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Gender Differences in Learning the SPSS-Software

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Abstract

In the literature it is often assumed that females are at a disadvantage when working with the computer. Whereas differences could be found in attitudes towards computers (Whitley, 1997) there are only few studies examining performance. As gender per se can not explain performance differences, we used the cognitive-motivational process model (Vollmeyer & Rheinberg, 1999, 2000) to find possible explaining variables. The model assumes that initial motivation affects strategies and motivation during learning which then influence performance. Therefore, we had male and female students solve four statistics tasks with the help of the SPSS-Software, which was an unknown program for them. Although males and females did not differ in initial motivation, male students were able to solve more statistical tasks than female students. Motivation and flow-experience could be identified as mediating variables.

Introduction

Not only psychologists but also politicians as the German Rectors' Conference (Hochschulrektorenkonferenz, 1998) demand that students at all educational levels should be prepared to use multi-media and communication technology because this offers the chance to create courses independent of time and space through distance learning. However, there are already warnings that developing such courses may put female learners at a disadvantage. Researchers describe this difference as "gender gap" (e.g., Jackson, Ervin, Gardner, & Schmitt, 2001) or even "digital divide" (e.g., Schaumburg, 2004).

What kind of differences were empirically observed? Three areas can be found: Computer use, computer attitudes, and computer performance. In the 1990ies, Whitley (1996) reported in his meta-analysis that females used the computer less frequently than males. Nowadays, this difference is more specific, for school male and female students work the same amount of time, but privately males spent more hours with the computer (for German students: Middendorf, 2002). Beside computer use males and females differ in their attitudes towards computers (Whitley, 1996).

In this context, the construct of self-efficacy has been studied most often. It is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses." (Bandura, 1986). Females describe themselves as less self-efficacious regarding the computer than males (e.g., Schaumburg, 2004; Whitley, 1996). However, there is a huge variety of how this construct has been operationalized. It ranges from asking about specific handling ("I feel confident getting software up and running", Durndell, Haag, & Laithwaite, 2000) to more general perceptions ("I find working with computers very easy", Cassidy & Eachus, 2002). In our own study (Imhof, Vollmeyer, & Beierlein, 2005) we used a questionnaire with general perceptions and could not find differences in self-efficacy between male and female students.

The most interesting question is whether there are also gender differences in computer performance. As gender is a descriptive variable that cannot explain effects, it is necessary to find mediating variables, explaining what male computer users do differently from female. Thus computer use or computer attitudes like self-efficacy, are candidates for such mediating variables. Searching for studies on this topic has been disappointing because there are only a few. Roy, Taylor, and Chi (2004) found that male students retrieved more task-relevant information on an online task than female students. In a formatting task, Shapka and Ferrari (2003) could not find gender differences. Schaumburg (2004) reported only gender differences in knowledge of standard software if explicit computer instructions were missing. In our own study (Imhof et al., 2005) students had to redesign a Power Point presentation. In this task male students could reconstruct more features of the presentation than female students. Taking self-efficacy into account, Shapka and Ferrari (2003) could not find its effect on performance. Imhof et al. (2005) reported some evidence that self-efficacy can be regarded as a mediating variable for the gender effect on performance.

As the empirical basis for gender effects on performance lacks theoretical explanations, we embedded this research question into the cognitive-motivational process model (Vollmeyer & Rheinberg, 1999, 2000) that offers possible mediating variables.

The Cognitive-Motivational Process Model

Vollmeyer and Rheinberg (1999, 2000) developed the model aiming (1) to specify aspects of initial motivation, (2) to collect possible mediators for the influence of initial motivation on performance, and finally (3) to emphasize the importance to measure the learning process as well as the outcome. To demonstrate how motivational and cognitive

variables interact it is necessary to interrupt the learning process to measure indicators for these variables.

Initial Motivation. Based on literature research Vollmeyer and Rheinberg (1999, 2000) described four aspects of initial learning motivation. These aspects are measured after learners have received the information about the learning material and the pertaining task.

(1) *Probability of success* is an aspect that has been discussed as early as in the models of Lewin, Dembo, Festinger, and Sears (1944), Atkinson (1957), and is also part of more recent theories such as Bandura's self-efficacy construct (1986), Anderson's ACT-R theory (1993) and Wigfield and Eccles's Expectancy-Value Model (2002). It is assumed that learners, at least implicitly, calculate the probability of success taking into account their ability and the perceived difficulty of the task.

(2) *Anxiety* can be partly interpreted as fear of failure in a specific situation (Atkinson, 1957). This aspect is not the opposite of high probability of success, as it can be high for learners who are in a social situation in which they do not want to fail even though they expect to succeed.

(3) *Interest* means that the content to be learned is important for a learner (e.g., Krapp, Hidi, & Renninger, 1992). If learners are interested they have positive affects and positive evaluations regarding the topic.

(4) *Challenge* assesses whether learners accept the situation as an achievement situation in which they want to succeed.

Mediating Variables. Initial motivation affects the learning process in that learners in a positive initial motivation are in a more positive *motivational and functional state* during learning and they also choose more effective *learning strategies*. The instruments assessing the mediating variables are administered several times during learning.

(1) *Motivational state*. Whereas *initial motivation* refers to participants' appraisals, affects and interpretations of the learning situation *before* having started to learn, motivational state refers to the participants' motivation *during* the learning period. This state variable reflects aspects of the initial motivation, however, shortened scales are administered in order not to disturb motivation.

(2) *Functional state*. This describes the learners' state of concentration and effort while they work with the learning material. As a construct, which comes close to what we mean by functional state, we chose *flow* (Csikszentmihalyi, 1975). Flow is a pleasant state, in which the following characteristics occur: (1) a challenge-skill balance, (2) merging of action and awareness, (3) unambiguous feedback, (4) concentration on the task at hand, (5) time transformation, and (6) merging of action and awareness.

(3) S*trategies*. Learning strategies are regarded as an important predictor for the learning outcome. Already Craik and Lockhart (1972) described why deep processing of the learning material leads to better knowledge than shallow strategies. However, it seems to be a problem to find indicators for deep processing. For example, Artelt (2000)

could show that there is no relationship between learners' self-reported strategies and their actual use. Therefore, we did not use questionnaires to measure learning strategies but tried to find objective measures. As a first explorative indicator we analyzed the number of mouse clicks the students did while using a computer program and the time for solving the tasks.

Predictions. We presented our students with four statistical tasks, which they had to solve in a certain time period. According to the literature, female students should differ from male students regarding their computer attitudes and computer self-efficacy. We took this into account in *Hypothesis 1*: Male students have a more positive initial motivation (more challenge, interest and probability of success, less anxiety) than female students. As we used statistical tasks as learning material, we controlled for differences in prior knowledge.

Hypothesis 2 covers all mediating variables: Male students are expected to have a more positive motivational state and to experience more flow (i.e., functional state). In addition, they use better strategies.

Hypothesis 3 postulates gender differences in computer performance: Male students solve more statistical problems with a computer program than female students.

Hypothesis 4 combines the single hypotheses and assumes causal relationships: Because male students have a more positive initial motivation and perhaps more knowledge about statistics they start already with better strategies and have more flow-experience and a more positive motivational state during learning. Thus, they outperform female students.

Method

Participants

Forty students (18 female, 22 male) from the Economics Department at the University of Frankfurt, Germany, participated in the study. They were enrolled in a statistics class, but had not been introduced to the SPSS-software. We chose this population as gender is equally distributed. Participants received € 7.00.

Procedure

We told prospective participants that they had a chance to learn about the SPSS software when they participated in our study. In the session we informed them that they had to work on four tasks (descriptive statistics, calculate a correlation, create a boxplot, create a histogram) using the SPSS-software. They had to solve them in a sequence as task difficulty increased. In total, they had thirty minutes for all tasks. Participants were interrupted every 10 minutes to measure their motivational and functional state. Following the instructions, we measured their initial motivation and their knowledge about statistics. We measured the process variables three times during the task.

Participants had to write down their solutions on a paper; for the graphical task they had to generate an output-file. For every correct feature in the task they scored one point. The total represents the performance measure for each individual.

Material

Knowledge about Statistics. To control for prior knowledge, we developed a multiple-choice questionnaire with nine items. If participants had learned the content of their statistics course well they would have been able to answer all the questions.

Initial Motivation. After reading the instructions, participants completed the QCM (*Q*uestionnaire of *C*urrent *M*otivation, by Rheinberg, Vollmeyer, & Burns, 1998). This questionnaire measures initial motivation on the four factors *probability of success* (example items: "I think I am up to the difficulty of the task", "I probably won't manage to do this task"), *anxiety* (example items: "It would be embarrassing to fail at this task", "I feel petrified by the demands of this task")*, interest* (example items: "After having read the instruction the task seems to be very interesting to me", "For tasks like this I don't need a reward, they are lots of fun anyhow."), and *challenge* (example items: "This task is a real challenge for me", "If I can do this task, I will feel proud of myself"). The answer format is a seven-point scale.

Mediating Variables. Three mediating variables were measured several times during learning.
(1) *Motivational state*. Participants answered eight items from the QCM every ten minutes, two for each scale. This reduction had the advantage that students were not interrupted for too long and the items became homogenous (Cronbach's α between .66 - .68).
(2) *Functional state*. To measure how much our participants got into flow when exploring the software, they filled in the FKS (*F*low *S*hort *S*cale, by Rheinberg, Vollmeyer, & Engeser, 2003) every ten minutes (example items "I am totally absorbed in what I am doing", "I know what I have to do each step of the way."). This scale consists of 10 items on a seven-point scale.
(3) *Strategy*. To obtain a rough indicator for what participants were doing, we counted the number of mouse clicks for each 10-minute period. To retrieve this information we used the program StatWin and also used Screen Virtuoso to videotape the students' learning. In addition, we took the time how long participants needed to finish each task (Time can also be regarded as performance measure).

Performance. As participants had to solve four tasks with 3 to 6 points each (in total 18), we calculated a total sum score by counting the points they had reached.

Results

Hypothesis 1. First, we tested whether male students have a more positive initial motivation (high interest, high challenge, high probability of success, low anxiety). or a better knowledge about statistics than female students. However, none of the means (see Table 1) was statistically different, all p's >.05. Therefore, we concluded that none of our variables, measured before working with the SPSS-software, could explain a potential effect of gender on performance. Hypothesis 1 had to be rejected.

Table 1: Descriptive statistics for the female ($n = 18$) and male students ($n = 22$) on knowledge about statistics, initial motivation, mediating and dependent variables.

	Gender	M	SD
Knowledge about Statistics	female	17.72	3.48
	male	19.64	4.70
Interest	female	4.28	0.94
	male	4.43	0.90
Challenge	female	5.33	1.04
	male	4.99	0.90
Probability of success	female	4.06	1.08
	male	4.61	0.84
Anxiety	female	3.66	0.97
	male	3.22	1.13
Motivational state (last 10 minutes)	female	4.19	0.82
	male	4.77	0.57
Functional state (flow) (last 10 minutes)	female	4.00	1.26
	male	4.62	0.87
Number of mouse clicks (last 10 min)	female(n=17)	41.53	22.52
	male (n=17)	76.24	23.65
Time on first task (in sec)	female (n=12)	861	432
	male (n=21)	476	493
Time on second task (in sec)	female (n=12)	318	239
	male (n=20)	241	207
Time on third task (in sec)	female (n=9)	354	165
	male (n=18)	345	219
Time on fourth task (in sec)	female (n=3)	378	160
	male (n=14)	282	118
Performance	female	5.86	4.35
	male	10.50	3.42

Hypothesis 2. As we had neither effects of prior knowledge about statistics nor initial motivation, we now regarded the mediating variables. For analyzing Hypothesis 2, we noticed that it took more male students ($n = 14$) less than 30 minutes to complete the tasks than female students, χ^2 (1) = 11.38, p < .001 (see Table 2). This result is complemented by the observation that only 12 out of 18 female students actually finished the first task, as compared to 21 out of 22 male

students. Among those students who finished the first task, male students had been faster than female students, $t(31) = 2.25$, $p < .032$, $d = 0.83$ (see Table 1). For the remaining three tasks, time on task was equal for male and female students, p's $> .20$. However, for each task, there were more male students who had completed it than female students. This produced missing data for the later time periods. Therefore, we decided to analyze the mediating variables for the individual's last ten minutes. For example, when students stopped working after 10 to 19 minutes, we looked at their motivation questionnaires that had been completed prior to this period, which was, in this case, the initial measure (0 – 10 minutes).

Another problem occurred that six protocols were incomplete. Therefore, only 34 out of 40 could be used for analyzing strategies.

First, we looked at the differences between male and female students concerning the mediating variables (see Table 1). As the number of participants is unequal at each time point, we report the means for each individual's last round. On the variables motivational and functional state male students report a higher motivation and a higher flow-experience than female students (motivational state: $t[38] = 2.61$, $p = .013$, $d = .82$; functional state: $t[38] = 1.80$, $p = .079$, $d = .57$). This result partially confirms the second hypothesis.

As an indicator for strategies, we used number of mouse clicks. However, at this time of our research, it is hard to say whether more or less mouse clicks are an indicator for a good strategy. Using this weak indicator, we found that male students had more mouse clicks than female students when exploring SPSS ($t[32] = 4.38$, $p < .001$, $d = 1.50$, see Table 1). These results can be summarized that, although male and female students had the same initial motivation, females' motivation and flow was already lower than males' after 10 minutes. In addition, they explored the program less than male students. Thus, Hypothesis 2 was confirmed.

Table 2: Number of male or female participants finishing before 30 minutes vs. working until the end.

	finishing	
	before 30 minutes	at the end
female	2	16
male	14	8

Hypothesis 3., We tested whether male students had an advantage in solving the four statistical tasks. We found a strong effect, $t(38) = 3.78$, $p < .001$, $d = 1.19$, that male students reached about 11 out of 18 points, but female students only 6 points (see Table 1).

Hypothesis 4. As gender affected neither initial motivation nor knowledge about statistics (Hypothesis 1) we restated the fourth hypothesis saying that gender affects performance through the mediating variables (i.e., motivational and functional state, strategies).

To test this assumption we calculated a path analysis ($n = 34$) The basis for the path analysis are the correlations between gender, mediating variables (always individual's last 10 minutes) and performance as shown in Table 3.

Table 3: Correlations between gender, process variables and performance (r, p).

	2	3	4	5
Gender (1)	-.38	-.31	-.61	-.54
	.025	.077	<.001	.001
Motivational state (2)		.55	-.08	.61
		.001	.65	<.001
Flow (3)			-.23	.55
			.19	.001
Mouse clicks (4)				.06
				.74
Performance (5)				

The theoretical model presumed that gender affected each of the mediating variables (i.e., number of mouse clicks, motivational and functional state), and that these variables affected performance. However, as was obvious from the correlations (see Table 3), the number of mouse clicks do not affect performance. So, to solve the tasks, it does not matter, whether a student looks at many features and tries many different options. Therefore, we dropped the link from mouse clicks to performance and instead had a direct link from gender to performance. The path analysis in Figure 1 shows the empirically gained model for which, as expected, the X^2-test is not significant, $X^2(1) = 0.58$, $p = .49$. This model has a good model fit, GFI =.99, CFI = 1.00, RMSEA = .001.
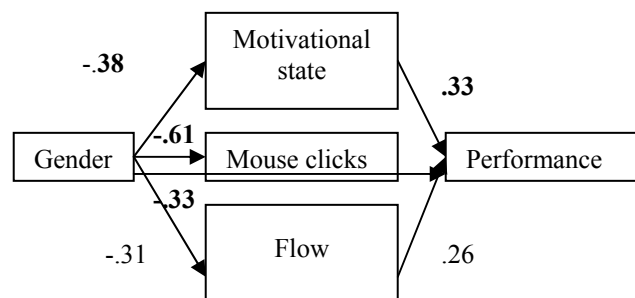

Figure 1: Path analysis of the variables explaining performance in using SPSS. (Numbers printed bold $p < .05$, others $p < .10$)

The model in Figure 1 demonstrates that indeed motivational and functional state are mediating variables: Male students are more motivated during learning and are more likely to experience flow than female students. These positive states facilitate performance, in this case to solve more tasks with the SPSS-program. However, beside the motivational and functional state, there is still an

unexplained link between gender and performance. Contrary to expectation the number of mouse clicks cannot explain the gender effects on performance and, thus, cannot be regarded as mediating variable. This result needs more explorative analyses.

Explorative Analyses. To find an explanation, why female students were less motivated already after 10 minutes into the task, we analyzed this first time period. In the first 10 minutes, 11 males and 12 females had found the button "Means" in the SPSS menu and had clicked on it (for males after $M = 120$ sec [$SD = 105$], for females after $M = 212$ sec [$SD = 192$], $t[21] = 1.42$, $p = .17$, $d = .60$). Although not significant, this difference has a medium effect size. It took the remaining four female students longer than the seven male students to press the "ok"-button in the menu "means" (for males $M = 199$ sec [$SD = 124$], for females $M = 281$ sec [$SD = 111$], $t[9] = 1.09$, $p = .31$, $d = .69$). These results demonstrate that it was harder for female students to understand the structure of the program, whereas male students seem to familiarize themselves more quickly with the program's surface. Although females click less often, this strategy cannot be regarded as the reason for their poorer performance (see path analysis).

Interestingly, male students were more motivated during learning even if they experienced failure. This conclusion can be deducted from Figure 2. As male students finish the task faster, their number decreases (see Table 2). It could be expected that the remaining male participants approach the same motivational state as the female students (after 20 or 30 minutes); however, their motivation is still as high as after 10 minutes. The same pattern was also found with the flow-measure.
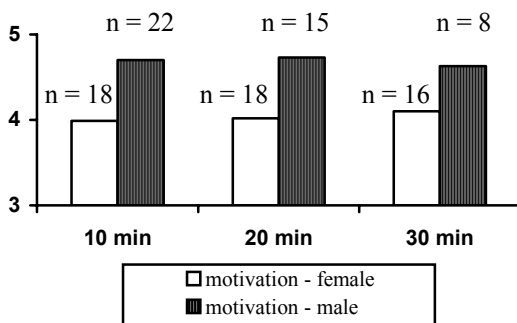

Figure 2: Motivational state while working on SPSS-tasks.

Discussion

The aim of this research was to investigate whether female students are at a disadvantage compared to male students when working with the computer. However, we not only wanted to describe this effect, we also wanted to explain it. We chose a student population, who was asked to solve statistical tasks with the SPSS-Software. We found that male students solved more statistical tasks than female students. Why did this expected disadvantage occur? When working with this statistical program, male and female students could already differ *before* they even start working. However, we could not find any differences in either knowledge about statistics or in initial motivation. Male students and female students estimated the challenge, their interest, their anxiety, and their probability of success at similar levels. It is especially interesting that we did not detect differences in probability of success. This aspect is similarly operationalized as self-efficacy, a construct for which gender differences have been reported rather frequently.

If there are no differences between males and females' attitudes and prior knowledge, it is necessary to look carefully at what happened in the 30-minutes learning period. According to the cognitive-motivational process model, we measured strategy and motivational and functional state every ten minutes. In doing this, we observed that already after ten minutes female students were less motivated and explored fewer features of the program (i.e., number of mouse clicks). Whereas a lower motivational and functional state was detrimental for learning, the number of mouse clicks did not influence performance. In the first ten minutes, females had problems to find the menu that they needed to complete the first task; in general it took them longer to answer the first out of four tasks.

On the basis of this result, it could be argued the females' failure during learning is responsible for their poorer learning outcome, as opposed to their low motivation during learning. To disentangle these influence variables it would be necessary to run a study with more participants so that a path analysis can be calculated. For the data of this study we would argue that motivational and functional state play an important role during learning, as male students who experienced similar failure than female students reported a higher motivation than female students.

To conclude, although initial motivation was similar between male and female students, they could not use the features of the program in the same way. Males enjoyed the computer work more than females. But why was it more easy for males to find the correct features? To answer this question, further studies should investigate computer use, a variable on which female and male students still differ, especially in using computers for private purposes (Imhof et al., 2005). Maybe male students have developed broader knowledge which they can access to better examine unknown programs.

Drawing on these conclusions, we want to address two issues: (1) improvement of the methods, and (2) remarks for the educational setting.

Improvement of the Methods. The measure that was used as an indicator for strategies was not satisfactory. As a rough indicator for deep versus shallow strategies, we counted the number of mouse clicks. Even when formulating the hypotheses we did not know whether many mouse clicks were indicative of a deep or a shallow strategy.

Now after analyzing the data it is safe to say that number of mouse clicks is not a valid indicator as it did not correlate with any performance measure. In this study we had used videos (ScreenVirtuoso) to explore how students use the SPSS-program, but as too many videotapes were incomplete, we have not enough statistical power for analyses. Therefore, further research should look for a valid measure of strategy and include observational data.

Remarks for Educational Settings. In this study, there was no evidence that male and female students differed before starting to work with the computer. Therefore, interventions should focus on the learning period. Female students need to be prepared that experiencing failure during work with an unknown computer program should not decrease their motivation. Therefore, they need some advice how to monitor their motivation in self-regulated learning environments. In addition, they need strategies how to explore an unknown program in a self-regulated learning task.

Acknowledgments

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