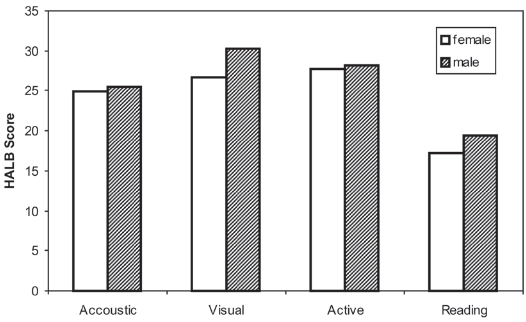

Figure 5: Scores in the HALB learning styles questionnaire for males and females, source: authors.

These findings indicate that male and female students could use both types of learning objects equally well. Moreover, males and females did not differ in learning strategies or learning styles. On the one hand this is an interesting finding, since the learning contents, which is dominated by physical effects of flow mechanics, and also the usage of technical computer simulations is generally attributed to males. On the other hand, these results are in accordance with prior results of studies regarding web-based learning (cf. [17]).

But if we take a closer look to these results and correlate the results regarding learning styles (HALB) and strategies (LASSI) with the mean scores in knowledge assessment (i.e., learning performance), we find different and very distinct results. Even when males and females did not differ in learning style and learning strategy scores on average, the degree of each learning strategy according to LASSI lead to significantly different test performance (Figure 6). Moreover, we found distinct interactions with the type of learning (text-based vs. simulation-based).

(a) LASSI subscale *Attitude and interest* (ATT): For this scale, no differences in correlations with test performance for males and females were found, however for text-based learning, we found a small negative correlation (females: r = -.22; males r = -.14). In contrast, for simulation-based learning we found positive correlations (females: r = .35; r = .16). We can interpret these findings with the assumption that students with high attitude and interest towards learning and the learning subject are rather demotivated by purely text-based lessons, while the possibilities of simulations to go deeper into a subject offer more motivation for students with higher attitude towards learning.

(b) LASSI subscale *Motivation* (MOT): Whilst in the text-based group only moderate correlations were found between motivation and learning performance, in the simulation-based group, male's score was highly positively correlated with motivation (r = .87). Female's scores, however, were highly negatively correlated with motivation (r = -.75). A possible explanation of this remarkable finding might be different approaches of using computer simulations. The probably most successful approach to use such simulations might be "playing" with the sliders and to explore the effects of different changes. As reported by Logan & Thomas (2002), women do have a significantly more pragmatic learning style than men. Maybe highly motivated females tried to pragmatically and systematically use the simulation while less motivated women listlessly played with the software, which might be the more successful approach.

(c) LASSI subscale *Time management principles* (TMT): Generally, we found negative correlations between this scale and test performance. Whilst for text-based learning of males (r = -.06) and females (r = -.18) and for simulation-based learning for females (r = .07) only small correlations were found, for the combination of being male and using simulation-based learning, however, we found a distinct highly negative correlation (r = -.62). A possible explanation for this phenomenon is that the use of time management principles might limit the time and degree of freedom for "playing" with the different options of simulations. The current findings suggest that males might stick more to their own limits than females. But for this distinct effect there might a variety of possible explanations.

(d) LASSI subscale *Anxiety and worry about school performance* (ANX): Generally, for anxiety we found negative correlations to test performance (r = .12, r = -.28, r = -.37, r = -.62). This means: the higher the degree of anxiety the lower test performance. This effect was larger for simulation-based learning. A possible reason might be that, in contrast to text-based learning, simulation-based learning offers further factors for being anxious, i.e. the use of a new and complex software tool for learning.

(e) LASSI subscale *Concentration and attention to academic tasks* (CON): Concentration correlated positively with test performance very slightly in the text-based learning group, for females (r = .13) as well as for males (r = .03). Remarkably, we found negative correlations with simulation-based learning, for females (r = -.39) as well as for males (r = -.23). Maybe high concentration on certain aspects of the simulation limited the "playing" and "trial" character of simulations like provided by Haemosim.

(f) LASSI subscale *Information processing, acquiring knowledge, and reasoning* (INP): While we found no or moderate negative correlations between this subscale and test performance in the text-based learning group (females: r = -.01; males: r = -.45) and for females in the simulation-based learning group (r = -.41), we found a distinct highly positive correlation to test performance for male students (r = .68). An interpretation might be that the use of reasoning and related cognitive strategies might not affect the learning from textbook lessons. On the other hand, the type of reasoning used by females had a negative impact on females' performance with simulations while the type used by males had a positive impact. This finding suggests that males and females are using different types of reasoning and other cognitive information processing strategies. On the basis of the current results, however, we cannot identify such differences.

(g) LASSI subscale *Selecting main ideas* (SMI): For the ability to recognize important main ideas of learning contents, we found only moderate, negative correlations with learning performance, in the text-based group and for females in the simulation group. For male students in the simulation group, however, we found a high positive correlation (r = .76). This finding might be related to different usage of simulation by male and female students as mentioned above. A possible explanation might be that male students who perform well in the selection of main ideas might be able to use the simulations in more appropriate and successful direction. Because of different approaches in the usage of simulations, this factor might not influence the results of female students to that extent.

(h) LASSI subscale *Use of support techniques and material* (STA): Similar results were found for the amount of using learning support techniques. Generally, only moderate correlations were found with the exception of male students in the simulation group. Here we found a highly positive correlation (r = .69). A reason for this difference between male and female students might be that male students probably use different support techniques than female students do.

(i) LASSI subscale *Self-testing, reviewing, and preparing for classes* (SFT): Similar as for the previous subscales, we found rather negative correlations to test performance for text-based learning (females: r = -.20; males: r = -.19) and for females in the simulation-based learning group (r = -.23). For males in the simulation-based learning group, in a strong contrast, we found a very high positive correlation (r = .95). As for the subscale INP, we assume that males do use different self-testing and preparation techniques, which had a more positive impact on the use of simulations.

(j) LASSI subscale *Test strategies and preparing for tests* (TST): For this subscale we found slightly negative correlations in the text-based group, for females (r = -.16) as well as for males (r = -.19). For simulation-based learning, we found moderate positive correlations (females: r = .25; males: r = .45). A possible reason for this effect might be the nature of this subscale. The development of test strategies implies the development of an overview of a subject. Such global view might enhance the working with simulations and its learning outcome.

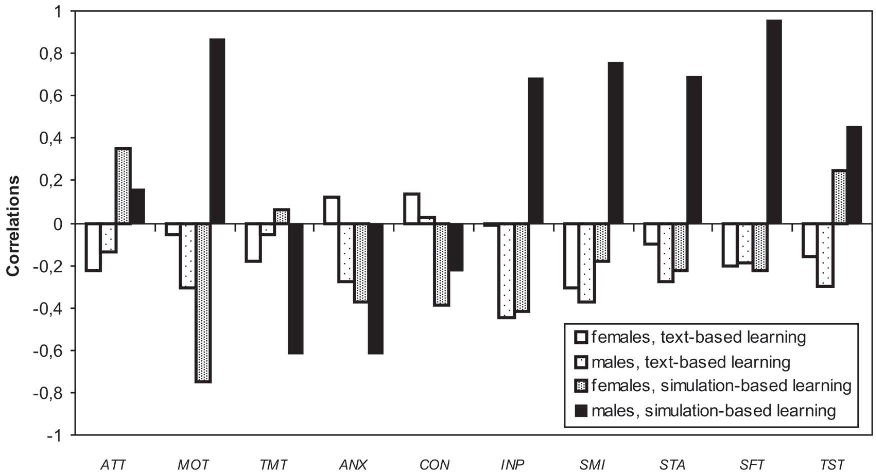

Figure 6: Correlations between LASSI subscale scores (ATT, MOT, TMT, ANX, CON, INP, SMI, STA, SFT, TST) and test performance for gender and type of learning object; source: authors.

Similar results were found for HALB learning styles (Figure 7). For *acoustic* learning preferences, we generally found only very slight correlations for text-based learning (females: r = -.12; males r = -.06) and for females in simulation-based learning (r = .10). For males in the simulation-based learning group, we found a moderate negative correlation (r = -.32). Males with high acoustic learning preferences could not use the Haemosim simulation equally well for learning than females. For *visual preferences* we found almost no correlations for males in the text-based learning group (r = -.08) and for females (r = -.05) and males (r = -.06) in the simulation-based learning group. Remarkably, for females in the text-based learning group, we found moderate positive correlations (r = .34).

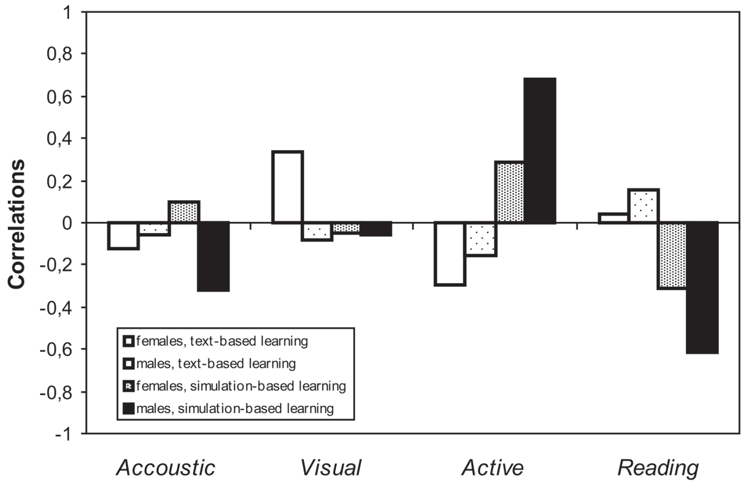

Figure 7: Correlations between HALB learning styles (acoustic, visual, active, reading) and test performance for gender and type of learning object; source: authors.

These results suggest that visual learning preferences generally had no impact on test performance. For some reasons, however, females with high acoustic preferences performed well in the test. For the *active* learning style, we found that a high degree had a negative impact on text-based learning (females: r = -.30, males: r = -.16) whereas it had a positive impact on simulation-based learning (females: r = .29; males: r = .68). A possible explanation for this effect is that simulation-based learning demands an active engagement and experimenting, while purely text-based learning requires concentrated reading, which is no active form of learning. Consequently, opposite results were found for *reading* preferences in learning. In the text-based learning group, we found slightly positive correlations (females: r = .04; males: r = .16) and in the simulation-based group, we found negative correlations for females (r = -.31) and also for males (r = -.62).

5. Conclusion

The preliminary results introduced here suggest that, generally, male and female students perform equally well during the usage of traditional text-based learning as well as computer simulations for learning. Still, these findings are remarkable since the learning contents had a strong physical nature and are strongly related to flow mechanics. It is interesting that generally, males are attributed to perform better with such contents. Moreover, also simulation-based learning and operating highly technical software is generally attributed rather to males than to females. Our results suggest that the gap between genders is more and more closing [17]. However, the results also indicate that some major gender differences in the impact of different learning styles and strategies on learning performance with computer simulations. So the current results suggest that gender is a strongly moderating factor for the impact of different learning styles and strategies on learning performance.

The current interpretations, of course, are based on a comparable small number of participants. The recording of data, however, is still in progress. A larger sample size and the investigation of further types of learning objects (e.g., video, or combinations of text, simulations, and video) will allow a more in-depth and stable analysis. Moreover, future analyses will investigate the interactions between different learning styles and strategies in order to approach a more holistic view of factors that influence learning success with different types of traditional and new learning technologies. Follow-up studies will also investigate long term memory for different types of learning objects and possible gender differences.

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Authors

Michael D. Kickmeier-Rust, Mag.rer.nat.
Cognitive Science Section, Dep. of Psychology, University of Graz, Austria
Universitätsplatz 2 / III, A-8010 Graz
+43-316-380-8549,
michael.kickmeier@uni-graz.at

Michael D. Kickmeier-Rust is a psychologist with major interests in computational psychology, human-computer interaction and e-learning. He is postgraduate researcher at the Cognitive Science Section, Department of Psychology, University of Graz, member of the ACM, and vice-chair of the Austrian Aviation Psychology Association. Currently, he is working on his dissertation related to game-based learning in the framework of the IST-project ELEKTRA.

Andreas Holzinger, Univ.-Doz., Dr.phil. Mag.rer.nat., Mag.phil, Ing.
Inst. of Medical Informatics, Statistics and Documentation, Medical University Graz, Austria
Auenbruggerplatz 2/V
A-8036 Graz
+43 316 385 3883
andreas.holzinger@meduni-graz.at

Andreas Holzinger is Associate Professor of Information Processing and works currently at the Institute of Medical Informatics, Statistics and Documentation. He is Head of the HCI&UE Group of the Austrian Computer Society and Leader of the special interest group HCI4EDU. His background is both in Psychology and

Computer Science and he is national expert for the European Union; more: www.basiswissen-multimedia.at

Sigi Wassertheurer, Mag. rer. soc. oec.
ARC Seibersdorf research GmbH, Div. Biomedical Engineering
Floragasse 7/407
A-1040 Wien
+43 664 8251043,
siegfried.wassertheurer@arcsmed.at

Sigi Wassertheurer is a mathematician with major intrests in physiological modelling and simulation. He is Head of the Cardiology and Hemodynamics Group of ARC Seibersdorf research Gmbh, Div. Biomedical Engineering and active in scientific societies like GI, OEGBMT or ASIM. Currently, he and his group focuses on model based non invasive measurement techniques.

Michael Hessinger, Dr.med.
Department of Vascular Surgery
Medical University Graz, Austria
Auenbruggerplatz 29
A-8036 Graz
+43 316 385 80529,
michael.hessinger@meduni-graz.at

Michael Hessinger is a general and vascular surgeon working at the Department of Vascular Surgery with a great experience in creating vascular accesses for hemodialysis. He also investigates the field of blood flow in different hemodynamic situations. He is a member of various scientific societies.

Dietrich Albert, Univ.-Prof. Dr.
Cognitive Science Section, Dep. of Psychology, University of Graz, Austria
Universitätsplatz 2 / III, A-8010 Graz
+43-316-380-5118,
dietrich.albert@uni-graz.at

Dietrich Albert is Professor of Psychology at the Department of Psychology at the University of Graz and he is the head of the Cognitive Science Section (CSS). His major interests are technology enhanced learning and teaching. He is a member of various scientific societies and advisory boards. More information is available at http://css.uni-graz.at.