Review Article

The Usability of classroom Technologies in English Language Teaching and Learning (ELT & ELL)

Linguistics

Keywords: Technology, Teaching and learning, Computer-assisted instruction, Good instructional practices, Student outcomes

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Abstract

In language teaching and learning, we have a lot to choose from the world of technology: Radio, TV, CD Rom, Computers, C.A.L.L., the Internet, Electronic Dictionary, Email, Blogs and Audio Cassettes, Power Point, Videos, DVD's or VCD's. The last two decades have witnessed a revolution due to onset of technology, and has changed the dynamics of various industries, and has also influenced the industries and the way people interact and work in the society. This rapid rising and development of information technology has offered a better pattern to explore the new teaching model. As a result technology plays a very importantrole in English teaching. Using multimedia to create a context to teach English has its unique advantages.Weexamined the effect of teaching and learning with technology on student cognitive and affective outcomes using the available technique. Screening studies obtained from an electric search of databases resulted in 58 studies (2013-2014). Overall, effect sizes were small to moderate across the cognitive and affective outcome measures. Specific teaching/learning components such as context/making sense, challenging activity, instructional conversation, and joint productivity were associated with effect sizes. Instructional features such as objectives, pattern of student computer use, and type of learning task also moderated effect sizes. Suggestions are made for teachers to include these instructional features and teaching strategies in teaching and learningwith classroom technology.

Introduction

Integrating technology into classroom teaching and learning has been an important issue in the last few decades. Several meta-analyses have been conducted to examine specific modes of instruction or educational practices that promote student learning and teaching with technology. Lou, Abrami, and d'Apollonia (2001), for example, examined the effects of small group versus individual instruction with technology and found that small-group learning had more positive effects than individual learning. Other meta-analyses in technology have examined topics such as the effectiveness of interactive distance education (Cavanaugh, 2001), the effect of computer-assisted instruction (CAI) on beginning readers (Blok, Oostdam, Otter, and Overmaat, 2002,) CAI in science education (Bayraktar, 2002), and the effect of technology on reading performance in grades 6-8 (Moran, Ferdig, Pearson,Wardrop, & Blomeyer, 2008). A recent meta-analysis by Li and Ma (2010) investigated the influence of computer technology on mathematics achievement in K-12 classrooms from 46 studies and found a greater effect for elementary over secondary school students and that the technology effect was greater when constructivist approach was incorporated in the teaching and learning process (Li & Ma, 2010). A more comprehensive meta-analysis for the effect of technology on learning was conducted using a second-order meta-analytic technique involving 25 metaanalyses encompassing 1055 studies in a 40 year span (Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011).

However, these recent reviews focused only on a particular issue (e.g. group size, CAI, or the general technology effect) and there is little information on what the effective strategies or appropriate approaches are in integrating and using technology in schools and classrooms. For example, Moran et al's study (2008) found very little researchreported outcomes on strategy use and metacognition. Ma & Li's study (2010), on the other hand, reported adifferential effect on constructivist approach versus traditional approach but no specific teaching strategies or instructional features were informed. Likewise, Tamim et al's study (2011), though very thorough and comprehensive, only included 2 moderator variables on grade level and purpose of technology use. As Ross, Morrison, and Lowther (2010) commented that "educational technology is not a homogeneous 'intervention' but a broad variety of modalities, tools, and strategies for learning. Its effectiveness, therefore, depends on how well it helps teachers and students achieve the desired instructional goals" (p. 19), in line with this statement, we aimed to explore what the effective practices are so that teachers and students can teach and learn effectively with technology.

Purpose of this study

The purpose of this study was to evaluate the effects of teaching and learning with technology on student outcomes in K-12 settings so as to inform instructional practices, by reviewing the experimental and quasi-experimental studies published between 1997 and 2011. Unlike prior syntheses, which may focus on a particular teaching practice, grade level, or subject area, we are interested in the overall effect and common technology characteristics, teaching strategies, and instructional features that benefit student learning and teaching across grade levels. Specifically the meta-analysis intends to address the following research questions:

.What is the general magnitude and direction of the relationship between teaching and learning with technology and student outcomes?

.Are there specific technology characteristics, teaching strategies, and instructional features that affect teaching and learning with technology on student outcomes?

In the following section, we provided a brief review and rationale for the coding of variables based on technology characteristics, teaching strategies, and instructional features.

Technology characteristics

Role of technology and pattern of computer use

Technology can take on several roles in education, such as role of resources, role of delivery system, or productivity. Computer programs were found to be most effective in supporting student centered learning if the programs can provide scaffolds for students with special needs, support factual knowledge acquisition, and emphasize the capacity of technology in creating new learning experiences for students (Pedersen & Liu, 2003). Besides, significant learning gains were found if computers serve as resources (Wegerif, 2004). Pattern of computer use concerns the size of participants working together with technology. Working with technology individually offers greater flexibility for participants to adjust their own pace; on the contrary, working in a larger group (e.g. 6-8 or more) may result in the dominant use of the technology by one or a few persons. Research has shown that students working in small groups (e.g. 3-5) with computers performed better than individual student working with computers (Lou, Abrami, and d'Apollonia, 2001).

Type of technology, software, and objective of technology

Type of technology refers to the carriers (e.g. laptops, PCs, PDAs…etc.) of the instructional material while software is the type of instructional material itself (e.g. tutorial, drill & practice, exploratory environment…etc). For example, laptop programs were found to be effective in student engagement (Penuel, 2006) and academic achievement (Zucker & Hug, 2008). Software, on the other hand, can be very useful if used for an appropriate learning purpose.For example, multimedia talking books can help beginning readers learn to read (Chera & Wood, 2003; Doty, Popplewell, Byers, 2001) and computer simulations can help learn dissection before the actual laboratory anatomy in a biology class (Akpan & Andre, 2000). As for objectives of technology use, technology was found to have a greater effect in learning when used to support instruction rather than for direct instruction (Tamim et al, 2011).

Effective Teaching Strategies

We included teaching strategies as moderators in the meta-analysis. The Center for Research on Education, Diversity, and Excellence developed five standards of effective teaching strategies, namely (1) Teachers and Students Producing Together (Joint Productive Activity), (2) Developing Language and Literacy Across the Curriculum (Language Development), (3) Making Meaning: Connecting School to Students' Lives (Contextualization), (4) Teaching Complex Thinking (Challenging Activities), and (5) Teaching Through Conversation (Instructional Conversation) (see Dalton, 1998; Tharp, 1997). These standards are based on the best theoretical and empirical knowledge in the field, and there is ample evidence that their use in classrooms may lead to dramatic improvements for the education of all students (Tharp, Estrada, Dalton, & Yamauchi, 2000).

Instructional features

Mode of instruction and role of teacher

Mode of instruction can be discussed in a variety of settings, such as whole-class, small-group, and individualized instruction. Waxman and Huang (1996) found whole-class approaches were frequently observed in lower technology use classrooms where students generally listened to and watched the teacher, while more independent work was observed in classrooms where technology was moderately used. Studies also showed that teachers' role as facilitator for student learning had a higher effect than as disseminator of knowledge or modeling processes (Dekker and Elshout-Mohr, 2004; Stonewater, 2005; McCrone, 2005).

Task difficulty, type of task, and learning responsibility

Task difficulty is similar to challenging activity to teach complex thinking in the teaching strategy section. Type of task can be for learning basic skills/factual learning, problem solving, project-based learning, or Inquiry/investigation. Project-based learning, for example, was found to have dramatic gains in student academic achievement across states in the U.S. (Thomas, 2000). Learning responsibility can be categorized into teacher directed, student-centered, system-directed or mixed. Nowadays, there is a trend to call for student-centered learning (Jonassen, 2000).

Methods

For this meta-analytic review, we used selection criteria and review methods that are similar to other recent major national reviews conducted in areas such as teacher preparation (Wilson, Floden, & Ferrini-Mundy, 2001) andreading (International Reading Panel, 2002). The synthesis included quantitative, experimental, and quasi-experimentalresearch and evaluation studies that have been published in refereed journals during a fifteen-year period (1997-2011).

Selection of articles

To be included in the synthesis, articles must satisfy the following criteria:

 Focus on teaching and learning with technology in K–12 classroom contexts where students and their teachers interact primarily face-to-face (> 50 percent of the time);

 Compare a technology group to a nontechnology comparison group, or compare the group at the beginning of the intervention (pretest) to a posttest measure; and

 Have reported statistical data (e.g., t tests or F tests) that allowed the calculation of effect sizes.

First, online computer databases like Education Resources Information Center (ERIC) or PsycInfo were used for search of articles. Keywords such as "Technology/computer" and "achievement" or "technology/computer" and "student outcome" or "technology/computer" and "attitude" were entered in the databases. Over 500 articles were left and met the desired publication time for coverage. Abstracts about these articles were then read to determine if they are relevant to the synthesis. Most of the studies were discarded because they are not comparing the experiment group to a control group that has no access to technology. Other studies were excluded because they are not directly linked with the use of technology for learning and teaching purpose in the K-12 setting. The search and selection procedures resulted in a collection of 58 studies.

Coding design

Our studies were coded on 17 variables. The study descriptors included 2 variables: grade level and publication features (technology journal or educational journal). Technology characteristic descriptors consisted of 5 variables: type of technology, type of software, role of technology, pattern of student computer use, and objective of technology use. The instructional descriptors included 5 variables: learning responsibility, task difficulty, type of

136 learning task, mode of instruction, and role of teacher. As for teaching strategy descriptors, we included the FiveStandards for Effective Pedagogy developed by the Center for Research on Education, Diversity, and Excellence (2002; see Dalton, 1998; Tharp, 1997).

Interrate reliability

Two investigators independently coded the studies based on the coding book of 17 characteristics for each of the 366 effect sizes from the 58 studies. Then, each investigator independently coded six studies from the other investigator. The interceder agreement for each study reviewed exceeded the 85-percent criterion and the average Cohen’s Kappacoefficient reached 0.88

Data analysis

The overall data analysis strategies were based on Lipsey and Wilson (2001). In the initial coding of studies, two types of student outcomes were identified: (a) cognitive, and (2) affective. Effect sizes of standardized mean difference were computed if means, standard deviations, and group size were reported in the selected studies. Otherwise, effects were computed from t-statistics or F-statistics if these were reported. Hedges and Olkin estimator in Lipsey and Wilson (2001) were used to produce unbiased effect size estimates (i.e., Hedge’s g), which areweighted with inverse variance weight (i.e. the inverse of squared standard error value,) so that effects with larger standard error are given a smaller weight because large standard error produces less precise effect size values. In order to insure the independence of ESs, a single combined ES was extracted from each study for each of the two outcomes as suggested by Lipsey and Wilson (2001).

Q-statistics were computed for each outcome based on the adjusted mean effect size weighted with the inverse variance weight function within each study to examine the heterogeneity of effect size (Lipsey & Wilson, 2001). The Q-statistic follows a chi-square distribution with degrees of freedom equal k-1, where k is the number of effect sizes (Hedges & Olkin, 1985). Moderators were evaluated using the meta-analytic analog to analysis of variance (Lipsey & Wilson, 2001). In interpreting the Q statistic, a significant Qb (Q statistic between) suggest a significant mean difference between/among levels of categorical variable, while a significant Qw (Q statistic within) evaluates the heterogeneity within groups and indicates that a moderator may be needed to group studies into homogenous subcategories (Lipsey & Wilson, 2001). If analysis of moderator effect is needed to investigate sources of variation in effect sizes, a Bonferroni correction with alpha level of .005 will be selected in the analysis to avoid inflated experiment-wise Type I error rate when numerous analyses were conducted for each outcome.

Results

A total of 366 effect sizes were computed from 58 studies included in the study. Mean effect sizes were calculated for each construct across studies. For the cognitive outcome, the weighted mean effect (Hedge’s g) was 0.42 with 243 effects from 48 studies. For the affective outcome, the effect was 0.18 with 92 effects from 21 studies.

The chi-square Q statistic was computed for each outcome to evaluate the homogeneity of the mean effects. For the cognitive outcome, Q (df =47) = 231.47, p< .001; for the affective outcome, Q (df =20) = 118.60, p < .001. The large Q statistics and small p values revealed that the effect sizes were heterogeneous within each construct. Therefore, we conducted analyses of the moderator effect for both outcome measures.

Analysis of moderator

Cognitive

Results for the cognitive outcome were presented in Table 1. Grade, context/ sense making, objective, pattern of student computer use, and type of learning task were significant moderators for effect sizes. Grade 9-12 had the lowest mean effect (.22) compared with grade K-3 (.50), 4-6 (.41), and 7-8 (.59). The finding was similar with Li andMa's study (2010) where secondary schools had a lower effect. Studies showing evidence of making sense or teaching and learning in context (.53) had higher mean effects than those without evidence (.39). Using technology for remediation of skill not learned (.83), finding out about ideas and information (.61), and expressing themselves in writing (.59) had higher effects than for analyzing information (.39), multiple objectives (.19), or others (.26). Studies reporting factual learning (.64), inquiry/investigation (.61), project-based learning (1.39), and others (.62) had higher mean effects than those reporting problem-solving (.39) and mixed type learning (.05). A differential effect was also found on pattern of student computer use. Three to five students per computer had the highest mean effect (1.08) followed by two students per computer (.65), mixed pattern (.57), and others (.44). One student per computer had the lowest mean effect size (.40).

***Table 1*. Categorical moderators for cognitive outcomes**

Variable	Mean	Q_B	df_B	Prob(Q_B)	Q_W	df_W	Prob(Q_W)
Overall	0.42						
GRADE		15.49	3	.0014	191.76	43	< .0001
24=K-3	0.50						
25=4-6	0.41						
26=7-8	0.59						
27=9-12	0.22						
Publication feature		7.86	1	.0051	199.40	45	< .0001
1=technology	0.41						
2= educational	0.66						
Type of Technology		5.49	4	.2408	124.85	27	< .0001
1=PCs	.56						
2=Laptops	.88						
3= Networked computer	.39						
5=Multimedia	.61						
6=Other	.44						
Software		6.70	4	.1529	187.07	33	< .0001
1=Tutorial .81							
2=Drill-and- Practice	.42						
3= Exploratory Environment	.38						
4=Tools for other task	.59						
6=Other	.41						
Role of Technology		6.82	3	.0779	177.21	38	< .0001
1=Productivity	.41						
2=Delivery system	.43						
3=Resources	.45						
4=Other	.24						
Pattern of Computer Use		21.13	4	.0008	60.31	27	.0002
3=1 student per computer .40							
4=2 students per computer .65							

5= 3-5 students per computer 1.08
7=Mixed pattern .57
8=Other .44
Objective 51.20 5< .0001 148.67 38< .0001
1=Remediation .83
2=Expressing themselves in writing .59
4=Finding out about information .61
5=Analyzing information .39
10=Multiple objectives .19
11=Other .26
Context/Making Sense 9.00 1 .0027 196.25 40< .0001
1=No evidence .39
2=Some evidence .53
Challenging activities . 7.47 2 .0239197.7743 < .0001
1=No evidence .28
2=Some evidence .42
3=Extensive evidence .51
Instructional conversation .8264 2 .6615 204.41 43< .0001
1=No evidence .39
2=Some evidence .43
3=Extensive evidence .45
Joint Productivity /Collaboration 6.77 2 .0338 198.47 43 <.0001
1=No evidence .42
2=Some evidence .54
3=Extensive evidence .32
Language Literacy Development 7.12 1 .0076 198.12 44<.0001
1= No evidence .39
2= Some evidence .53
Task difficulty 5.145 3 .1615 113.13 26 < .0001
1=Difficult .35
2=Moderately difficult .58
3=Not difficult .88
4=Mixed level of difficulty .42
Type of learning task 52.31 5< .0001 139.20 37< .0001
1=Basic skill/factual learning .64
2=Problem-solving .39
3=Inquiry/Investigation.61
4=Project-based 1.39
5=Mixed-Type.05
6=Other .62
Learning responsibility 8.72 3 .0333 131.26 35 < .0001
1=Student-controlled .31
2=Teacher-directed .54
3=System-directed .43
4=Mixed .57
Mode of Instruction 6.29 4 .1783 120.77 33< .0001
1=Whole-group .47
2=paired .48
3=Small-group (3-5) .48
4=Individualized .39
5=Mixed .55
Role of teacher 11.87 3 .007850.2176 22 < .0001
2=Facilitator .62
3=Modeling processes -.39
4=Mixed .61
5=Other .39

Affective

Results for affective outcome were presented in Tables 2. Challenging activities, instructional conversation, and joint productivity/collaboration were significant moderators for effect sizes. Studies reporting some evidence (.36) or extensive evidence (.25) of challenging activities had higher mean effects than those with no evidence of challenging activities (.06). Likewise, studies with some evidence of instructional conversation (.44) exhibited greater effect sizes than those without evidence of instructional conversation (.12). Those studies showing some evidence (.34) or extensive evidence (.32) of joint productivity/collaboration also had higher mean effects in the affective outcome than those with no evidence (.06) of joint productivity/collaboration.

Table 2. Categorical Moderators for Affective Outcomes

Variable	Mean	Q_B	df_B	Prob(Q_B)	Q_W	df_W	Prob(Q_W)
Overall	.18						
GRADE		7.33	3	.0619	115.18	17	<.0001
24=K-3	.17						
25=4-6	.13						
26=7-8	.60						
27=9-12	.21						
Publication feature		.33	1	.5645	122.18	19	<.0001
1=technology	.19						
2= educational	.07						
Type of Technology		10.89	3	.0123	19.04	12	.0876
1=PCs .30							
3= Networked-computer	.07						
5=Multimedia	.38						
6=Other	.04						
Role of Technology 7.45 3 .0589 25.77 10 .0041							
1=Productivity .04							
2=Delivery system .29							
3=Resources .17							
4=Other .21							
Objective 8.50 5 .1304 28.28 13 .0083							
1=Remediation .17							
4=Finding out about ideas And information	.30						
5=Analyzing information .64							
7= Improving Computer Skills 1.07							
10=Multiple objectives .16							
Pattern of Student Computer Use		1.05 3 .7881 7.2091 6.3019					
3=One student	.19						
4=Two student	.37						
7=Mixed pattern	.29						
Context/Making Sense		5.40	1	.0201	38.70	18	.0031
1=No evidence	.10						
2=Some evidence	.27						
Challenging activities		12.69	2	.0018	31.41	17	.0178
1=No evidence	.06						
2=Some evidence	.36						
3=Extensive evidence	.25						
Instructional conversation		8.63	1	.0033	35.47	18	.0082
1=No evidence	.12						

2=Some evidence	.44						
Joint Productivity /Collaboration		14.55	2	.0007	29.55	17	.0298
1=No evidence	.06						
2=Some evidence	.34						
3=Extensive evidence	.32						
Language Literacy Development		2.93	1	.0871	41.17	18	.0014
1= No evidence	.11						
2= Some evidence	.23						
Learning responsibility		3.78	3	.2857	19.02	12	.0881
1=Student-controlled	.33						
2=Teacher-directed	.76						
3=System-directed	.17						
4=Mixed	.29						
Mode of Instruction		14.61	4	.0056	1.79	3	.6168
1=Whole-group	1.07						
2=paired	.64						
3=Small group (3-5)	.25						
4=Individualized	.19						
5=Mixed	1.09						
Role of teacher		3.76	2	.1523	9.0719	4	.0593
1=Disseminator	1.07						
2=Facilitator	.25						
5=Other	.19						

Discussion & Conclusions

The main purpose of this meta-analysis was to bring together 15 years of investigations on the effect of teaching and learning with technology on student cognitive and affective outcomes. In terms of magnitude and direction, the overall effect sizes for the two outcomes exhibited a positive effect in teaching and learning with technology.

Cognitive outcome, in particular, had an effect size (.42) that was larger than several of the past meta-analytic reviews that were old or covering multiple decades of studies (e.g. Bayrakter, 2002; Christmann & Badgett, 2003; Kulik and Kulik, 1991; Ouyang, 1990; Tamim et al., 2011) but was comparable with meta-analyses analyzing more recent studies (e.g. Li & Ma, 2010; Moran et al., 2008). It is very likely that effect sizes increased with the evolution of technology itself and the advancement of pedagogy in teaching and learning with technology.

Suggestions for pre-service and in-service teachers

Based on the meta-analytic review, we gained invaluable information as to the best practices in teaching and learning with technology. For the cognitive outcome, we found technology was best use for the purpose of basic skills and factual learning which refers to “rote learning and the extent to which participants were able to repeat facts presented during the lesson” (p. 800, Jang, 2008). Factual or rote learning is relatively less complex and less difficult compared to other purposes because it utilizes a more straightforward strategy to learning, such as memorization (Vansteenkiste, Simons, Lens, Soenens, & Matos, 2005). Nevertheless, acquiring basic skills or factual learning is an essential step for students to use technology for other purposes such as expressing themselves in writing, finding out information, analyzing information, and multiple objectives. Our argument can be verified by the fact that projectbased learning also yielded the highest effect in terms of type of learning task. The scope of project-based learning usually span across subjects and help learners to see the interconnectedness of multiple domains; it encourages students to search for information, find out about facts, exchange findings, and collaborate with their peers (Kwok &Tan, 2004). Each of these significant knowledge building steps were anchored upon basic skills/ factual learning and instructional elements that are sense-making and contextualized (Arnseth and Saljot; 2007). Therefore, for teachers to improve student cognitive outcomes, the take-home messages are to

 Collaborate in small or paired groups with computers;

 Develop instructional elements that are sense-making in context

 Build student basic skills and help them see the interconnectedness of subject knowledge in a project-based learning

For the affective outcome, collaboration is also an important factor. By working collaboratively, students not only share their cognitive capacity, reduce their mental efforts, but also increase their confidence in the task, which in turn lead to better affective outcome, especially in processing complex tasks (Kirschner, Paas, Kirschner, 2011). The evidence of challenging activity or in some sense similar to task difficulty also contributed to higher student effects. According to the flow theory, people gain their optimal experience in learning and performing when their perceived challenge of task and skill reach a balanced state (Csíkszentmihályi, 1990; Moneta & Csíkszentmihályi, 1996). In addition, evidence of instructional conversation also promoted student outcome because it is interesting, engaging, focusing on concepts relevant to students, and not dominating by any one student so that extended discussions are found among teacher and students (Goldenberg, 1991). Therefore, the take-home messages for the affective outcome are to include challenging activities, instructional conversation, and joint productivity or collaboration in teaching and learning with computers.

Based on the findings of the study, we would like urge that professional development and teacher preparation be set up with a wide variety of training scopes to include these investigated technology and pedagogical practices for preservice and in-service teachers in teaching and learning with technology.

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(Asterisks indicate studies included in the meta-analysis.)

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