The Effects of Computer-mediated Communication (CMC) on L2 Writing Achievement: A Meta-analysis of the Research

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Based on sociocultural (Vygotsky, 1978) and interactionist (Krashen, 1985, 1989) theories, it has been suggested that computer-mediated communication (CMC) environments promote interaction and communication among second language (L2) learners, which may facilitate their L2 acquisition (Lin, 2014). Therefore, many studies have examined various aspects of CMC, such as a critical review of CMC from different theoretical perspectives (Nguyen, 2008), the overall effect of computer assisted language learning (CALL) (Felix, 2005, 2008), a narrative review on the role of synchronous computer-mediated communication (SCMC) in second language acquisition (SLA) (Sauro, 2011), and the effect of text-based SCMC on SLA (Lin, Huang, &Liou, 2013). However, results of these previous studies were unable to conclusively support the benefits of CMC in SLA (Lin, 2014). In an earlier meta-analysis on the overall effect of CMC in SLA, Lin (2014) attempted to systematically synthesize the findings from 59 CMC studies conducted between 2002 and 2012 and provide an estimate of the overall effect of CMC in SLA. The results of her study revealed a "medium but positive effect" of CMC on SLA compared to face-to-face or no communication (Lin, 2014, p. 132). Furthermore, Lin (2014) found that communication taking place either asynchronously or synchronously does not have a significant impact on SLA, while factors such as learners' language proficiency level, interlocutor type, research context, and task type significantly moderate the effectiveness of intervention.

However, Lin (2014) examined the effect of CMC interventions on all language

outcomes, including all four language skills (i.e., speaking, listening, reading, writing) as well as the "respective components that make up the tool", such as grammar, pronunciation, vocabulary, etc. (Lin, 2014, p.123), and she did not classify the effect of CMC on each language outcome (e.g., what the effect of CMC was on L2 learners' writing development or reading development). Thus, a more systematic synthesis of each language outcome is needed. Moreover, Lin (2014) only synthesized the immediate/short-term effectiveness of CMC on various language outcomes and did not account for the delayed effectiveness of CMC. Finally, there are still conflicting findings regarding the effectiveness of CMC on L2 writing development. Therefore, the present meta-analysis aims to examine the overall effectiveness of CMC intervention on L2 learners' writing achievement and identify variables that might moderate the effects of CMC on L2 learners' writing development.

Literature Review

Computer-mediated Communication (CMC)

CMC alludes to multimodal interaction, most of the times internet-mediated communication (Thorne, 2008). CMC uses "...a wider variety of online tools which include social networking sites, virtual realities, and gaming…" (Goertler, 2009, p. 75). In this article, CMC loosely refers to any real-time or delayed online interaction that happens to take advantages of the available communicative technology tools. Based on sociocultural theory of Lev Vygotsky, CMC has been conducive to creation of an engaging environment that promotes second language acquisition (SLA) (Warschauer, 1997). Previous findings (Sims, 2000; Warschuer, 1997; Hoven, 2006) show that instructional

practices are more focused on the “communicative and interactive” features of language learning today than ever before with the transition from the traditional use of multimedia or stand-alone programs to expedite without sacrificing quality of second language learning.

CMC offers distinct features to further language learning experience embedded in the tools and technologies used in the communication process (Smith, Alvarez Torres & Zhao, 2003). Four characteristics were described by Smith et al. (2003) to exemplify the distinctiveness of CMC: temporality, degree of anonymity, modality, and spatiality. Temporality indicates the mode of time when communication takes place. This can be either simultaneous (synchronous) or delayed (asynchronous). The mode of time choice depends on the time gap between the responses or messages that were sent/received between/among the communicators. Anonymity points out to the degree of familiarity of the communicator; whether the participants know each other in the CMC setting. Some methods of delivery are more discrete (e.g., email) than others (e.g., video-conferencing). Modality describes the way interaction is assisted. Some technology tools like chats promote both written and spoken interaction while other tools, such as bulletin boards, allow only written communication. Lastly, spatiality indicates to the distance among the communicators and has consequence because it is believed to affect the nature of the communication.

CMC and L2 Writing Development

Although in the past writing was believed to be an individual task, an increasing

number of researchers have argued for the promotion of collaboration among learners (Knowles & Hennequin, 2004). It has been suggested that through collaboration, students can receive valuable input from others (Vygotsky, 1962) and are given more opportunities to practice (Oxford, 1997). Through collaborative writing, two or more learners produce a piece of written work together, and they contribute to all aspects of writing including content, structure, and language (Storch, 2005). It has been suggested that collaborative writing can be beneficial particularly to L2 learners (e.g., Ansarimoghaddam & Tan, 2013; Foroutan, Noordin, & Hamzah, 2013).

An effective way to provide a collaborative writing environment to L2 learners is by engaging L2 learners in CMC environment. It allows a group of learners from the same or different writing classes in local or international settings to work in teams for exchanging ideas, providing feedback and sharing resources (Show-Mei, 2009). For example, they can discuss their ideas collaboratively through CMC tools such as an email, discussion forum, wiki and CMS messengers. Previous researchers have found that this CMC environment can enhance L2 learners' writing development. For example, Ansarimoghaddam and Tan (2013) found that the students who participated in collaborative writing through wiki scored much higher in the post essay task compared to the counterparts who participated in face-to-face collaborative writing. Similarly, use of email-dialogue journal was found to enhance the university students' overall writing performance as well as their language use (Foroutan, Noordin, & Hamzah, 2013).

Furthermore, CMC environment can improve L2 learners' motivation and participation especially for beginner writers (e.g., Sullivan & Pratt, 1996) by facilitating

peer interaction and collaborative activities. For example, some researchers have shown that L2 learners are more motivated to write (e.g., Dauite, 1986) and thus, tend to revise their writings more often (e.g., Bernhardt, Wojahn, & Edwards, 1989; Li & Cumming, 2001) when they engage in writing activities in CMC environment.

Research Questions

This meta-analysis aims to systematically synthesize findings from experimental and quasi-experimental studies conducted between 2013-2017 to investigate if there is a connection between CMC and second language learners' writing development. More specifically, this meta-analysis will (a) provide an overview of the previous studies on the effects of CMC on second language learners' writing development, (b) examine the overall effectiveness of the various CMC interventions/tasks used in L2 writing classrooms, and (c) identify variables that might moderate the effect of CMC on L2 learners' writing development. We will focus on the following research questions:

1. How effective is CMC in facilitating L2 writing development compared to face-to-face communication?
2. Do the following methodology features impact the effects of CMC differently: (a) treatment length, (b) L2 proficiency level, (c) CMC mode, (d) research setting?

Method

Literature Search

The following search steps were used to identify the primary studies. First, electronic databases in the area of language teaching and education were searched.

Electronic databases included Educational Resources Information Center (ERIC), Linguistics and Language Behavior Abstracts (LLBA), and Scopus. The keywords that used for searching included "computer mediated communication" at the first level; and English language learners (ELL), English as a second language (ESL), English as a foreign language (EFL), and second language learner at the second level.

Inclusion/ Exclusion Criteria

Next, using inclusion/exclusion criteria from a previous meta-analysis (Lin, 2014), and referring to the current meta-analysis goals, the following criteria were developed and followed when identifying articles. In order for the empirical studies to be reviewed in this meta-analysis, each study had to meet the following criteria:

1. The study was published between 2013 and 2017.
2. The study investigated some form of CMC (e.g., e-mail, chat, video, discussion forums, Wiki, blogs, etc.) either exclusively or in conjunction with other instructional strategies/intervention as long as the effect of CMC can be teased out by making comparisons between treatment groups for which the only difference between them is the CMC intervention.
3. The study employed an experimental or quasi-experimental design.
4. Participants were L2 or foreign language learners who are college-level students or above.
6. The studies reported adequate quantitative information for effect sizes to be calculated.
7. The outcome measure of the article was about writing achievement.

After initial review of potential primary studies, the following exclusion criteria were applied to filter out unqualified studies. A study was excluded if it was:

1. An article which was not published in English or in a peer-reviewed journal.
2. An article which was a systematic review, a case study, an uncontrolled pilot study, or a methodology article.
3. An article whose participants were not college and above level second language (SL) or foreign language (FL) learners.
4. An article which did not include CMC as their intervention.
5. An article which did not include writing achievement as their outcome measure.
6. An article which did not report sufficient quantitative data for effect sizes to be calculated.
7. An article which employed questionnaires/interviews to explore students' perceived effectiveness of the use of CMC (Samsonov, 2001).

Data Collection

Initially we searched each database and identified a total of 741 peer reviewed journal articles. During the data collection process, we only focused on published peer reviewed journal articles due to time constraints. After removing duplicates this number was reduced to 678 articles. Next, 243 articles which were irrelevant to CMC and L2 writing development were excluded based on their title. After that, we further excluded 71 articles, which included systematic reviews (n=40), case studies (n=23), uncontrolled pilot studies (n=2), and methodology articles (n=6). Then, we assessed the full texts of each article and excluded 137 articles based on the following exclusion criteria: intervention not

CMC (n=31), outcome not writing (n=80), not college and above level students (n=13), articles about students' attitudes and perceptions (n=12), and articles dealing with learners with disabilities (n=1). After this stage, we had 35 articles. Finally, we excluded 24 studies which used qualitative data analyses, resulting in 11 studies (Table 1) for our meta-analysis. When following the above searching steps, we used the Rayyan web app (https://rayyan.qcri.org/). The PRISMA Flow Diagram of our search process is presented in Figure 1.

Table 1

Details of Included Articles for the Meta-analysis

Author	L1	L2	L2 proficiency	Sample size	Study type	Research setting	CMC platform	CMC modality	CMC mode	Treatment length	Outcome measure
Mellati and Khademi (2014)	Persian	English	Advanced	70	Mixed	FL	Email	Text	asynchronous	Short	Institutional assessment
Sung and Wu (2013)	English	Chinese	Advanced	17	Mixed	FL	Discussion Forum	Text	asynchronous	Short	Researcher-developed assessment
Foroutan, Noordin and Hamzah (2017)	Malay	English	Advanced	42	quasi-experimental	FL	Email	Text	asynchronous	Short	Institutional assessment
Ansarimoghaddam and Beehoon (2013)	Malay, Mandarin, Tamil & French	English	Intermediate	30	Mixed	SL	Wiki	Text	asynchronous	Short	Institutional assessment
Ferriman (2013)	Thai	English	Intermediate	30	Experimental	SL	Chat	Text	asynchronous	Medium	Institutional assessment
Marandi and Seyyedrezaie (2017)	Persian	English	Advanced	84	quasi-experimental	FL	Google drive	Both	Both	Short	Standardized assessment
Zaini and Mazdayasna (2015)	Persian	English	Intermediate	44	quasi-experimental	FL	Email and/or Chat	Both	Both	Longitudinal	Researcher-developed assessment
Wang (2015)	Taiwanese	English	Intermediate	48	quasi-experimental	FL	Wiki	Text	asynchronous	Medium	Researcher-developed assessment
Jose and Abidin (2016)	Arabic	English	Advanced	56	quasi-experimental	FL	Blog	Both	syncronous	Medium	Standardized assessment
Wang and Vasquez (2014)	English	Chinese	Advanced	18	quasi-experimental	FL	Facebook	Text	asynchronous	Short	Researcher-developed assessment
Tare et al. (2014)	English	Russian	Intermediate	25	Experimental	SL	Chat	Text	asynchronous	Short	Researcher-developed assessment

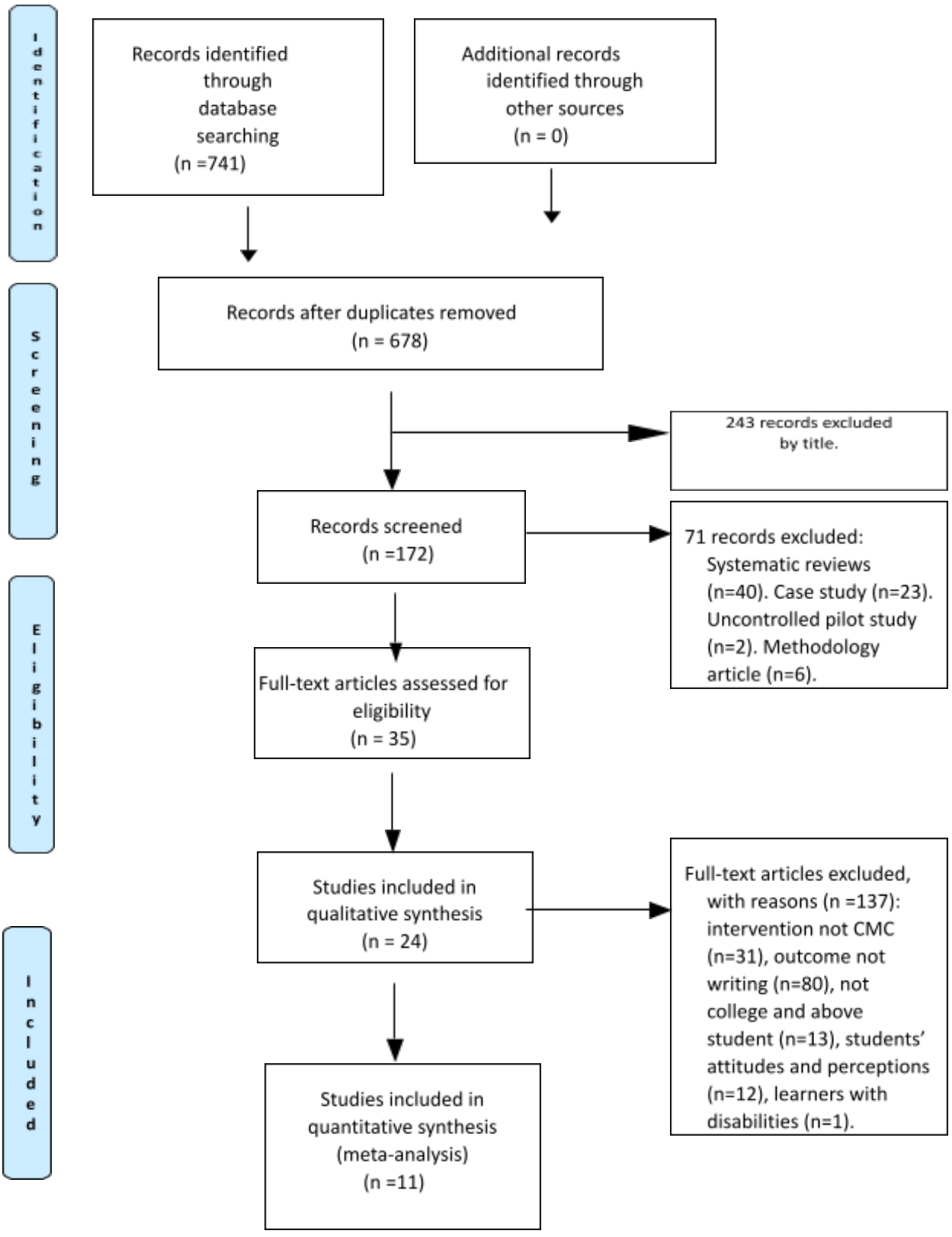
Identification
Records identified through database searching (n =741)
Additional records identified through other sources (n = 0)
Screening
Records after duplicates removed (n = 678)
243 records excluded by title.
Records screened (n =172)
71 records excluded: Systematic reviews (n=40). Case study (n=23). Uncontrolled pilot study (n=2). Methodology article (n=6).
Eligibility
Full-text articles assessed for eligibility (n = 35)
Included
Studies included in qualitative synthesis (n = 24)
Full-text articles excluded, with reasons (n =137): intervention not CMC (n=31), outcome not writing (n=80), not college and above student (n=13), students' attitudes and perceptions (n=12), learners with disabilities (n=1).
Studies included in quantitative synthesis (meta-analysis) (n =11)

Figure 1. Prisma Flow Diagram. *From:* Moher , D., Liberati, A., Tetzlaff, J., Altman, D. G., The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Coding Procedures

Coding and Inter-coder reliability.

Three doctoral students in ESL, who had received substantial training in research methodology and quantitative data analysis, participated in the coding process. Each coder was assigned roles both as a primary, secondary and third coder in that he/she had to independently code the assigned eleven studies and then acted as a second or third coder of another. As such, each study was coded at least three times. The inter-coder reliability was calculated by comparing the agreement between codes given by the two coders for each variable, and a ratio was calculated by dividing the number of agreed-upon codes by the total number of codes generated for all variables. Disagreement between codes as well as high-inference codes went through another coding by another two coders and final codes were assigned based on resolved discussions or the best estimation. The final inter-coder reliability was 100% for publication and learner variables, and 88.9% for methodological variables.

Table 2
Coding Scheme

Features	Descriptors
ARTICLE CHARACTERISRISTICS	
Publication year	Year of publication

LEARNERS	
L1	Learners' first language
L2	Learners' Second Language
Age	Age of the participants
Educational Level	Educational level of the participants (i.e., Undergraduate/ Graduate)
L2 Proficiency	Participants' initial target language proficiency level (i.e., Advanced/Intermediate/Elementary)
Sample Assignment	How the samples were assigned (i.e., Random/Naturally Occurring/ Matched/NA/NI)
Sample Size	Number of the sample size (i.e., Total, Treatment, Control)
METHODOLOGY	
Type of research design	Experimental/Quasi-Experimental/Mixed
Research Design	FL/SL
CMC platform	E-mail/Chat/Discussion forum/Instant/CMS Messenger/Blog/E-portfolio/Wiki/GoogleDrive/ Facebook/Email and/or Chat
Task Type	Information gap/Jigsaw/Problem-solving/ Decision-making/ Opinion-exchange/Mixed
CMC Mode	Synchronous/Asynchronous/Both
Treatment Length	Short (Less than or equal to 10 weeks)/ Medium (between 11 to 24 weeks)/ Longitudinal (more than 24 weeks)
Outcome Measures	Commercial or standardized assessment/ Institutional assessment/ Researcher

The coding scheme consisted of three major aspects of the retrieved studies, i.e., article characteristics (one feature), learners (seven features) and methodology (seven features) as presented. A brief description is provided for features and descriptors that are clear in Table 2. During the coding process, we omitted three articles which intervention not CMC. For a complete coding of the features please refer to Table 1.

Variables

CMC mode. In online settings, language learners can engage in communication either asynchronously or synchronously. The latter involves interlocutors in a real-time situation in which they "converse" either by typing messages or by speaking into

microphones. Due to its real-time nature, synchronous CMC, such as via chat rooms and Yahoo messenger, is considered to resemble face-to-face interaction to some degree. On the other hand, asynchronous CMC, such as web-based bulletin boards and email, simulate a delayed-time interaction in which extended planning, decoding and encoding time are allowed (Abrams, 2003).

CMC modality. CMC modality was coded as either text or voice, which may significantly affect the quality and nature of interaction. Voice-based CMC allows students to engage in verbal communications in which repair and negotiation are more likely to occur than in the text-based modality (Jenks, 2009) in which participants use personal computers to send typed messages with a potential delay of seconds before appearing on their partner's computer screen. Text-based modality may better fit certain communicational styles, and provide opportunities for more language production (Jepson, 2005).

Research setting. Research setting refers to the environment in which SLA is taking place, and is broadly divided into learning the target language either as a L2 or a FL. In the former setting, students have the benefits of using and practicing the target language in daily life, both inside and outside the classroom; however, in the latter setting, language learning is mostly limited to within the classroom, and there is little chance to use the language in an authentic environment. The degree of exposure to the target language is different in SL and FL settings both in the nature and amount of SLA, and practitioners tend to design learning activities differently for the two different settings.

Learners' L2 proficiency level. L2 learners' target language proficiency level has been used either as an independent variable or as a covariate in primary studies, proving its importance in writing achievement. This meta-analysis also seeks to answer this question. Learners' initial target language proficiency level was coded as one of the following four levels: elementary, intermedia, advanced, or mixed. The code was determined based on the participants' background information as provided in the primary studies. The original labels used by the researchers to classify participants into different levels were retained and no inferences were made based on this feature. It should be noted that some primary

researchers administered proficiency tests to participants while others did not.

Effect Size Calculations

The effectiveness of CMC on writing was expressed by calculating effect sizes for each study of different learning outcomes. Using the notations from Lipsey and Wilson (2001) and Borenstein, Hedges, Higgins, and Rothstein (2009), we calculated Cohen's effect sizes. The effect sizes represented as standardized mean difference were calculated by dividing the mean difference in a study by its pooled standard deviation, that is, Cohen's *d* (*Equation 1*). If a study did not provide descriptive analysis data but did provide *t* or *p* values, effect sizes were calculated using the procedure suggested by Copper, Hedges and Valentine (2009). The alternative equations that we used are presented in *Equation 2, 3, 4,* and *5*. We included 11 articles, but we had 13 effect sizes in total. One study by Jose and Abidin (2016) had three effect sizes because there were three different outcome measurements for writing achievement.

$$d = \frac{\bar{Y}^T - \bar{Y}^C}{S_{pooled}} = \frac{\bar{Y}^T - \bar{Y}^C}{\sqrt{\frac{(n^T-1)(S^T)^2 + (n^C-1)(S^C)^2}{n^T + n^C - 2}}} \quad (1)$$

$$t, n_1, n_2 \quad (2)$$

$$d = t\sqrt{\frac{n_1 + n_2}{n_1 n_2}} \quad (3)$$

$$p(two\text{-}tailed), n_1, n_2 \quad (4)$$

$$d = \pm t^{-1}\left(\frac{p}{2}\right)\sqrt{\frac{n_1 + n_2}{n_1 n_2}} \quad (5)$$

Then, we calculated the variance of the effect size using *Equation 6*.

$$var_d = \frac{n^T + n^C}{n^T n^C} + \frac{d^2}{2(n^T + n^C)} \quad (6)$$

Publication Bias

This meta-analysis included 13 effect sizes from 11 identified studies. Funnel plots have been used to identify publication bias (Bartolucci & Hillegass, 2010; Egger, Smith, Schneider, & Minder, 1997). Studies with larger sample sizes present towards the top of the funnel plot, whereas studies with smaller sample sizes present towards the bottom of the funnel plot (Rothstein, 2008). In our study, most of the effect sizes showed symmetry in the funnel plot. We also carried out Egger's regression test (Egger et al., 1997), which is a linear regression method that assesses the publication bias by the funnel plot. The Egger test of the intercept was not significant, t = -1.0526, p = 0.2925, suggesting that the funnel plot is symmetric (Figure 1). Therefore, publication bias was not a problem for the validity of our study.

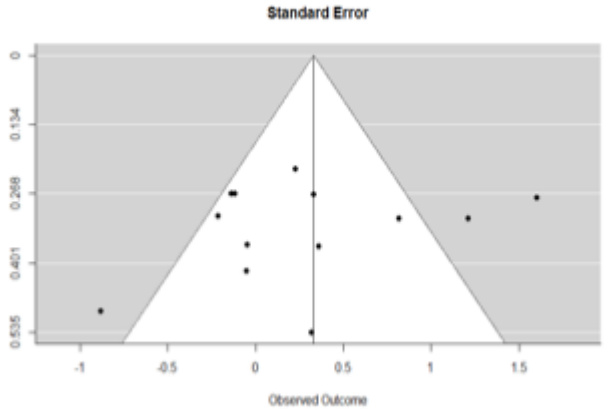

Figure 2. Funnel Plot of Cohen's d and Standard Error

Data Analysis

As a first step in the data analysis, we ran the fixed-effect model. The forest plot for the fixed-effect model is presented in Figure 3. The result of the fixed-effect model

yielded a significant result, Q (12) = 48.75, $p < 0.001$, meaning that there is variability in the effect sizes between the studies due to the sampling error.

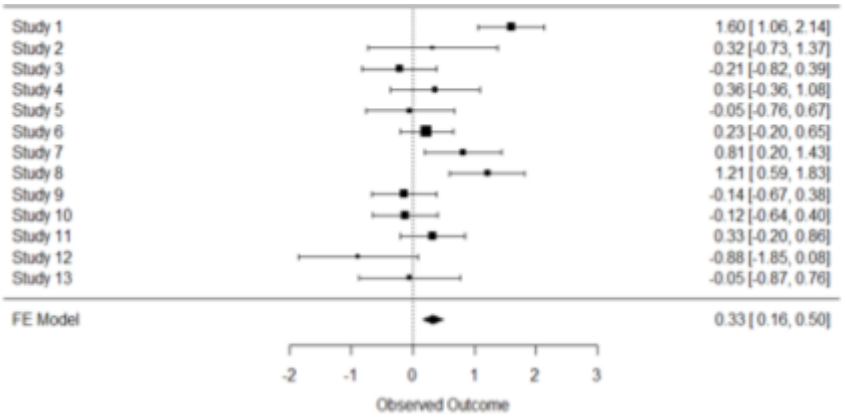

Figure 3. Forest Plot for Fixed-effect Model

Table 3

Results of Fixed-effect Model

	Estimates	Standard error	95%confidence interval	*Q*	*P*
Fixed effects Components	0.33***	0.08	[0.16, 0.49]	48.75	<0.0001

Then, we ran the RE model. RE model produces more conservative estimates because we are including more error into the model. Also, study weights are more balanced under the random-effects model than under the fixed-effect model. Thus, we chose the RE model for our study. As shown in Figure 4, half of the effect sizes were positive and greater than zero. The overall effect estimate was 0.29. Confidence interval of overall estimate was between -0.06 and 0.64. As displayed in Table 4, the Q (12) = 48.75, $p < 0.001$ for the RE model was also statistically significant, indicating that there was variability in the effect sizes among the studies beyond the sampling error. $I^2$was

calculated as 75.60%, suggesting that there was 75.60% of effect-size variability which could not be explained by sampling error.

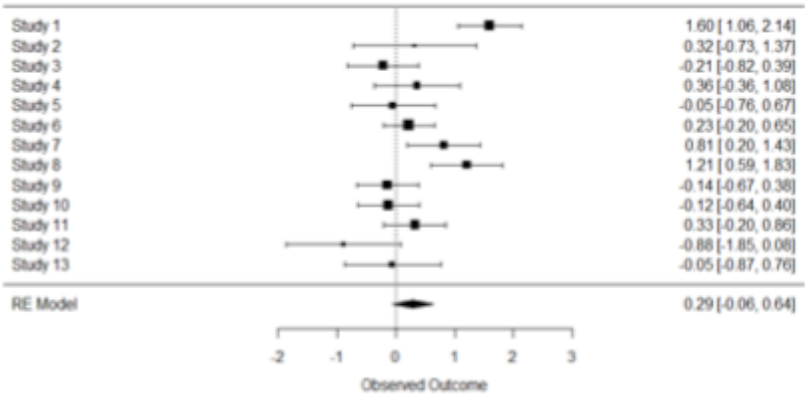

Figure 4. Forest plot for random-effects model

Table 4

Results of random-effect model

	Estimates	Standard error	95% confidence interval	*Q*	*P-value*	I^2	T^2
Random effects Components	0.29***	0.18	[-0.06,0.64]	48.75	<0.0001	75.60	0.30

The Homogeneity Test

A homogeneity test determines whether the studies all have the same effect in the population. The null hypothesis is that the effect sizes are homogeneous. The homogeneous model states the variation among the studies is only due to sampling error. However, if the model is heterogeneous, the variance among the studies is larger than one would expect based on sampling error alone. In addition, a significant *Q* test suggests that the outcomes are heterogeneous. To support the heterogeneity test results, I^2statistics, which represents the percentage of the heterogeneity where higher values of I^2 represent

higher-level of heterogeneity, was calculated.

The heterogeneity test yielded a significant result, Q (12) = 48.75, $p < 0.001$. Also, the I^2 value was calculated as 75.60% suggesting there was 75.60% of effect-size variability cannot be explained by sampling errors. Based on these statistics, the effect sizes from the studies showed heterogeneity.

Results

Research Synthesis

This meta-analysis has included 11 studies for our overall analysis. However, the authors found 13 effect sizes as one of the study (Jose and Abidin, 2016) had three effect sizes. There were 464 participants in total and all of the articles have been taken from peer-reviewed journals.

Table 5 shows the descriptive statistics of included studies with the study counts. Of the 11 studies six studies included advanced level of L2 learners whereas five studies included intermediate level of L2 learners. None of the included studies had elementary level L2 learners as participants. Also, regarding the research setting, FL setting was more prominent (8 studies) than the SL setting (3 studies). Regarding the CMC mode, asynchronous mode (8 studies) was more likely to be used for intervention than the synchronous mode (1 study) or combining both modes (2 studies) together. The fourth moderator, treatment length, has three levels. These are: the short treatment length (less than or equal to 10 weeks), medium (between 11 to 24 weeks), longitudinal (more than 24 weeks). From Table 5, we can see that there are 7 studies including short treatment length,

whereas 3 studies included medium treatment length and only 1 study incorporated longitudinal treatment length.

Table 5

Descriptive Statistics of Included Studies

Moderator variable	Identified categories	Counts (%)
L2 proficiency	Advanced	6 (54.5%)
	Intermediate	5 (45.5%)
	Elementary	0 (0.0%)
Research setting	FL	8 (72.7%)
	SL	3 (27.3%)
CMC mode	Synchronous	1 (9.1%)
	Asynchronous	8 (72.7%)
	Both	2 (18.2%)
Treatment length	Short (less than or equal to 10 weeks)	7 (63.6%)
	Medium (between 11 and 24 weeks)	3 (27.3%)
	Longitudinal (more than 24 weeks)	1 (9.1%)

Overall Analysis

Initially, we ran the fixed-effect (FE) model and random effect (RE) model. Table 6 and 7 displayed the results of FE and RE model. The *Q* statistics was statistically significant for the Fixed effect model which means there was some variability in the effect sizes due to sampling error. The *Q* statistics for the Random-effect model was also

significant meaning that the effect sizes were different except for sampling error. Also, from the Random-effects model we know that the variance of the between group studies was $\tau^2 = 0.30$ and there was $I^2 = 75.60\%$ variability in the effect sizes which was unexplained except for the sampling error. Therefore, we believe that random-effects model was more appropriate than fixed-effect model because our measures of effect-size heterogeneity (Q, I^2, τ^2) indicated model appropriateness.

Table 6

Results of Fixed-effect and Random-effect Models I

	Q	*df*	*p*	I^2	$\widehat{\Gamma}^2$
FE model	48.75	12	<0.0001		
RE model	48.75	12	<0.0001	75.60%	0.30

Table 6 shows that the CMC experimental group students scored an average of 0.291 (random-effects) or 0.3305 (fixed-effects) standard deviation higher than the face-to-face communication group on the assessment of writing achievement. Our overall mean $\mu = 0.18$

says that, on average, students in the CMC group scored 0.18 standard deviations higher than students in the face-to face group on the assessment of writing achievement. Also, the overall average effect is statistically significant [-0.06, 0.64] which confirms effect-size heterogeneity.

Table 7

Results of Fixed-effect and Random-effect Models II

Number of studies (K)	*Overall estimate*	*SE*	95% *Confidence Interval*	
			Lower limit	Upper limit
All studies (11)	0.33 (FE)	0.08	0.16	0.49
	0.29 (RE)	0.18	-0.06	0.64

Moderator analysis

We ran the mixed-effects ANOVA-like model including the moderators to examine whether the moderator variables had any effect on the outcomes of the studies. From table 5, we can see that for all the moderators, *Q* between came to be non-significant and *Q* within came to be significant meaning that there is no heterogeneity between the studies but there was heterogeneity within the group. However, R^2 meta show that the moderators can explain only 0% heterogeneity among the studies.

Table 8

Q Statistics of the Moderators

Moderators	*Q between*	*Q within*	*R^2 meta*
L2 proficiency	3.21, p=0.39	45.93, p<.0001	0.00
Research setting	2.81, p=0.25	47.41 p<.0001	0.00
CMC mode	3.08 p=0.38	42.85 p<.0001	0.00
Treatment length	2.93, p=0.40	45.55, p<.0001	0.00

Table 8 provides the effect size statistics for categorical moderators. None of the moderators came to be statistically significant.

Table 9

Description of the Effect Size Statistics for Categorical Moderators

Moderators		*Estimates*	*SE*	*p*	*CI*
L2	Advanced	0.18	0.23	0.44	[-0.27, 0.62]
proficiency	Intermediate	0.48	0.30	0.10	[-0.10, 1.06]
Research	FL	0.34	0.21	0.09	[-0.06, 0.75]
setting	SL	0.09	0.40	0.82	[-0.69, 0.87]
CMC mode	Syncronous	0.02	0.38	0.95	[-0.71, 0.76]
	Asyncronous	0.34	0.25	0.17	[-0.15, 0.83]
	Both	0.50	0.46	0.27	[-0.40, 1.40]
Treatment	Short	0.24	0.27	0.36	[-0.28, 0.77]
length	Medium	0.24	0.29	0.41	[-0.34, 0.83]

Longitudinal	0.81	0.67	0.23	[-0.51, 2.14]

Discussion

To respond to the first research question, the results suggested a moderately significant mean effect size. There was a difference in the writing achievement score favoring the CMC treatment group compared to the face-to-face group. Results of the moderator analysis for the second research question are discussed below:

L2 Proficiency: It should be noted, however, that most primary studies relied on printed chat log files as the sole data to interpret chat interactions–files which might not be able to capture all the repairs that go on. This data collection method may have rendered the results severely flawed and not comparable (Smith, 2008). Also, the level of proficiency was determined by the primary researchers, who employed various types of measurements or who simply made such judgments based on their understanding of the students, and thus this variable is by no means to be taken as valid (Lin, 2014).

Research Setting: Findings revealed a much larger effect for studies in which the target language was a foreign language (FL) (Sung & Wu, 2013; Foroutan, Noordin& Hamzah, 2017; Marandi &Seyyedrezaie, 2017; Zaini&Mazdayasna, 2015; Wang, 2015; Jose &Abidin, 2016; Wang & Vasquez, 2014; Mellati&Khademi, 2014) than for studies in which it was a second language (SL) (Ansarimogaddam& Hoon, 2013; Ferriman, 2013; Tare, Golonka, Vatz, Bonilla, Crooks, & Strong, 2014). A more striking observation is that studies conducted in SL contexts generated negative effects, while those in FL contexts

generated a moderate positive effect. One plausible explanation may be that learners in FL contexts are more enthusiastic about making use of the opportunities offered for the simulated communication afforded in the CMC environment than those in SL contexts, in which such opportunities are also available to them beyond the classroom.

CMC mode: This variable did not turn out to be significant moderator as was expected. In empirical studies, researchers tend to manipulate the independent variables to examine their relative effects on the learning outcomes (Lin, 2014). For example, through cross-tabulation analysis of the effect sizes incorporating outcome skills, Abrams's (2003) and Hirotani's (2009) found that, almost exclusively, writing tasks were carried out either asynchronously or synchronously, while speaking tasks were almost exclusively conducted synchronously, with few exceptions. However, studies including both synchronous and asynchronous mode (Zaini & Mazdayasna, 2015; Marandi & Seyyedrezaie, 2017) had a larger effect size than the studies that used synchronous (Jose & Abidin, 2016) or asynchronous (Sung & Wu, 2013; Foroutan, Noordin& Hamzah, 2017; Wang, 2015; Wang & Vasquez, 2014; Mellati&Khademi, 2014; Ansarimogaddam & Hoon, 2013; Ferriman, 2013; Tare et al., 2014). It may indicate that using both synchronous and asynchronous CMC mode may be more effective than using only synchronous or asynchronous CMC mode.

Treatment Length: The longitudinal study (Zaini & Mazdayasna, 2015) had a much larger effect size than the studies that had short (Wang & Vasquez, 2014; Mellati & Khademi, 2014; Ansarimogaddam & Hoon, 2013; Tare et al., 2014; Marandi & Seyyedrezaie, 2017; Sung & Wu, 2013; Foroutan, Noordin & Hamzah, 2017) or medium

(Jose & Abidin, 2016; Wang, 2015; Ferriman, 2013) treatment length and therefore it can be assumed that researcher should implement the intervention for a larger period of time.

Conclusion

This meta-analysis showed several tentative findings regarding the effectiveness of CMC on writing achievement in SLA. In recent years, there has been a rapidly increasing number of empirical studies investigating the use of CMC tools in second language education. This meta-analysis ventured to find out whether CMC would produce an equal or even superior performance on writing achievement compared to the face-to-face contexts, and thus would be more effective to promote SLA. Overall, the evidence is in support of CMC setting. Also, CMC can perform as an alternative to the traditional classroom based face-to-face interaction.

Although the four moderators, namely, L2 proficiency, research setting, CMC mode, and treatment length did not turn out to be variables that differentiated the effectiveness of CMC; it is safe to state that CMC setting supports the interaction hypothesis (Krashen, 1985, 1989) that online interactions/communications mediated by computers/technology can generate similar or better opportunities for L2 learning compared to the face-to-face settings. However, the authors had a small number of primary studies (n=11). For future research the authors would recommend incorporating more moderators such as interlocutors, and/or task type and so on. Also, for future research the authors would suggest attempting to combine two or more moderators together and run the moderator analysis.

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