Computer usage questionnaire: Structure, correlates, and gender differences

Ulrich Schroeders *, Oliver Wilhelm

Humboldt-Universität zu Berlin, 10099 Berlin, Germany

Abstract

Computer usage, computer experience, computer familiarity, and computer anxiety are often discussed as constructs potentially compromising computer-based ability assessment. After presenting and discussing these constructs and associated measures we introduce a brief new questionnaire assessing computer usage. The self-report measure consists of 18 questions asking for the frequency of different computer activities and software usage. Participants were N = 576 high school students who completed the questionnaire and several covariates. Based on theoretical considerations and data driven adjustments a model with a general computer usage factor and three nested content factors (Office, Internet, and Games) is established for a subsample (n = 379) and cross-validated with the remaining sample (n = 597). Weak measurement invariance across gender groups could be established using multi-group confirmatory factor analysis. Differential relations between the questionnaire factors and self-report scales of computer usage, self-concept, and evaluation are reported separately for females and males. It is concluded that computer usage is distinct from other behavior oriented measurement approaches and that it shows a diverging, gender-specific pattern of relations with fluid and crystallized intelligence.

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In order to capitalize on the promising possibilities of computer-based ability measurement, such as enriching test material with videos and interactive elements (Dragshaw & Mattern, 2006), there is a trend to transfer paper-based ability measures to computers. In the course of this transition, a major concern is to ensure comparability of data gathered on different test media. In the last decades, several factors contributing to differences in performance across test media have been discussed and identified (Leeson, 2006). Some of these factors primarily deal with the specific hardware or software realization such as screen size and resolution (Bridgeman, Lennon, & Jackenthal, 2003). Other factors of performance differences across test media are person centered. For example, the individual differences in coping with the demands of computerized testing have been recognized such as computer anxiety and to measure. For instance, which construct is tapped by degrees of endorsement to a statement such as “I feel like a fool when I am using a computer and others are around”? The ambiguity exemplified by this item taken from the CAAFI (Computer Aversion, Attitudes, and Familiarity Index; Schulenberg, Yutrzenka, & Gohm, 2006) is not unique and similar items can be found in other questionnaires designed for assessing computer-related constructs. As constructs potentially compromising computer-based ability assessment, after presenting and discussing these constructs and associated measures we introduce a brief new questionnaire assessing computer usage. The self-report measure consists of 18 questions asking for the frequency of different computer activities and software usage. Participants were N = 576 high school students who completed the questionnaire and several covariates. Based on theoretical considerations and data driven adjustments a model with a general computer usage factor and three nested content factors (Office, Internet, and Games) is established for a subsample (n = 379) and cross-validated with the remaining sample (n = 597). Weak measurement invariance across gender groups could be established using multi-group confirmatory factor analysis. Differential relations between the questionnaire factors and self-report scales of computer usage, self-concept, and evaluation are reported separately for females and males. It is concluded that computer usage is distinct from other behavior oriented measurement approaches and that it shows a diverging, gender-specific pattern of relations with fluid and crystallized intelligence.

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a new measure actually reflects a new construct. Testing for novelty of a construct requires evidence showing that a construct is both different from a single established construct and from combinations of various established constructs as well. Losing sight of the possibility that a supposedly new construct is actually a familar one under disguise is known as Jangle fallacy (Kelley, 1927; Wilhelm, 2009). The construct CU – operationalized as the extend someone is engaged with specific computer programs and activities – is clearly defined and could easily be assessed. This conceptualization of CU is neither a prototypical self-report because participants are not asked to express their agreement or disagreement. Nor is the CU questionnaire a prototypical ability measure. Instead CU is behavior-based by asking how frequently computers are used for specific purposes. Obviously, such behavior-based measures do not ask about perceived causes of a specific behavior.

1.1. Research questions

The new questionnaire focuses on the behavioral aspect of computer usage. More precisely, it relies on how frequently specific software packages are used and how often specific computer activities are carried out. We hypothesize that CU is not a unidimensional construct, and that salient groups (notably, females vs. males) might use computer technology for different purposes. Therefore, a description of factors of computer usage might vary across gender groups. Bearing in mind the potentially qualitative difference of CU across gender it is relevant to examine how CU is related to measures inquiring about computer-related attitudes or self-concept. Furthermore, the relationship to biographical facts of CU such as the overall time spent with computers is of interest.

More formally, our research questions are as follows: First, can we establish a measurement model of the computer usage questionnaire (CUQ) with a general CU factor and a variety of nested factors assessing special content domains? Second, are there qualitative differences between gender groups? The answer to this question includes testing the established model for measurement invariance across gender groups as tested by multi-group confirmatory factor analysis. Third, we claim that the general CU factor cannot be explained through variables such as (a) time of computer usage (both as hours per week and years since first use of a computer), (b) access to computers (at school, at home, etc.), (c) number of electronic devices at one’s disposal, (d) self-perceived computer expertise, and (e) a cognitive appraisal of computers. Fourth, we want to check for differential relations between factors of the CUQ questionnaire and both fluid and crystallized intelligence - if necessary separately for females and males – to gain further insight into the measured concept.

2. Method

2.1. Participants

Participants were 976 German high school students (intermediate-track Realsschule and academic-track Gymnasium, 9th and 10th grade) who worked on a German version of the CUQ and all covariates. The mean age of participants was 15.9 years (SD = .71) and 493 were females.

2.2. Measures

The CUQ (see Appendix A) is composed of two sets of questions asking for the frequency of usage of applications (“How often do you use word processing software (e.g., Word)?”) or the frequency of special activities (“How often do you surf the Internet?”). The answer had to be given on a five-point rating scale with the categories never, rarely, sometimes, often, and very often.

Additional information about the average number of hours per week and overall years of computer experience, access to computers (e.g., in school or at home), and the number of different computer devices used (e.g., Playstation/X-Box/Wii or Computer/Laptop) is inquired. Participants were also asked to express their degree of consent with ten statements covering self-concept of computer skills (e.g., “In comparison to my contemporaries my computer skills are superior”) and evaluation of computers (e.g., “The significance of computers is nowadays heavily overrated”).

A newly developed measure for fluid and crystallized intelligence was implemented as well (BFEK; Wilhelm, Schroeders, & Schipolowski, 2009). To assess fluid intelligence we used Char-kow-style items because the figural content has been postulated to be a prototypical fluid intelligence task (Horn & Cattell, 1966). The test for crystallized intelligence is a test of declarative knowledge covering three broad content domains (natural sciences, humanities, and civics) with a total of 64 multiple-choice items.

2.3. Design/procedure

The questionnaire and all covariates were included in two computer-based studies assessing language proficiency in English as a foreign language. In study 1, all participants (n = 379) worked on a computerized version of the questionnaire, whereas in study 2 the test medium was randomly assigned to participants (n = 597). The two studies were different with respect to the tasks assessing language proficiency but identical with respect to all the covariates considered here. Given the fact that we had no prior experience with the CUQ we allowed for data driven modifications in the measurement model we proposed. These modifications were introduced for study 1 and replicated with the second sample. All analyses subsequent to establishing the measurement model are based on the total sample of N = 976 participants. Missing values were imputed with an Expectation–Maximization algorithm.

3. Results

This results section has four parts corresponding to our research questions. First, we look at competing measurement models for the CU self-reports. Second, we test for qualitative differences between gender groups using multi-group confirmatory factor analysis. Third, we explore how the CUQ correlates with related constructs. Fourth, we check for differential relations between the factors of the CUQ and intelligence.

Let us now turn to the competing measurement models. We expected that the use of computers expresses the interests or obligations of computer users. Some users might be obligated to work with spreadsheets, others take an interest in editing the snapshots of their last summer holiday. Some computer activities and the corresponding changes in expertise may be more desirable than others (e.g., programming vs. gaming). Nevertheless, four broad categories seemed sufficient to describe the scope of computer activities inquired in the questionnaire: (a) using classical office products (e.g., word and spreadsheet processing), (b) activities involving the Internet (e.g., chatting), (c) gaming, and (d) advanced computer activities, mostly multimedia (e.g., sound editing). One way to capture the expected structure of the questionnaire was to specify a model with a general factor and three additional factors, each representing a different content domain. The content factors – Office, Internet, and Games – were orthogonal to the general factor and to each other. The factor Multimedia was set as reference because it seemed to prototypically instantiate CU.
Accordingly, in the proposed measurement model all indicators contribute to a general latent variable, labeled general CU, and to one of three nested factors named Office, Internet, and Games, respectively, except for the Multimedia items which only load on the general factor. In addition to this setup of the model, two types of adjustments had to be made. First, we allowed for residual correlations between corresponding variables that actually inquired for identical or highly similar activities (e.g., “How often do you use a chat program?” and “How often do you chat?”). Second, three items loaded on two method factors (e.g., online gaming covers both factors Internet and Games).

Fig. 1 shows the empirically adjusted model that yielded good model fit for the first sample \(\chi^2(114, n = 379) = 240.2, \text{CFI} = .963, \text{RMSEA} = .054\). This model was also estimated for the second sample that was considered for cross-validation purposes. The model fit was essentially identical and acceptable \(\chi^2(114, n = 597) = 293.4, \text{CFI} = .962, \text{RMSEA} = .051\). All factor loadings and variances in both studies were statistically significant. Therefore, we accepted the specified measurement model as a starting point for subsequent analyses.

The second research question was whether qualitative differences between females and males exist. We did not distinguish between female and male participants in establishing the measurement model. To know which comparisons between females and males are feasible it is necessary to validate the invariance of the measurement instrument across gender (e.g., Little, Card, Slegers, & Ledford, 2007; Wu, Li, & Zumbo, 2007). An adequate statistical method to test for equivalence across gender is multi-group confirmatory factor analysis in which a set of increasingly strict constraints of equality are imposed on the parameters of the measurement models for females and males, respectively. Here, different levels of invariance are assessed with a hierarchical procedure comparing four multi-group models in a fixed order, from the least to the most restrictive model. In the first step, also referred to as configural invariance, all measurement parameters are freely estimated and only the overall configuration of the model is identical. If the model fails, all subsequent steps are unnecessary. Metric invariance (step 2) is achieved if constraining the factor loadings to be equal in both gender groups provides adequate model fit. This condition is a prerequisite for meaningful cross-group comparisons. The third step tests for scalar invariance by fixing the intercepts in both groups to equality on top of the restrictions of step 2. Only if this level of invariance is reached, potential differences in the means of the latent variables are interpretable. In the most restrictive model (step 4) all measurement parameters – factor loadings, intercepts, and residual variances – have to be equal. In

![Diagram](image-url)

Study 1: \(\chi^2(114, n = 379) = 240.2, \text{CFI} = .963, \text{RMSEA} = .054\)
Study 2: \(\chi^2(114, n = 597) = 293.4, \text{CFI} = .962, \text{RMSEA} = .051\)
Combined sample: \(\chi^2(114, N = 976) = 396.5, \text{CFI} = .965, \text{RMSEA} = .050\)
All parameter estimates were derived from the combined sample.

Fig. 1. The empirically adjusted measurement model with three nested content factors and a reference domain. Note. CFI, Comparative fit index. RMSEA, Root mean square error of approximation. Variable labels refer to the labeling in the questionnaire (see Appendix A). Study 1: \(\chi^2(114, n = 379) = 240.2, \text{CFI} = .963, \text{RMSEA} = .054\). Study 2: \(\chi^2(114, n = 597) = 293.4, \text{CFI} = .962, \text{RMSEA} = .051\). Combined sample: \(\chi^2(114, N = 976) = 396.5, \text{CFI} = .965, \text{RMSEA} = .050\). All parameter estimates were derived from the combined sample.
Correlations of the questionnaire scales with related and unrelated constructs.

Table 2

<table>
<thead>
<tr>
<th>Step</th>
<th>Model</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>CFI</th>
<th>RMSEA</th>
<th>RDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Configural invariance</td>
<td>517.1</td>
<td>229</td>
<td>.963</td>
<td>.051</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Metric invariance</td>
<td>633.1</td>
<td>259</td>
<td>.951</td>
<td>.054</td>
<td>.054</td>
</tr>
<tr>
<td>3</td>
<td>Scalar invariance</td>
<td>752.1</td>
<td>273</td>
<td>.938</td>
<td>.060</td>
<td>.088</td>
</tr>
<tr>
<td>4</td>
<td>Strict factorial invariance</td>
<td>910.9</td>
<td>295</td>
<td>.920</td>
<td>.065</td>
<td>.080</td>
</tr>
</tbody>
</table>

Note. Reported RDR values (Browne & DuToit, 1992) relate the model fit of two successive models. \( N = 976 \).

\( ^* \) Comparative fit index.
\( ^{**} \) Root mean square error of approximation.
\( ^{***} \) Root deterioration per restriction \( (RDR = \sqrt{(\chi_1^2 - \chi_0^2)/\chi_0^2}) \).

Table 2 shows the correlations of the general computer usage scale and the content domains, respectively, with all covariates.

The third and fourth research questions dealt with the relationship between the CUQ factors and the covariates. More precisely, the third research question asked to what extend individual differences in CUQ factors can be accounted for by the following computer-related variables: (a) time of computer usage (both as hours per week and years since first use of a computer), (b) access to computers (at school, at home, etc.), (c) number of electronic devices at one’s disposal, (d) self-perceived computer expertise, and (e) the cognitive appraisal of computers. The fourth research question examined the differential relations between the CUQ constructs and both fluid (gf) and crystallized (gc) intelligence.

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Table 2 shows the correlations of the general computer usage scale and the content domains, respectively, with all covariates. The general CU factor was substantially correlated with convergent constructs such as the self-rated computer expertise (female: \( \rho_{CU, \text{comp.exp.}}(493) = .58, p < .01 \), vs. male: \( \rho_{CU, \text{comp.exp.}}(483) = .67, p < .01 \)). It was also moderately correlated with a positive appraisal of computers (female: \( \rho_{CU, \text{pos.appra.exp.}}(493) = .28, p < .01 \), vs. male: \( \rho_{CU, \text{pos.appra.exp.}}(483) = .25, p < .01 \)). The moderate correlation to the three manifest variables – time of computer usage, access to computers, and number of electronic devices – clearly indicates that CU is more than a simple function of these environmental variables. Only about 10% of the variance in the CU factor can be explained by regressing CU on these variables (female: \( R^2 = .09 \); male: \( R^2 = .12 \)), that is, the linear combination of the access to computers, the number of electronic devices, and the time spent using computers hardly determines the level of CU. Apart from relations with the general CU factor there was a stronger association for the content factor \( \text{Internet} \) – more than 16% of the variance was explained by the three environmental variables (female: \( R^2 = .18 \); male: \( R^2 = .16 \)).

The fourth research question concerned the relation of the CUQ scales with intelligence. We modeled crystallized intelligence as nested below fluid intelligence. Crystallized intelligence is negatively correlated with general CU in both groups. The negative correlation of fluid intelligence and CU was only significant in the female group (\( \rho_{CU, g_f}(493) = -.25, p < .01 \)). Comparing the correlations of the content domain factors with intelligence across gender groups, the high positive correlation between \( \text{Office} \) and fluid intelligence in the female group is remarkable (\( \rho_{Office, g_f}(493) = .38, p < .01 \)), whereas the same correlation is significantly lower and not statistically different from zero in the male group (\( \rho_{Office, g_f}(483) = .10, p = .15 \), Satorra-Bentler adjusted \( \Delta \chi^2(1) = 6.7, p = .01 \), see notes Table 2).
4. Discussion

Based on theoretical considerations and data driven adjustments we established a measurement model with a general computer usage factor and three nested content factors – Office, Internet, and Games. Using multi-group confirmatory factor analysis we found that gender considerably influence the construct of CU. In future research, the content- and gender-specificity has to be taken into account when considering CU as covariate in computer-based assessment. With this article we also want to argue for the use of CFA and multi-group CFA in the development of new measures in order to approach questions on validity. The CUQ showed significant relations to self-rated computer expertise, cognitive appraisal of computers and other computer-related covariates (e.g., usage time or accessibility). With respect to our introductory notion – that different person characteristics that may affect performance on a computer-based ability measure are reflected in the usage of computers, these positive relations might be interpreted as evidence for the validity of the construct.

One unanswered question is how computer-related constructs causally depend on each other. Do attitudes towards computers cause the quantity and quality of CU or is it the other way around? How strong are these relations? And how do self-perceived computer expertise and other computer-related constructs fit into the picture? A longitudinal study assessing different computer-related constructs in combination with performance data would provide valuable information about the interdependencies. One of our predictions is that both quantity and quality of CU are even moderately associated with academic success. Presumably, this relation is partly mediated through other constructs such as intellectual engagement or need for achievement.

One important and potentially controversial finding is that the gender of participants is a variable that has to be taken into consideration when discussing CU. Differential relations of the CUQ factors with criteria for the female and the male group emphasize the differences in construct meaning for the two groups. For instance, the correlations between the Office factor and intelligence diverge significantly. While boys’ usage of computers in general and in specific domains is independent of intelligence, for girls the usage of office programs is associated with intelligence. Obviously, the causal direction of this correlation is ambivalent. On the one hand, engagement in office products may positively affect intelligence, that is, the direction of this correlation is ambivalent. On the other hand, more intelligent girls might be tempted or obligated to use office software more frequently. However, it should be kept in mind that the magnitude of this relation must be seen relative to the negative correlation between general CU and fluid intelligence for girls.

Another potentially controversial and surprising finding deals with the low relation of the other specific CUQ factors with intelligence. Correlations between the factors Internet and Games and intelligence are not distinct from zero. This means that no positive or negative effect of gaming on the intelligence is identifiable – contrary to the widely held, but rarely empirically tested opinion (e.g., van Schie & Wiegman, 1997). However, in an extreme group of teenagers that are addicted to computer gaming or extensive use of social networking services these relations might be different because the specific usage of computers interferes with scholastic development.

Otherwise, CU could also support competency development in a group of teenagers that are extremely devoted to a scholastic discipline and use computers accordingly and intensively. Also the gender-specific relationships between the content factors and positive appraisal of computers are intriguing: For girls the correlation with Internet is higher than for boys (female: $\rho_{\text{Internet, pos. appraisal}}(493) = .60$, vs. male: $\rho_{\text{Internet, pos. appraisal}}(483) = .32$, $p < .01$, $\chi^2(1) = 12.4$, $p < .01$) whereas for boys the correlation with Games turned out to be higher (female: $\rho_{\text{Games, pos. appraisal}}(493) = .11$, vs. male: $\rho_{\text{Games, pos. appraisal}}(483) = .42$, $p < .01$, $\chi^2(1) = 15.5$, $p < .01$). However, these gender-specific relations must not be misinterpreted in terms of differences in latent means.

It is necessary to keep in mind two possible limitations of this study: First, new computer technologies and software products permanently evolve and for this reason computer-related constructs such as CU are changing rapidly, too. Consequently, measures assessing these constructs are more prone to be outdated than measures covering more stable personality traits. On the one hand, more and more activities are carried out using computers, for example, reading an online newspaper with a mobile device or online shopping. On the other hand, there is a change in existing computer activities. For instance, creating a blog entry requires more than simple word processing. In addition to the actual writing process one surfs the web in search of topics, answers comments to a blog entry, and uses an FTP-client to upload the content. The second limitation applies to the fact that not only the computer-related constructs are changing but also the ability to work with computer technology in the population. We investigated a homogenous sample of 15-year-old high school students which limits the generalizability of the findings. For instance, relative to these teenagers older persons will use computers in different ways and for other purposes. Accordingly, the underlying structure of CU is likely to be different, too. It is important to point out that these differences are rooted in the construct and persist even if we restrict the measurement instrument to survey questions about the number of electronic devices, et cetera.

Taken together, the CUQ is a new, psychometrically sound, and behavior-based measure to assess computer experience that can be used either as a covariate in computer-based measurement or as an outcome measure itself. Usually differences in performance data gathered on different test media are explained either through measures of typical behavior (e.g., rating the acceptance of computer-based testing), measures of maximal behavior (e.g., computer-related knowledge) or background variables (e.g., availability of computers). Classical survey questions – comparable to the ones we used as covariates in our study – are inappropriate to comprehensively assess CU. The construct is more complex because computers are just tools to achieve specific goals such as seeking information, social networking, working or spending one’s leisure time. The CUQ is a measure that taps how teenagers actually use information technology. Rather than assessing whether they enjoy working with computers, experience self-efficacy, or have access to information technology it is crucial to ask teenagers what they do with a computer and how intense this usage is.

Appendix A. Computer usage questionnaire (CUQ)

<table>
<thead>
<tr>
<th>(1) How often do you use the following programs?</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Word processing (e.g., Word)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Spreadsheet (e.g., Excel)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(c) Presentation program (e.g., Powerpoint)</td>
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<tr>
<td>(d) Programming language (e.g., ...)</td>
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</table>

(continued on next page)
Appendix A (continued)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Never</th>
<th>Rarely</th>
<th>Some times</th>
<th>Often</th>
<th>Very often</th>
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<tbody>
<tr>
<td>(e) Graphics software</td>
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<tr>
<td>(f) Sound or video editing software</td>
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<td>(g) e-mail client</td>
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<td>(h) Chat program</td>
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<tr>
<td>(i) Web browser</td>
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<tr>
<td>(j) Games</td>
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</tbody>
</table>

(2) How often do you perform the following computer activities?

(a) Creating a presentation
(b) Programming
(c) Sound editing
(d) Writing e-mails
(e) Chatting
(f) Surfing the web
(g) Playing alone
(h) Playing online

References


