From the
AERA Online Paper Repository
http://www.aera.net/repository

Paper Title The Effect of Computer-Supported Collaborative Learning on Students' Performance: A Meta-Analysis

Author(s) Fei Wang, East China Normal University; Xiaoqing Gu, East China Normal University; Dacheng Feng, East China Normal University

Session Title Advances in Cooperative Learning Theory and Research

Session Type Paper

Presentation Date 4/7/2019

Presentation Location Toronto, Canada

Descriptors Cooperative Learning, Meta-Analysis

Methodology Quantitative

Unit SIG-Cooperative Learning: Theory, Research and Practice

DOI https://doi.org/10.3102/1436505

Each presenter retains copyright on the full-text paper. Repository users should follow legal and ethical practices in their use of repository material; permission to reuse material must be sought from the presenter, who owns copyright. Users should be aware of the AERA Code of Ethics.

Citation of a paper in the repository should take the following form: [Authors.] ([Year, Date of Presentation]). [Paper Title.] Paper presented at the [Year] annual meeting of the American Educational Research Association. Retrieved [Retrieval Date], from the AERA Online Paper Repository.

The Effect of Computer-Supported Collaborative Learning on Students' Performance: A Meta-Analysis

Objective

The purpose of this study was to perform a meta-analysis to investigate the effect of CSCL on student learning performance. In addition, the study was interested in exploring the moderator variables which influence student achievements. An analysis of moderator variables was conducted to examines whether associated moderators could promote or hinder collaborative learning impacting student achievements. The following three research questions guided this meta-analysis:

1. What is the overall effect of CSCL research on student learning performance?
2. To what extent do the effects of CSCL on student learning performance?
3. What are major moderator variables influencing the effects of CSCL on student learning performance?

Perspectives

Computer-Supported Collaborative Learning (CSCL) has become pervasive in education over the past two decades. In CSCL, two or more students, each sharing and creating knowledge through a series of collaborative activities, and working together to solve problems or build knowledge with supported by computer technology (Prinsen, Volman, & Terwel, 2007).

Research on the effectiveness of CSCL has shown divergent results. Many studies on CSCL have reported that CSCL is effective in enhancing learning improvement, since it helps to test their ideas against others' opinions and reveals incorrect assumptions, misunderstandings, and conflicting solutions (Walker, 2005; Doise, Mugny, & Pe´rez, 1998). However, some studies have pointed out that students for different reasons do not participate very intensely in CSCL, and not all collaboration is effective (Hara, Bonk, & Angeli, 2000; Hoadley & Linn, 2000; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003; Muukkonen, Lakkala, & Hakkarainen, 2005).

Previous studies have shown that it is necessary to use meta-analysis to estimate the impact of CSCL on student achievement, which helps to gain a deeper understanding of the effectiveness of collaborative learning.

Method

Data sources and search strategy

Journal articles published between 2008 onwards were searched electronically, and via reference-list checking to retrieve the relevant literature. For electronic searches, the main databases were Springer, IEEExplore, Science Direct, Web of Science, ERIC, and Google Scholar. The following two sets of keywords were used: (1) keywords related to CSCL, including computer-supported collaborative learning, CSCL, and group learning; and (2) keywords related to learning performance, including performances, outcomes, and achievements. The two sets of keywords were combined when searching the electronic databases. To ensure that no relevant literature was overlooked, another round of searches was conducted using the reference lists found in the literature yielded by the electronic search.

Search Results

Initial Screening

The initial search identified 1121 abstracts published between 2008 and 2018 that were related to CSCL. Two researchers of this study read the title, abstract, and keywords of the article and judged whether or not the article was related to the achievements of CSCL. This process resulted in the selection of 374 articles.

Screening for experimental and quasiexperimental research

The second stage focused on literature related to the research method. Experimental studies and quasi-experimental studies were included. Conceptual analysis, review articles and case studies, qualitative research and surveys were all excluded from this study, which left 87 articles for inclusion.

Criteria for inclusion or exclusion from the meta-analysis

A set of criteria were established for inclusion of studies in the present analysis:

1. The study results included learning achievements, as measured by examinations, cumulative posttest scores and other quantified assessments;.
2. The study contained at least one control group and one experimental group;
3. The study used technology to support collaborative learning;
4. The study offered statistical information needed for meta-analysis.

Studies that did not meet the above criteria were excluded from the current meta-analysis. After the third stage of screening, there were 22 articles left in the meta-analysis.

Coding Framework

Coded moderator variables used to explore between-study variability in effect sizes. Major moderator variables, include learning stage, domain subject, intervention duration, group size, collaboration, and pedagogy.

Data analysis

Calculating the effect size

This study used the following steps recommended by Borenstein, Hedges, Higgins, and Rothstein (2009) to calculate the effect size : (a) calculate the effect sizes of each article, (b) calculate the overall weighted mean effect size of the present meta-analysis study, (c) use the random effects model to calculate the confidence interval of the overall average effect size for CSCL, and (d) use a heterogeneity analysis (QB) to determine whether the effect size was influenced by specific moderator variables.

Evaluating publication bias

The fail-safe N (e.g., classic fail-safe N) proposed by Rosenthal (1979) was used to estimate the number of studies with nonsignificant results (unpublished data) needed to reduce the overall effect size to an insignificant level. This study also adopted the funnel plot for the visual inspection and Egger's regression intercept to verify the publication bias for the current meta-analysis.

Results

Descriptive statistics information

Table 1 presents the distribution of moderator variables and their corresponding effect sizes (g) in CSCL. The 22 studies that were included in the analysis offered a total of 37 effect sizes. Total sample size was 3378 participants. The largest proportion of studies in the learning stage was college, followed by elementary school and high school. The most frequently studied domain subject were computer and information technology, followed by mathematics, science, and education. Regarding

intervention duration, the most frequently studied was >1 month and ≤6 months, followed by ≤4 h and >1 week and ≤4 weeks. With respect to group size, Triad and Mixed were was the most frequently researched. Synchronous was the most often studied collaboration.

Overall effect size for learning achievement

Comprehensive Meta-Analysis^{TM} software (Borenstein et al. 2005) was used to calculate and analyze the effect size. The overall effect sizes of the 22 articles with both fixed and random effects models are shown in Table 2. The Q statistics revealed that the effect sizes in the meta-analysis were heterogeneous (Q-total = 291.994, z = 13.871, p < .001), which indicates that there are differences among the effect sizes resulting from factors other than subject-level sampling error. Thus, the random-effect model was selected to evaluate the effect size of our research. The overall mean effect size in this meta-analysis was 0.543, with a 95% confidence interval of 0.359-0.728. According to Cohen`s standards (1988, 1992), the effect sizes of 0.80, 0.50, and 0.20 are considered to be large, medium, and small, respectively. The findings suggest that CSCL has a medium effect size, which means CSCL have a positive effect on student learning, and applying CSCL to students' learning is beneficial to improving their learning.

Effect sizes of learning performance for moderator variables

As indicated in Table 1, some levels of the moderator variables had small numbers of articles, and so the levels with a small number of articles were merged. For the learning stage, middle school and high schools were combined into “secondary school” category, and college and adults were combined together into “adult”. With respect to domain subject, mathematic, chemistry, geography, science, computer and information technology were combined into a “STEM” category, while education, finance and economics, language, specific abilities, sociology were combined together into “Non STEM”. In terms of intervention durations,≤4 h, > 4 and ≤24 h, and >1 day and ≤7 days were combined into “≤ 1 week”. Regrading group size, dyad, triad, and terad were combined into “small group”, more than four people and mixed were combined into “large group”. Table 3 lists the effect sizes for the moderator variables.

Learning stage

Table 3 indicates that secondary school had a high effect size on learning achievement (g =0.985, z = 4.087, p < .001), followed by adults (g = 0.512, z = 3.776, p < .001) and elementary school (g = 0.341, z =1.753, p < .01). The QB did not reach significance at the p < .05 level (QB =4.499, p= .105), meaning that the mean effect size did not differ significantly between the categories.

Domain subject

The data given in Table 3 indicated that STEM subject (g = 0.588, z = 5.078, p < .001) and Non STEM subject (g = 0.452, z = 2.701, p < .01) had medium effect sizes. The Q_B did not achieve significance at the p < .05 level (QB =0.538, p= .764), which means that the average effect size did not differ significantly between the two categories.

Intervention Duration

The data regarding the effect size for intervention duration are given in Table 3. Interventions of >1 month and ≤6 months duration had a high effect size (g = 0.958, z = 5.125, p < .001), followed by those of >1 week and ≤4 weeks duration (g = 0.617, z = 3.003, p < .01) ,and those of ≤1 weeks duration (g = 0.331, z = 2.240, p < .05). The Q_B achieved significance (QB = 8.474, p = .037), meaning that the mean effect size different significantly between the categories.

Group Size

As showen in Table 3, the mean effect size for studies employed large group size (g = 1.337, z =

5.339, p < .001) was significantly higher than studies used small group (g = 0.421, z = 4.365, p < .001), indicating students' affective outcomes were higher in a large group instruction. The Q_B was significant (QB = 11.636, p = .001), indicating that the effect sizes differed significantly among the two categories.

Collaboraion

The data in Table 3 indicate the effect sizes for different collaboration. Various collaboration had a high effect size (g = 1.073, z = 3.119, p < .01), followed by mediated collaboration with a medium effect size (g = 0.668, z = 4.562, p < .01) and synchronous collaboration with a small effect size (g = 0.432, z = 3.281, p= .001). The Q_B reached statistical significance (QB = 8.163, p = .043), showing that the average effect sizes differed significantly between the categories.

Pedagogy

Table 3 indicate that other pedagogy (g = 2.633, z = 6.172, p < .001) and discussions (g = 0.835, z = 3.602, p < .001) had a high effect size, followed by inquiry and exploration (g = 0.610, z = 3.307, p = .001), various (g = 0.308, z = 1.795, p= .073), and teacher directed (g = 0.261, z = 1.670, p= .095). The Q_B reached statistical significance (QB = 30.844, p < .001), showing that the average effect sizes differed significantly between the categories.

Evaluation of publication bias

Comprehensive Meta Analysis™ was adopted to verify the publication bias for the current meta-analysis. The funnel plot indicated in Fig. 1, showed the symmetrical dispersion of effect sizes around the mean of the distribution. As shown in Table 4, the classic fail-safe N test determined that a total of 1741 studies with null results would be needed in order to nullify the effect size. Egger's regression intercept reported that t-value is 1.497, p = 0.071. This means that there is no significant deviation in publication bias. All tests suggest that there was no publication bias in the current meta-analysis.

Significance of the study

This article reports a meta-analysis about the effects of CSCL on learning achievements. The results suggest that CSCL are positive on learning outcomes compared to traditional instruction substantially. A medium positive effect on learning achievement was produced and some moderate variables were analyzed to estimate the effects of CSCL. The findings of this meta-analysis help teachers make informed decisions when planning, designing, and implementing effective CSCL teaching strategies.

Acknowledgement

This article was supported by the Special Fund for the Graduate International Conference of East China Normal University.

Appendix

Table 1

Categories and learning achievement effect sizes for 22 articles.

Variable	Category	Number of studies (k)	Number of effect	Effect size (g)
Learning stage	1. Elementary school	5	10	0.343
	2. Middle school	1	2	0.267
	3. High school	3	5	1.463
	4. College	12	19	0.483
	5. Adults	1	1	1.398
Domain subject	1. Mathematics	4	9	0.396
	2. Education	3	3	1.155
	3. Chemistry	2	2	–0.245
	4. Finance and economics	1	1	0.605
	5. Geography	1	2	0.267
	6. Language	1	2	0.198
	7. Specific abilities	1	4	0.407
	8. Science	3	3	1.717
	9. Sociology	1	2	–0.220
	10. Computer and information technology	5	8	0.720
Intervention duration	1. ≤4 hours	6	12	0.513
	2. > 4, ≤24 h	0	0	0
	3. >1, ≤7 days	2	4	–0.330
	4. >1 week, ≤4 weeks	5	7	0.617
	5. >1 month, ≤6 months	8	10	0.950
	6. >6 months	1	4	0.176
Group size	1. Dyad	4	7	0.429
	2. Triad	6	3	0.288
	3. Tetrad	2	10	0.561
	4. More than four people	4	5	1.353
	5. Mixed	6	12	0.329
Collaboration	1. Mediated	8	14	0.668
	2. Synchronous	10	19	0.432
	3. Asynchronou	1	1	–0.531
	4. Various	3	3	1.073
Pedagogy	1. Discussions	3	5	0.835
	2. Inquiry and exploration	6	9	0.610
	3. Teacher directed	4	12	0.261
	4. Others	2	2	2.633
	5. Various	7	9	0.308

Table 2

The overall achievement effect sizes.

Analytical Models	k	g	SE	95% Confidence interval
Fixed Effects Model	22	0.397***	0.029	[0.341–0.453]
Random Effects Model	22	0.543***	0.009	[0.359–0.728]
Heterogeneity	Q–total = 291.994, df = 36, p < .001			I^2 = 87.671

***p < .001

Table3

The learning-achievement effect sizes of categories and their related moderator variables.

Category	k	g	z	95% Confidence interval	Q_B	df
Learning stage					4.499	2
1. Elementary school	5	0.341	1.753**	[–0.040 to 0.772]		
2. Secondary school	4	0.985	4.087***	[0.513 to 1.458]		
3. Adults	13	0.512	3.776***	[0.246–0.777]		
Domain subject					0.447	1
1. STEM	15	0.588	5.078***	[0.361–0.815]		
2. Non-STEM	7	0.452	2.701**	[0.124–0.780]		
Intervention Duration					8.474*	3
1. ≤1 week	8	0.331	2.240*	[0.041–0.620]		
2. >1 week, ≤4 weeks	5	0.617	3.003**	[0.214–1.019]		
3. >1 month, ≤6 months	8	0.958	5.124***	[0.592–1.325]		
4. >6 months	1	0.176	0.558	[–0.442 to 0.794]		
Group size					11.636**	1
1. Small group (2-4 persons)	18	0.421	4.365***	[0.232–0.611]		
2. Large group (>5 persons)	4	1.337	5.339***	[0.846–1.828]		
Collaboration					8.163*	3
1. Mediated	8	0.668	4.562***	[0.381–0.955]		
2. Synchronous	10	0.432	3.281**	[0.174–0.691]		
3. Asynchronou	1	–0.531	–1.031	[–1.539 to 0.478]		
4. Various	3	1.073	3.119**	[0.399–1.748]		
Pedagogy					30.844***	4
1. Discussions	3	0.835	3.602***	[0.381–1.290]		
2. Inquiry and exploration	6	0.610	3.307**	[0.249–0.972]		
3. Teacher directed	4	0.261	1.670	[–0.045 to 0.568]		
4. Others	2	2.633	6.172***	[1.797–3.469]		
5. Various	7	0.308	1.795	[–0.028 to 0.645]		

Note. CI = confidence interval, Non-STEM = Social Sciences, Humanities and STEM: Science, Technology, Engineering and Math

*p < .05; **p < .01; ***p < .001

Figure 1. Funnel plot with effect size for using random model

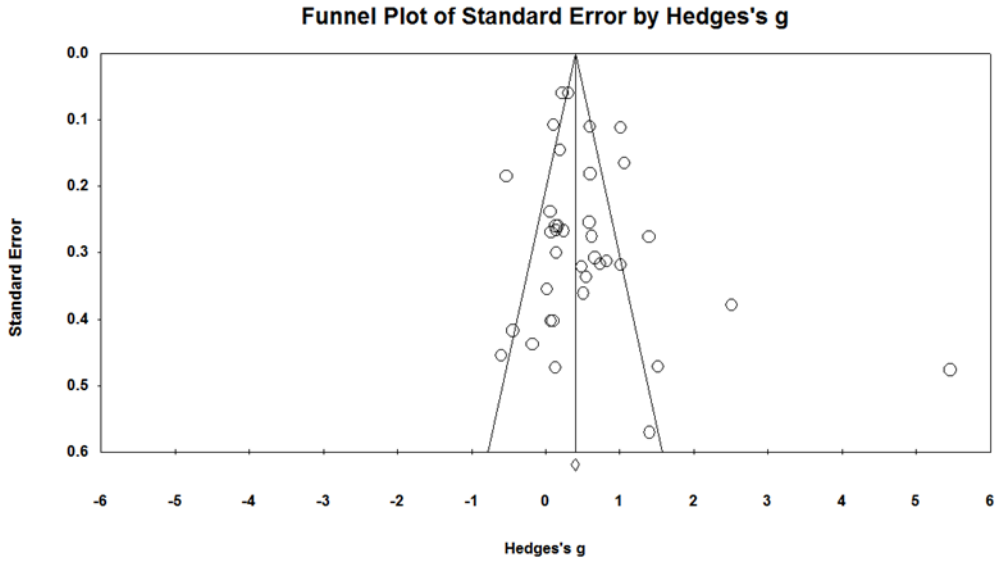


Table 4

Results of the classic fail-safe N.

Z value for observed studies	13.58
p value for observed studies	0.00
Alpha	0.05
Tail	2.00
Z for alpha 1.96	1.96
Number of observed studies 108.00	37.00
Number of missing studies that would bring the p value to >alpha	1741.00

References

References marked with an asterisk include studies included in the meta-analysis.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). Introduction to meta-analysis. Chichester, England: Wiley.

*Chen, C.-M., & Chang, C. -C. (2014). Mining learning social networks for cooperative learning with appropriate learning partners in a problem-based learning environment. Interactive Learning Environments, 22(1), 97-124.

*Chou, S. -W., & Min, H. -T. (2009). The impact of media on collaborative learning in virtual settings: The perspective of social construction. Computers & Education, 52(2), 417-431.

Doise, W., Mugny, G., & Pe´ rez, J. A. (1998). The social construction of knowledge: Social marking and socio-cognitive conflict. In U. Flick (Ed.), The psychology of the social (pp.77–90). New York, NY: Cambridge University Press.

Hara, N., Bonk, C., & Angeli, C. (2000). Content analyses of on-line discussion in an applied educational psychology course. *Instructional Science, 28*, 115–152.

Hoadley, C. M., & Linn, M. C. (2000). Teaching science through online, peer discussions: SpeakEasy in the Knowledge Integration Environment. International Journal of Science Education, 22, 839–858.

*Hursen, C. (2016). The impact of curriculum developed in line with authentic learning on the teacher candidates' success, attitude and self-directed learning skills. Asia Pacific Education Review, 17(1), 73-86.

*Huang, C. S. J., Su, A. Y. S., Yang, S. J. H., & Liou, H. -H. (2017). A collaborative digital pen learning approach to improving students' learning achievement and motivation in mathematics courses. Computers & Education, 107, 31-44.

*Jackson, A.T., Brummel, B.J., Pollet, C.L., & Greer, D. D. (2013). An evaluation of interactive tabletops in elementary mathematics education. Educational Technology Research & Development, 61(2), 311-332.

*Ke, F., & Carafano, P. (2016). Collaborative science learning in an immersive flight simulation. Computers & Education, 103, 114-123.

*Kirschner, P. A., Kreijns, K., Phielix, C., & Fransen, J. (2015). Awareness of cognitive and social behaviour in a CSCL environment. Journal of Computer Assisted Learning, 31(1), 59-77.

*Lee, Y.-H.(2015). Facilitating critical thinking using the C-QRAC collaboration script: Enhancing science reading literacy in a computer-supported collaborative learning environment. Computer & Educatiion, 88, 182-191.

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction, 13*, 487–509.

*Liu, M. -C., Huang, Y. -M., & Xu, Y. -H. (2018). Effects of individual versus group work on learner autonomy and emotion in digital storytelling. Educational Technology Research & Development, 66(4), 1009-1028.

*Liu, M., Liu, L., & Liu, L. (2018). Group awareness increases student engagement in online collaborative writing. The Internet and Higher Education, 38, 1-8.

Muukkonen, H., Lakkala, M., & Hakkarainen, K. (2005). Technology-mediation and tutoring: How do they shape progressive inquiry discourse? *Journal of the Learning Science*s, *14*, 527–565.

*Prinsen, F. R., Terwel, J., Zijlstra, B. J, & Volman, M. R. (2013). The effects of guided elaboration in a CSCL programme on the learning outcomes of primary school students from Dutch and immigrant families. Educational Research & Evaluation, 19(1), 39-57.

Prinsen, F. R., Volman, M. L. L., & Terwel, J. (2007). Gender-related differences in computer-mediated communication and computer-supported collaborative learning. *Journal of Computer Assisted Learning, 23*(5), 393–409.

*Popov, V., Noroozi, O., Barrett, J. B., Biemans, H. J., Teasley, S. D., & Slof, B. , & Mulder, M. (2014). Perceptions and experiences of, and outcomes for, university students in culturally diversified dyads in a computer-supported collaborative learning environment. Computers in Human Behavior, 32, 186-200. Doi: 10.1016/j.chb.2013.12.008.

*Rau, M. A., Bowman, H. E., & Moore, J. W. (2017). An adaptive collaboration script for learning with multiple visual representations in chemistry. Computers & Education, 109, 38-55.

*Reychav, I., & McHaney, R. (2017). The relationship between gender and mobile technology use in collaborative learning settings: An empirical investigation. Computers & Education, 113, 61-74.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. Psychological Bulletin, 86, 638e641. http://dx.doi.org/10.1037/0033-2909.86.3.638.

*Sung, H. -Y., & Hwang, G. -J. (2016). Facilitating effective digital game-based learning behaviors and learning performances of students based on a collaborative knowledge construction strategy. Interactive Learning Environments, 26(1), 118-134.

*Takači, D.,Marić, M., Stankov, G., & Djenić, A. (2017). Efficiency of using VNS algorithm for forming heterogeneous groups for CSCL learning. Computers & Education, 109, 98-108.

*Takači, D., Stankov, G., & Milanovic, I. (2015). Efficiency of learning environment using GeoGebra when calculus contents are learned in collaborative groups. Computers & Education, 82, 421-431.

*Tegos, S., Demetriadis, S., & Karakostas, A. (2015). Promoting academically productive talk with conversational agent interventions in collaborative learning settings. Computers & Education, 87, 309-325.

Walker, G. (2005). Critical thinking in asynchronous discussions. *International Journal of Instructional Technology and Distance Learning*, *6*(2). Retrieved Jan 5, 2010, from http://itdl.org/Journal/Jun_05/article02.htm.

*Wang, X., Wallace, M. P., & Wang, Q. (2017). Rewarded and unrewarded competition in a CSCL environment: A coopetition design with a social cognitive perspective using PLS-SEM analyses. Computers in Human Behavior, 72, 140-151.

*Yu, S., & Ren, N. (2018). A Study of learning achievements in collaborative construction knowledge space in seamless learning. Mobile and Ubiquitous Learning, 211-227.

*Zheng, L. (2017). Scripted collaborative learning using the modified jigsaw method: An empirical study. Knowledge Building and Regulation in Computer-Supported Collaborative Learning. (pp.115-127). Restreved from https://link.springer.com/chapter/10.1007%2F978-981-10-1972-2_8.