Is Computer Support More Significant than Collaboration in Promoting Self-Efficacy and Transfer?

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Abstract: In the learning sciences, we assume that deep learning is more likely to occur in complex social and technological environments. Deep learning, in turn, is related to higher degrees of transfer and self-efficacy. It follows that population correlation estimates of the relationship between self-efficacy and training transfer should be higher in those conditions that afford computer support and collaboration. This meta-analysis (29 studies, $k = 33$, $N = 4,158$) tested this assumption. Based on social cognitive theory, results suggested positive population correlation estimates between self-efficacy and transfer ($\rho = 0.39$). Results also showed that effect sizes were higher in trainings with rather than without computer support, and higher in trainings without rather than with collaboration. These findings are discussed in terms of their implications for theories of complex social and computer-mediated learning environments and their practical significance for scaffolding technology-enhanced learning and interaction.

Introduction
In the learning sciences, we assume that deep learning is more likely to occur in complex social and technological environments (Sawyer, 2006). Deep learning, in turn, is related to higher degrees of transfer (Pugh & Bergin, 2006) and self-efficacy (Bandura, 1997). It follows that estimates of the relationship between self-efficacy and transfer of training should be higher in those conditions that afford computer supported collaborative learning (CSCL). To test the predictive validity of this assumption, the present meta-analysis sets out to investigate whether higher population correlation estimates between self-efficacy and transfer are found in training conditions that afford computer support and collaboration compared with other training conditions.

Self-Efficacy and Transfer of Training
Self-efficacy refers to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Efficacy beliefs are among the most widely documented predictors of achievement, which has been documented in domains including sports (Trost, Ow, Bauman, Sallis, & Brown, 2002), work (Stajkovich & Luthans, 1998), and education (Nelson & Ketelhut, 2008; Van Dinther, Dochy, & Segers, 2011). According to social cognitive theory (Bandura, 1997), people with high self-efficacy set high and demanding goals; these goals create negative performance discrepancies to be mastered (Bandura, 2001). Expectations about the perceived efficacy of one’s capability to master those discrepancies regulate whether effort is initiated, how much continuous effort is expended, and whether effort is maintained or even increased in face of difficulties during goal attainment. Because the power of self-efficacy to predict task achievement has been so widely documented (Bandura, 1997; Bandura, 2001; Efklides, 2011; Gegenfurtner, 2011; Gegenfurtner, Festner, Gallenberger, Lehtinen, & Gruber, 2009; Gegenfurtner & Vauras, 2012; Gegenfurtner, Vauras, Gruber, & Festner, 2010; Gegenfurtner, Veermans, Festner, & Gruber, 2009; Juntila, Vauras, & Laakkonen, 2007; Sadri & Robertson, 1993; Trost et al., 2002; Van Dinther et al., 2011; Zimmerman, 2000), it seems reasonable to assume that self-efficacy also predicts the initiation, expenditure, and maintenance of efforts toward transfer of training.

Transfer of training can be defined as the productive use of newly acquired knowledge and skills (De Corte, 2003). If it is true that efficacy beliefs predict sufficient execution of effort to achieve successful outcomes, it follows that efficacy beliefs should also predict successful transfer of training. However, the literature shows mixed evidence. For example, some investigations showed high correlation estimates between self-efficacy and training transfer (Yi & Davis, 2003), while other investigations suggested that the magnitude of this relationship is negligible (Brown & Warren, 2009). One possible explanation for the mixed evidence is the influence of sampling error and error of measurement (Hunter & Schmidt, 2004) that may have induced biases on the true score population correlation. Therefore, one aim of the present study was to use meta-analytic methods to inquire whether performance self-efficacy, after controlling for sampling error and error of measurement, exhibits a stable influence on transfer and whether this relationship would be higher after training than before training. Another possible explanation for the mixed evidence is that population correlation estimates have been moderated by different study conditions. As Kanfer (2005) argued, identification of boundary conditions has important implications for testing the predictive validity of social cognitive theory. Therefore, a second aim of the study was to identify and estimate the boundary conditions under which self-
efficacy and training transfer correlate. Inquiring into these characteristics as boundary conditions is significant, because it enables accounting for artifactual variance in the total variance of a correlation, which, in turn, may explain some of the disagreements in the existing literature. Two boundary conditions were analyzed: computer support and collaboration.

**Computer-Supported Collaborative Learning**

The rationale for choosing CSCL as boundary conditions was derived from a belief in the learning sciences that “deep learning is more likely in complex social and technological environments” (Sawyer, 2006, p. 13). Deep learning, in turn, is related to higher degrees of transfer (Pugh & Bergin, 2006) and self-efficacy (Bandura, 2001). If these assumptions hold, it follows that population correlation estimates of the relationship between self-efficacy and training transfer should be higher in those conditions that afford CSCL. Conditions for CSCL can be examined as (1) computer support and (2) collaboration. For the purpose of this article, computer support was defined as technological material in learning environments intended to promote understanding (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999); collaboration was broadly defined as the working-together of two or more individuals to attain the shared training goals and task at hand (Dillenbourg, 1999). We acknowledge substantial variation in how the term ‘collaboration’ is defined in the literature (for an overview, see Dillenbourg, 1999; Volet, Vauras, & Salonen, 2009). We use the term ‘collaboration’ here for the sake of simplicity and do acknowledge gradual nuances in how key conditions of the nature of joint working (e.g., shared goals, co-construction of knowledge, co-regulation, etc.) are reflected in prior literature to capture different sociopsychological processes of interpersonal coordination and their relation to actualizing motivation in training situations (Vauras, Salonen, & Kinnunen, 2008). An example of training including both computer support and collaboration is reported by Day and colleagues (2007), who trained participants with a collaborative computer game. An example of a training including computer support but no collaboration is Yi and Davis’s (2003) study, in which they trained participants to use computer software individually and without interaction among trainees. An example of a training including no computer support but collaboration is Gibson’s (2001) description of nursing team training, which included group discussions, brainstorming, and peer assessment. Finally, an example of a training program including neither computer support nor collaboration was a study by Karl, O’Leary-Kelly, and Martocchio (1993), in which participants were trained in a speed-reading skill individually with paper handouts. If it is true that complex social and technological environments promote self-efficacy and transfer (Bandura, 1997; Pugh & Bergin, 2006; Sawyer, 2006), then it follows that population correlation estimates should be higher in conditions with computer support rather than in conditions without and in conditions with collaboration rather than without. Importantly, population correlation estimates should be highest in conditions affording both computer support and collaboration. Figure 1 illustrates these four conditions. The top-left quadrant represents training conditions that neither afford computer support nor collaboration; it is thus assumed to have no particular positive effects. The bottom-left quadrant represents training conditions that afford computer support but no collaboration. The top-right quadrant represents training conditions that afford collaboration, but no computer support. Finally, the bottom-right quadrant represents training conditions that afford both computer support and collaboration. Conditions of CSCL here are understood from a systemic perspective (Arnseth & Ludvigsen, 2006). Examination of computer support and collaboration as boundary conditions can contribute to our understanding of how reshaping traditional training by technological media is related to trainee motivation and transfer on the job (Tynjälä & Häkkinen, 2005).

![Figure 1: Hypothesized effects of study conditions on the relationship between self-efficacy and transfer.](image-url)
The Present Study—Hypotheses
In summary, the focus of the present study was the relationship between performance self-efficacy and transfer of training. The first aim was to cumulate previous research in order to correct the size of true score population correlations. A second aim of the study was to estimate the moderating effects of computer support and collaboration. Two hypotheses were formulated. Based on social cognitive theory (Bandura, 1997), we assumed that transfer of training would be positively related with performance self-efficacy (Hypothesis 1). Based on the assumption that deep learning is more likely to occur in complex social and technological environments (Sawyer, 2006), we hypothesized that the relationship between self-efficacy and transfer would be more positive in training conditions affording computer support and collaboration (Hypothesis 2).

Method

Literature Searches and Criteria for Inclusion
To test these hypotheses, we used meta-analytic methods (Hunter & Schmidt, 2004). Studies that reported correlations between performance self-efficacy and transfer of training were located. To be included in the database, a study had to report an effect size \( r \) or other effect sizes that could be converted to \( r \) (\( \beta \) coefficient; Cohen’s \( d \); \( F \), \( t \), or \( Z \) statistics). Formulae reported in Peterson and Brown (2005; formula c) and Rosenthal and DiMatteo (2001) were used to convert effect sizes. Because the focus of inquiry was on self-efficacy as an individual capacity (Bandura, 1997), the database included studies that reported data on individuals. Studies reporting data on group efficacy were omitted. Studies on children as well as animal studies were also excluded, because they represent different premises on training and work performance. Using these inclusion criteria, the literature was searched in three ways. First, the PsycINFO, ERIC, and Web of Science databases were searched using the keywords self-efficacy, behavior change, training application, training use, and transfer of training. In addition, a manual search of journal issues covering a 25-year period (from January 1986 through December 2010) was conducted. Finally, studies that cited Noe’s (1986) seminal paper, which was the first to model the influence of motivation on transfer in professional training, were searched with the Web of Science and the Google Scholar databases. A total of 29 articles, book chapters, conference papers, and dissertations that contributed at least one effect size to the meta-analysis were included in the database. A full list of all included studies is available from the first author. The 29 studies offered a total of \( k = 33 \) independent data sources. Total sample size was \( N = 4,158 \) participants.

Recorded Variables
To answer the study hypotheses, different characteristics were tabulated from the selected research literature. Specifically, each study was coded for effect size estimates, computer support, and collaboration. Effect size estimates included Pearson product-moment correlation \( r \) of the self-efficacy–transfer relationship, Cronbach’s reliability estimate \( \alpha \) of the independent variables (self-efficacy), and Cronbach’s reliability estimate \( \alpha \) of the dependent variable (transfer). We also coded the first author, publication year, the number of participants, their age (in years), and gender (percentage of females). Computer support for learning afforded during training was coded as 1 = computer support and 0 = no computer support. Collaboration among participants afforded during training was coded as 1 = collaboration and 0 = no collaboration. Two independent raters first coded fifteen of the remaining studies. Because intercoder reliability was generally high (Cohen’s \( \kappa = .91 \)), one rater continued to code the remaining studies. If a study reported more than one effect size, a single composite variable was created to comply with the assumption of independence. As an exception to this rule, linear composites were not created for the theoretically predicted moderator variables, as composite correlations would have obscured moderator effects and prohibited further analysis.

Meta-Analytic Methods Used
Analysis occurred in two stages. A primary meta-analysis aimed to estimate the true score population correlation \( \rho \) of the pre- and post-training relationship between performance self-efficacy and transfer of training. A meta-analytic moderator estimation then aimed to identify moderating effects in those relationships.

The primary meta-analysis was done using the methods of artifact distribution meta-analysis of correlations (Hunter & Schmidt, 2004). These methods provide an improvement from earlier statistical formulae when information such as reliability estimates is only sporadically reported in the original studies. First, study information was compiled on three distributions: the distribution of the observed Pearson’s \( r \) of the transfer–self-efficacy relationship, the distribution of Cronbach’s \( \alpha \) of the independent variable, and the distribution of Cronbach’s \( \alpha \) of the dependent variable. Next, the distribution of Pearson’s \( r \) was corrected for sampling error. Note that the correction was conducted using a weighted average, not Fisher’s \( z \) transformation, since the latter was shown to produce upwardly biased correlation estimates (Hall & Brannick, 2002). The distribution corrected for sampling error was then further corrected for error of measurement using the compiled Cronbach’s \( \alpha \) reliability estimates. This last step provided the final estimate of the true score population correlations \( \rho \)
between self-efficacy and transfer. Finally, standard deviations of the corrected observed correlation $r_c$ and of the population correlation $\rho$ were calculated; these were used to derive the percentage of variance attributable to attenuating effects, the 95% confidence interval around $r_c$, and the 80% credibility interval around $\rho$.

The meta-analytic moderator estimation followed the primary meta-analysis. Theory-driven nested sub-group analyses were used to estimate the moderating effects of computer support and collaboration. Nested sub-group analysis assumes that the moderator variables are independent and additive in their effects. A criticism of the use of sub-groups is that it reduces the number of data sources per analysis, resulting in second-order sampling error. Although the present study contained a large number of data sources and participants, the possibility of second-order sampling error cannot be completely ruled out. This is therefore indicated when warranted for interpreting the results.

Results

Primary Meta-Analysis

Table 1 summarizes the number of studies, participants, and participant characteristics by condition. The mean estimates in Table 1 are age in years and percentage of females. Across all conditions, the uncorrected correlation coefficient $r$ between performance self-efficacy and transfer of training is 0.34 ($k = 33, N = 4,158$). The population correlation estimate corrected for sampling error and error of measurement is $\rho = 0.39 (SD_\rho = 0.23; 80\% CV = .10; .68)$. This estimate is in the positive direction, thus supporting Hypothesis 1. The difference between $r$ and $\rho$ represents a depression of the true score population correlation through sampling error and error of measurement by 14.7%.

Table 1: Number of studies, participants, and participant characteristics by condition.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>k</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer support and collaboration</td>
<td>7</td>
<td>730</td>
<td>27.28</td>
<td>4.55</td>
<td>39.60</td>
<td>27.48</td>
</tr>
<tr>
<td>Computer support, but no collaboration</td>
<td>7</td>
<td>1,044</td>
<td>26.42</td>
<td>9.90</td>
<td>61.43</td>
<td>17.90</td>
</tr>
<tr>
<td>No computer support, but collaboration</td>
<td>17</td>
<td>2,172</td>
<td>31.51</td>
<td>10.11</td>
<td>50.88</td>
<td>15.38</td>
</tr>
<tr>
<td>No computer support and no collaboration</td>
<td>2</td>
<td>257</td>
<td>20.70</td>
<td>0.99</td>
<td>21.87</td>
<td>29.89</td>
</tr>
</tbody>
</table>

Meta-Analytic Moderator Estimation

The specific hypothesis was that the relationship between self-efficacy and transfer is moderated by computer support and collaboration. Four conditions were evaluated: trainings with computer support and collaboration (condition 1), trainings with computer support but no collaboration (condition 2), trainings with collaboration but no computer support (condition 3), and trainings with neither computer support nor collaboration (condition 4). There were no systematic age $\chi^2 (3,25) = 4.17, ns$ or gender $\chi^2 (3,21) = 2.77, ns$ differences between conditions (computer support, no computer support, collaboration, no collaboration). A nested sub-group analysis of computer support and collaboration as confounding moderator variables signaled two trends. First, computer support and collaboration were highly correlated, with Spearman’s $\rho = .44$ (95% CI = .43; .46). Second, effect sizes were highest when the training was computer-supported. Third, effect sizes were twice as high in computer-support trainings without collaboration (condition 2) compared to computer-supported trainings with collaboration (condition 1). Table 2 summarizes the results. However, unequal sample sizes and small cell sizes for some of the training conditions warrant caution when interpreting these results.

Table 2: Nested moderator effects of computer support and collaboration.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>$\rho$</th>
<th>$SD_\rho$</th>
<th>80% CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer support and collaboration</td>
<td>0.31</td>
<td>0.03</td>
<td>0.27; 0.55</td>
</tr>
<tr>
<td>Computer support, but no collaboration</td>
<td>0.62</td>
<td>0.07</td>
<td>0.53; 0.71</td>
</tr>
<tr>
<td>No computer support, but collaboration</td>
<td>0.30</td>
<td>0.04</td>
<td>0.25; 0.35</td>
</tr>
<tr>
<td>No computer support and no collaboration</td>
<td>0.25</td>
<td>0.01</td>
<td>0.24; 0.26</td>
</tr>
</tbody>
</table>

Discussion

One aim of this meta-analysis was to cumulate the research of the past 25 years to correct the relationship between performance self-efficacy and transfer of training for sampling error and error of measurement. A second aim was to estimate the moderating effects of computer support and collaboration. The heterogeneity and disagreement in the training literature ultimately led this study to seek a better understanding of whether, to what extent, and under which conditions efficacy beliefs influenced transfer.
The results of the primary meta-analyses suggested positive relationships between performance self-efficacy and training transfer. These estimates provide support for Hypothesis 1 and are in line with previous meta-analytic examinations (Colquitt, LePine, & Noe, 2000; Gegenfurtner, 2011). These findings empirically support the theoretical assumption that efficacy beliefs influence transfer (Bandura, 1997; Pugh & Bergin, 2006), and are consistent with earlier conceptual frameworks in the training literature, such as the integrative theory of training effectiveness (Colquitt et al., 2000) or the integrative model of motivation to transfer training (Gegenfurtner, Veermans, Festner, & Gruber, 2009).

The results of the meta-analytic moderator estimation suggested systemic effects of computer support and collaboration (Arneseth & Ludvigsen, 2006). Specifically, computer-supported collaborative learning does not per se promote the relationship between self-efficacy and transfer. The results showed that computer support played a more significant role than collaboration among trainees. Trainings affording CSCL were not generally more effective in promoting efficacy beliefs and transfer than trainings not affording CSCL (see estimates in Table 2). One possible explanation for this unexpected finding may be the form of collaboration (Dillenbourg, 1999; Lehtinen et al., 1999) in the individual study reports. We had no information on how social interaction emerged in the training situations, as the primary studies reported correlation estimates only but did not engage in analyzing interaction with methods currently available (Puntambekar, Erkens, & Hmelo-Silver, 2011). Nor had we information on the degree that the collaborative learning situations were scaffolded or scripted in the original studies. Without sufficient guidance and scaffolding of collaboration activities among training participants, efforts toward collaboration may result in unequal or heterogeneous participation (Barab & Duffy, 2000; Weinberger & Fischer, 2006), non-reciprocal interpretations of the learning situation (Järvelä, 1995; Veermans, 2003), and/or lack of co-regulation (Vauras et al., 2008; Volet et al., 2009). Future research may take this meta-analytic evidence to test designs for scaffolding collaboration in technology-rich environments intended to promote self-efficacy and transfer. In summary, analysis of the moderating effects of computer support and collaboration illustrate boundary conditions for self-efficacy and transfer in professional training.

Results of this study may have some practical value for the scaffolding of collaborative learning. Specifically, the low confounded moderator effect of computer support and collaboration tends to highlight the danger of ignoring adequate guidance and scaffolding of participatory interactions among trainees in the learning environment. This finding is reported in the literature elsewhere (e.g., Järvelä, 1995; Weinberger & Fischer, 2006) and is now reiterated with a special emphasis on how important scaffolded collaboration is for promoting self-efficacy and transfer (Latham, 2007; Pugh & Bergin, 2006). It can be speculated that the provision of networks can scaffold trainees during training and that post-intervention enhancement of contacts among trainees could facilitate transfer after training. Methodologically, it would be interesting to follow these educational interventions with different methods, including social network analysis, to trace how they influence processes of sharing and co-construction during collaborative team learning and how they promote transfer to typically practice-bound situations at work (Gegenfurtner, 2011; Säljö, 2010; Tynjälä & Häkkinen, 2005).

This study has some limitations that should be noted. One limitation is that the population correlation estimates were corrected for sampling error and error of measurement. This decision was based on the frequent reporting and availability of sample size and reliability information. However, the original research reports may be affected by additional biases, such as extraneous factors introduced by study procedure (Hunter & Schmidt, 2004). Although the estimation of moderators sought to lessen this bias, the true population estimates may be somewhat greater than those reported here. An additional limitation is that some of the relationships in the nested subgroups were based on small sample sizes. However, some authors have noted that correcting for bias at a small scale mitigates sampling error compared to uncorrected estimates in individual studies (Hunter & Schmidt 2004; Rosenthal & DiMatteo, 2001). Still, although most of the cells contained sample sizes in the thousands, some did contain fewer, which indicates underestimation of sampling error in those few cases and that, therefore, computer-supported collaborative training may show more positive correlation estimates. Finally, the study reports two moderator variables. Although an analysis of the relationship between performance self-efficacy and transfer of training under different boundary conditions clearly goes beyond previous meta-analytic attempts, selection of the boundary conditions was, of course, eclectic and exclusively driven by an interest to better understand technological and social affordances in CSCL environments for motivation and transfer (Lehtinen et al., 1999; Säljö, 2010; Sawyer, 2006). More conditions exist that would warrant inclusion in the meta-analysis and in turn raise concerns of the generalizability of the moderating effects. However, this limitation can be addressed only by additional original research reports that systematically vary different study conditions.

As noted at the outset, self-efficacy and transfer were assumed to be more positive in in complex social and technological environments (Sawyer, 2006). The present meta-analytic study sought to test the predictive validity in an examination of the population correlation estimates between self-efficacy and transfer in computer-supported and collaborative training conditions. This examination was done by using meta-analysis to summarize 25 years of research on pre- and post-training self-efficacy, by cumulating 33 independent data sources from 4,158 participants, and by examining two confounded moderator variables (computer support and
collaboration) on the self-efficacy–training transfer relationship. The findings seem to imply that computer support is more significant for promoting self-efficacy and transfer than is collaboration. Future research is encouraged to extend these first steps reported here to the examination of social and technological conditions moderating self-efficacy and transfer in other educational and learning settings.

References


