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A Review of Intervention Studies On Technology-assisted Instruction From 2005-2010

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ABSTRACT

By reviewing papers published in five important SSCI journals from 2005 to 2010, this study aimed to provide insights into intervention studies on technology-assisted instruction. It was found that still relatively little research on educational technology which addresses the effects of specific instructional interventions on student learning was conducted during this period. Moreover, most reviewed studies were conducted in higher education, rather than in high school, elementary school, or adult education contexts. The two subject domains, science and engineering (including computer studies), were most frequently involved in these studies, the majority of which addressed achievement as research (learning outcome) foci, while relatively fewer studies investigated students' learning process or affective outcomes. Regarding technology adoption, this study revealed that, in both the 2005-2007 and 2008-2010 periods, technologies for specific instructional purposes(e.g., a specially designed system for online collaborative writing) were more frequently adopted than those for general purposes (such as PowerPoint). This study also reveals that technology-mediated interpersonal interactions are commonly utilized in these intervention studies, with the focus mainly on student-student interactions.

Keywords

Technology-assisted instruction, Intervention studies, Research trends

Introduction

In the past two decades, advancements in information and communication technology have made considerable impacts on educational practices. In particular, the use of technology in assisting teaching and learning has become a new educational paradigm, and teachers are largely advised to adopt technology more to enrich their instructional practices (Lawless & Pellegrino, 2007).

Many educators and researchers have advocated that pedagogical considerations are crucial in the use of technology in education (e.g., Leijen et al., 2008). From their perspectives, instructional designs within technology-assisted instruction should be highlighted. In the past, a large body of research addressing the use of technology in instructional practices has been undertaken. These studies focused on various issues and were conducted using different research methods. In particular, some of them were conducted with specific instructional interventions. An intervention study means that certain technology-assisted instructional activities are conducted and empirical data from participants are collected for analysis and evaluation. Reviewing intervention studies published in the literature can help us to understand the actual influences of using technology in instructional practices.

In recent years, some reviews and meta-analyses focused on issues regarding technology-assisted instruction have been conducted (e.g., Bernard et al., 2004; Bernard et al., 2009; Dillon & Gabbard, 1998; Fabos & Young, 1999; Lawless & Pellegrino, 2007; Lee et al., 2011; Straub, 2009; Tamim et al., 2011; van Rooij, 2009). These review studies had various foci, including comparisons of the instructional effects between technology-assisted instruction and traditional instruction (e.g., Bernard et al., 2004; Tamim et al., 2011), meta-analysis of the interactive design of technology-assisted instruction (Bernard et al., 2009), and reviews of the use of specific technologies in instruction (Dillon & Gabbard, 1998; Fabos & Young, 1999; van Rooij, 2009), as well as reviews of teachers' professional developments in technology-assisted instruction (Lawless & Pellegrino, 2007; van Rooij, 2009). However, it should be noted that most of these meta-analyses merely addressed the effects of certain specific forms of technology-assisted instruction, such as hypermedia (Dillon & Gabbard, 1998), telecommunication (Fabos & Young, 1999), and open-source software (van Rooij, 2009). None of them were conducted to provide an overall understanding of intervention studies on technology-assisted instruction. As an intervention study on technology-assisted instruction is conducted in a real learning environment (physical or online) with certain research treatments, this kind of study can provide educators and instructors with more authentic and meaningful information regarding the effectiveness of the specific technology-assisted instruction. An overall review of intervention studies on technology-assisted instructions would be helpful in providing important insights into the future research tendencies. To this end, this study was conducted to review intervention studies on technology-assisted instruction published in the literature from 2005 to 2010.

Besides, most of the existing reviews or meta-analyses in technology-assisted instruction merely analyzed its effects on learners' achievements (e.g., Bernard et al., 2004; Bernard et al., 2009; Tamim et al., 2011). Recently, more and more relevant studies have focused on the effects of technology-assisted instruction on learners' affective learning outcomes, such as attitudes, motivation, and learning processes (e.g., Hewitt, 2003, 2005; Hou & Wu, 2011; Lee & Tsai, 2011; Wever et al., 2006). However, a comprehensive analysis of all kinds of research foci (i.e., including learning achievements, affective learning outcomes and process) based on intervention studies of technology-assisted instruction is still not available. Therefore, the research foci of the reviewed intervention studies on technology-assisted instruction from 2005-2010 were analyzed in this study.

Generally speaking, technology-assisted instruction involves technology adoption of various software or hardware. The software or hardware used in intervention studies on technology-assisted instruction may have been developed for general and widespread usages, such as PowerPoint (Susskind, 2008), or for specific instructional purposes, such as learning systems or educational games. Therefore, the technology adoption (adopted for general or specific purposes) in the reviewed intervention studies on technology-assisted instruction (i.e., technologies used in these studies are for general purposes or for specific instructional purposes) was analyzed in this study.

In addition, the rapid development of information technologies in Web 2.0 has made interpersonal interaction in learning environments more flexible and efficient. As a result, various novel information technologies or tools have been commonly used in technology-assisted instruction to promote interpersonal interactions. Therefore, interpersonal interactions, including interaction types (i.e., face-to-face interaction, technology-mediated interaction, and blended interaction) and participant interactions (i.e., student-teacher, student-student, and both), were analyzed in this study.

Finally, some cross-analyses were also conducted among technology adoption, sample group and subject domain. Linn (2003) proposed that new technologies generally support user customization, indicating that while adopting technologies to assist learning or teaching, the features of subject domains and characteristics of learners should be taken into account. Therefore, this study further conducted cross-analyses between the technology adoption and the sample groups (as well as subject domains). Moreover, the use of technologies may have changed the manner of interpersonal interactions. To further understand the possible associations between interpersonal interaction types and participant interactions, cross-analyses between interaction types and participant interactions were also conducted.

To sum up, this study aimed to conduct a meta-analysis review of the empirical intervention studies on technology-assisted instruction published in the literature for a period of six years from 2005 to 2010. The research purposes of this study are:

- To explore the future research trends in sample groups, subject domains, research foci, technology adoption, and interpersonal interaction (including interpersonal interaction types and participant interactions) based on intervention studies on technology-assisted instruction articles published from 2005 to 2010.

- To investigate how the research trends revealed from the reviewed studies may differ in terms of sample groups, subject domains, research foci, technology adoption, and interpersonal interaction from 2005 to 2007 and 2008 to 2010.
- To conduct cross analyses among the sample groups, subject domains, interpersonal interaction, and technology adoption for the reviewed intervention studies on technology-assisted instruction.

Method

Research papers for analysis

This study aimed to review the intervention studies on technology-assisted instruction published in 2005-2010. To this end, the papers published in the five Social Sciences Citation Index (SSCI) journals on educational technology, including the *British Journal of Educational Technology* (BJET), *Computers & Education* (C&E), *Educational Technology Research and Development* (ETRD), the *Journal of Computer Assisted Learning* (JCAL), and the *Journal of Educational Technology & Society* (ET&S), were selected as the literature source for this review. There were a total of 4,093 papers published in these five journals from 2005 to 2010.

Review processes

There were two stages of the review conducted in this study. In the first stage, all of the empirical intervention studies on technology-assisted instruction published in the five journals from 2005-2010 were selected. In this stage, three individual researchers read the full-text of all the publication items and systematically screened the articles to identify those to be analyzed. There were two criteria used for the paper selection in this stage. First, the study should include specific technology-assisted instruction as intervention for designing activities. Second, the study should collect empirical data with at least one of the following types: achievement, process, or attitudes from the designed learning activities. It should be noted that those studies simply describing the design of educational technology or a learning system without the support of empirical data were excluded from this review. The three individual researchers with doctoral degrees or professorship in the instructional technology field conducted the screening tasks and had discussions in order to reach overall consensus based on the described selection rules. The experts read the full text of each article one by one to decide if it could be included in this review. Finally, a total of 322 articles out of 4,093 were selected for the analyses in this study.

In the second stage, a coding scheme (a detailed description is given below) was discussed and established by the authors. Then, a series of content analyses were conducted by using the articles selected in the first stage. All the reviewers (i.e., the authors) in this study have doctoral degrees or professorship in the instructional technology field, and most of them have published more than one article in the five key journals. After the two stages of the review in this study, all the reviewers (i.e., the authors) discussed and reached consensus on the interpretations of the quantitative results in this study.

Coding scheme

The coding scheme used in this study consists of six major categories. Each category contains several sub-categories. A detailed description of the categories is provided below:

Sample groups

In this study, four sample groups were identified based on the educational backgrounds of the participants in all the reviewed studies. These groups are: (1) elementary school students (K-6 graders), (2) high school students (7-12 graders), (3) higher education students (college and graduate students), and (4) adults. If a study had more than one sample group, only one major sample group was coded.

Subject domain

Similar to Hsu et al. (2012), the subject domains in this study were grouped into seven sub-categories: (1) Science (e.g., Physics, Chemistry, Biology, Medical and Sport Science), (2) Mathematics, (3) Arts & Language, (4) Social Studies, (5) Engineering (including Computers), (6) Others, and (7) Unclear. If a study involved more than one subject domain, only one major subject domain was coded.

Research focus

In this study, the research foci (learning outcome) of all the selected studies were divided into the three major categories: *achievement* (Ac), *learning processes* (Pr), and *affective outcomes* (Af). A study with a research focus on "*achievement*" aims to explore learners' recall of information or acquisition of knowledge or skills measured by test scores (e.g., Truman & Truman, 2006) or by other assessments, such as concept maps (Hoskins & van Hooff, 2005); a research focus on "*learning process*" may investigate, for example, the patterns of online discussion (e.g., Liu & Tsai, 2008), learning approaches used by students (e.g., Fessakis, Tatsis, & Dimitracopoulou, 2008), or interactions between students (e.g., Monteserin, Schiaffino, & Amandi, 2010); a study addressing "*affective outcomes*" may explore perceptions of the subject domain, perceptions of the learning, peer acceptance (e.g., Balram & Dragićević, 2008), enjoyment of the learning materials (e.g., Grimshaw, Dungworth, McKnight, & Morris, 2007), or satisfaction with the course (e.g., Alonso, Manrique, & Viñes, 2009). It should be noted that a reviewed study may contain more than one research focus. According to its multiple research foci, the "research focus" of such a study was coded as "Ac, Pr," "Ac, Af," "Pr, Af," or "Ac, Pr, Af."

Technology adoption

To explore the issue of technology adoption, each of the reviewed studies was examined to identify its adopted technology and was categorized as either *technology for general purpose* or *technology for specific instructional purpose* for its technology adoption attribute. For example, a study identified as using technologies for general purposes means the software and/or hardware used had been developed for common and widespread usages, such as PowerPoint, Wikipedia, E-mail or asynchronous discussion forums. For example, in Susskind (2008), the PowerPoint software was used, and the effects of accompanying lectures with computer-mediated PowerPoint presentations or PowerPoint generated overheads on students' self-efficacy, attitudes, course performance, and class-related behaviors were examined. On the other hand, a study identified as using technologies for a specific purpose means the software/hardware was designed for specific instructional activities and needs, such as a specially designed course management system, a learning management system or a virtual learning environment. For instance, in Cho and Schunn (2007), a web-based reciprocal peer review system for scaffolding writing and rewriting was specially developed to help students generate constructive comments on others' writing and to facilitate the administration of students' writings and reviews. Therefore, the technology adoption of Cho and Schunn (2007) was coded as "technology for specific instructional purpose" in this study.

Interpersonal interaction type

According to the face-to-face interaction and technology-mediated interaction used, the interaction type of each study was coded into one of three categories: *face-to-face interaction*, *technology-mediated interaction*, and *blended interaction*. Technology assisted face-to-face interaction means that teachers and students interacted face to face with the assistance of technologies. For example, a teacher conducted face-to-face instruction while using an electronic whiteboard (e.g., Lopez, 2010) or students discussed together in face-to-face mode via a shared screen with digital contents (e.g., Zydney, 2010). In terms of technology-mediated interaction, technologies are used as the major channel for facilitating interactions, such as a web-based discussion forum (e.g., Wei & Chen, 2006). As for blended interaction, it refers to using both face-to-face and technology-mediated interactions for instruction (e.g., Looi, Chen, & Ng, 2010).

Participant interaction

In this study, the participant interaction is defined as interactions in which a participant interacts with other participants or with the teacher. In general, students often interact with their peers or teacher in a technology-assisted learning environment. Therefore, this study classifies the participant interactions of the reviewed papers into three categories: *student-teacher*, *student-student*, and *both*. For example, the participant interaction type of a teacher conducting a lecture with an electronic whiteboard was coded as *student-teacher* interaction (e.g., Lopez, 2010). Those studies in which students collaboratively played a game (e.g., Susaeta et al., 2010) or discussed together online (e.g., Wei & Chen, 2006) were coded as student-student interactions. A study including both of the abovementioned kinds of interaction was coded as “both” (e.g., Tsai, 2010).

Inter-coder reliability

A total of six experts with doctoral degrees or professorship in the instructional technology field participated as the coders. To achieve satisfactory inter-coder reliability, the coders discussed the contents and details of the above coding scheme to reach consensus prior to the official coding. Afterwards 30 articles were randomly extracted from the *Journal of Computer Assisted Learning*, and all the coders coded the articles based on the aforementioned scheme, and multi-coder reliability tests were conducted based on the results of all the coding items. The multi-coder Fleiss Kappa reliability of all items was between 0.27 and 0.44, thus reaching the fair agreement level (κ=0.21~0.4) (Landis & Koch, 1977), indicating that there was an acceptable inter-coder reliability among all six coders. Every paper was then assigned to be coded by an individual coder. Afterwards, all 322 articles were allocated to the six coders for coding.

Results and discussion

The descriptive data for the content analysis results

Table 1 shows the descriptive data for the content analysis results regarding the selected 322 papers. Among these 322 intervention studies, 104 were from 2005 to 2007 and 218 were from 2008 to 2010. The number for the last three years is double that for the first three years, indicating that an increasing number of intervention studies regarding technology-assisted instruction were conducted in the later period. However, it should also be noted that, among the 4,093 papers published in these five journals from 2005 to 2010, only a total of 322 were recognized as being empirical intervention studies on technology-assisted instruction. It seems that still relatively little research on educational technology has addressed the actual effects of specific instructional interventions on student learning.

Table 1. Descriptive data for the content analysis results

		Total n (%)	2005-2007 n (%)	2008-2010 n (%)	Chi-Square[a]
Sample group	Elementary school	69 (21.4)	24(23.1)	45 (20.6)	0.895
	Junior and Senior high school	66 (20.5)	23(22.1)	43 (19.7)	(n.s.)
	Higher education	164 (50.9)	49(47.1)	115 (52.8)	
	Adults	23 (7.1)	8(7.7)	15 (6.9)	
Subject domains	Science	98 (30.4)	34 (32.7)	64 (29.4)	2.125
	Mathematics	31 (9.6)	11 (10.6)	20 (9.2)	(n.s.)
	Art & Languages	29 (9.0)	8 (7.7)	21 (9.6)	
	Social studies	67 (20.8)	24 (23.1)	43 (19.7)	
	Engineering & Computer	74 (23.0)	21 (20.2)	53 (24.3)	
	Others	10 (3.1)	3 (2.9)	7 (3.2)	
	Unclear	13 (4.0)	3 (2.9)	10 (4.6)	
Research focus (foci)	Achievement (Ac)	156 (48.4)	45 (43.3)	111 (50.9)	4.052
	Learning process (Pr)	50(15.5)	20 (19.2)	30 (13.8)	(n.s.)
	Affective domain (Af)	22 (6.8)	7 (6.7)	15 (6.9)	
	Ac, Pr	28 (8.7)	11 (10.6)	17 (7.8)	

	Ac, Pr, Af	9 (2.8)	3 (2.9)	6 (2.8)	
	Ac, Af	46 (14.3)	13 (12.5)	33 (15.1)	
	Pr, Af	11 (3.4)	5 (4.8)	6 (2.8)	
Technology adoption	Technology for general purpose	113 (35.1)	41 (39.4)	72 (33.0)	1.264 (n.s.)
	Technology for specific instructional purpose	209 (64.9)	63 (60.6)	146 (67.0)	

[a] The comparison between 2005-2007 and 2008-2010; n.s: non-significant

Sample groups in the reviewed studies

The analysis of sample group is shown in Table 1. Regarding the distribution percentages of the sample groups analyzed from 2005 to 2010, higher education (50.9%) ranked highest, followed by high school (20.5%), elementary school (21.4%), and adult education (7.1%). This ranking sequence is the same for both the 2005-2007 and 2008-2010 sub-groups. The results above may indicate that technology-assisted instruction studies have tended to be conducted more often in higher education contexts. One possible interpretation is that most of the researchers in this field are academic scholars, and it may be easier for them to recruit their own students as participants in their experiments; in contrast, adults are less accessible to academic researchers, and thus may have limited opportunities to participate in such kinds of studies. Similar perspectives have also been proposed by Hsu et al. (2012). However, it should be noted that the finding above was derived from the five key journals reviewed in this study, which may be insufficient to generalize the findings to the entire field of educational technology research. In the last decade, the importance of fostering lifelong learning, including continuing education or employees' professional development, has been recognized by educators worldwide (Lüftenegger et al., 2012). Recently, some researchers in educational technology have also advocated the use of educational technology for promoting lifelong learning (e.g., Min, 2008). However, this study reveals that researchers have conducted relatively little research on the use of technology-assisted instruction in adult learning. It is suggested that more research on the use of technology-assisted instruction in continuing education is urgently needed.

Subject domains involved in the reviewed studies

The most studied subject domain is science (30.4%), followed by engineering & computers (23.0%), social studies (20.8%), mathematics (9.6%), and art & language (9.0%) for papers published in the period of 2005 to 2010 as shown in Table 1. Though the ranking sequence is slightly different between the periods of 2005-2007 and 2008-2010, the ratio of each subject domain did not change significantly according to a chi-square test.

The results above show that "science" and "engineering and computers" are the two major subject domains that were studied in those papers. The popularity of science as a subject domain may be attributed to its distinct nature. On the one hand, many scientific concepts seem to be more abstract and thus are difficult to elaborate just in words. This difficulty could be overcome by the adoption of technology, such as using simulation and animation to explicitly demonstrate related scientific models and/or phenomena. On the other hand, learning science involves the learning of scientific methods or inquiry processes (e.g., Kong, Yeung, & Wu, 2009). With the aid of technology, science educators can create a better learning environment for facilitating scientific experiments which allow students to practice scientific skills. The widespread adoption of the engineering and computer domains may be accounted for by the availability of participants to the researchers. Since many academic researchers in instructional technology are computer scientists, it would be much easier for them to examine the effectiveness of the instructional technology they have developed by inviting their own students to participate directly.

Research Foci of the reviewed studies

Regarding the research foci of the reviewed papers, the majority (74%, including the categories of "Ac," "Ac, Pr," "Ac, Af," and "Ac, Pr, Af") focus on learning achievement as a part of or as the only research outcome. However, it should be noted that relatively fewer studies investigated students' learning processes (30%, combining the categories of "Pr," "Ac, Pr," "Pr, Af," and "Ac, Pr, Af") or affective outcomes (27%, totaling the categories of "Af," "Ac, Af," "Pr, Af," and "Ac, Pr, Af"). Besides, studies covering all three categories were very rare (3%, "Ac, Pr, Af"). The Chi-square analyses on the research foci for the two periods (i.e., 2005-2007 and 2008-2010) indicate no significant differences in any of the categories. Researchers have suggested the importance of using high density observation to understand how changes would occur in a learning process (Shih, Feng, & Tsai, 2008). The findings above suggest that future research should focus not only on participants' learning achievements but also on their learning processes and affective aspects, as advocated by Kuiper, Volman and Terwel (2005).

Technology adoption in the reviewed studies

Table 1 shows that 64.9% of the studies adopted technologies for a specific instructional purpose, while only 35.1% used technologies for general purposes (such as Power Point). Technology for specific instructional purposes is more commonly adopted than technology for general purposes for both of the two groups (2005-2007 and 2008-2010).

The higher adoption rate of technology for specific instructional purposes in the reviewed studies may be due to some practical concerns. These technologies were developed for specific learning environments and activities, and thus one might expect them to be more practically useful and to enhance learning and instruction. In addition, since most technologies for specific instructional purposes were developed to be capable of automatically recording students' learning log files, it is easier for these educational researchers to collect essential and meaningful data. When common technologies or software for general purpose were used, researchers may not have full access to these records for advanced analyses. Moreover, some educators might have been dissatisfied with the limited functions of the contemporary technology for general purposes, and thus attempted to design some pedagogical-oriented technologies, systems or software for instructional purposes to fulfill their specific instructional needs.

Interpersonal interaction types in the reviewed studieS

Among the 322 reviewed papers, 199 studies involved technology-assisted-interpersonal interaction, while the remaining 123 only involved human-technology interaction. In this study, the technology-assisted interactive types were divided into three categories: face-to-face interaction (FTF), technology-mediated interaction (TMI), and blended interaction. Among the 199 studies which had technology-assisted-interpersonal interaction, technology-mediated interactions (58.8%) are more popular than face-to-face interactions (20.1%) and blended interactions (21.1%) as shown in Table 2. The results reveal that technology-mediated interactions are commonly utilized in technology-assisted instruction. The popularity of technology-mediated interactions in technology-assisted instruction may be attributed to the rapid advancement of technologies in recent years. For interpersonal interactions, new technologies provide abundant tools and media. For example, instant messages, conferencing meetings, and interactive whiteboards can provide rapid and convenient channels for synchronized interaction; emails, forums, and short message systems can provide synchronous or asynchronous interactions. It is not easy to improve most of the interpersonal interactions mentioned above in traditional learning contexts.

In the Web 2.0 era, various novel information technologies or tools have been widely used in technology-assisted instruction to promote interpersonal interactions. However, it should be noted that, among the reviewed 322 papers in the current study, 123 (38%) did not involve the use of technology to promote interpersonal interactions. That is, only human-technology interactions were involved in these studies. Moreover, a slightly growing trend in face-to-face interaction from 2005 to 2010 was also observed (from 14.5% in 2005-2007 to 23.1% in 2008-2010). It seems that face-to-face interaction can provide more information, such as facial expressions, body language, and emotions. Thus, face-to-face interaction still has its irreplaceable value, a perspective revealed in social presence theory (Short, Williams, & Christie, 1976). In other words, face-to-face interactions should also be highlighted in technology-supported learning environments.

Participant interactions in the reviewed studies

This study further explored participant interactions in the reviewed papers. The distribution of participant interactions is shown in Table 2. The results show that the focus was on student-student interactions (59.8%), followed by both interactions (29.6%), while very few studies (10.6%) investigated student-teacher interactions only.

The results reveal that most studies focused on student-student interactions. This may be due to the fact that the change of pedagogical paradigm has influenced teachers' application of new technologies in their instruction. In recent years, the pedagogical paradigm has shifted from teacher-centered to student-centered or constructivist-oriented teaching. In a so-called traditional classroom, the interactions mostly occur between the teacher and students. With the aid of technologies, however, students now have more opportunities to interact with each other. Educational researchers have proposed that technology can foster more student-centered learning (Ringstaff & Kelley, 2002) which is echoed by the findings in this study. Additionally, technologies could help to extend the period of interaction from in-class to out of class settings; thus the places of interaction are no longer limited to the classroom. This flexibility allows students to have more opportunities to interact with both peers and teachers. Nevertheless, in constructivist-oriented learning environments, the teacher may still play an essential role in the learning process (Chrenka, 2001). Despite this important role, based on the reviewed papers in this study, teacher-student interactions were relatively less emphasized. Further research may address teacher-student interactions under the constructivist pedagogical paradigm.

Table 2. Interpersonal interaction types and participant interactions revealed in the reviewed intervention studies on technology-assisted instruction from 2005-2010

		Total n (%)	2005-2007 n (%)	2008-2010 n (%)	Chi-Square[a]
Interpersonal interactive type	FTF (n=40)	40 (20.1)	10 (14.5)	30 (23.1)	2.901 (n.s.)
	TMI (n=117)	117 (58.8)	41 (59.4)	76 (58.5)	
	Blended (n=42)	42 (21.1)	18 (26.1)	24 (18.5)	
Participant interaction	Student-student (n=119)	119 (59.8)	43(62.3)	76 (58.5)	1.228 (n.s.)
	Student-teacher (n=21)	21 (10.6)	5 (7.2)	16 (12.3)	
	Both (n=59)	59 (29.6)	21 (30.4)	38 (29.2)	

[a] The comparison between 2005-2007 and 2008-2010
TMI: Technology-mediated Interaction
n.s: non-significant

Cross analysis results

In recent years, the development of new technologies has generally aimed to support user customization (Linn, 2003). In other words, when adopting technology-assisted learning, the features of subject domains and characteristics of learners should be taken into account. Moreover, the use of technologies may have changed the ways interpersonal interactions occur. Therefore, this study further conducted cross analyses between technology adoption and sample group, technology adoption and subject domain, as well as interpersonal interaction type and participant interaction.

Technology adoption vs. sample group

The associations between technology adoption and sample group are shown in Table 3. In general, technology adoption is significantly associated with sample group for the period of 2005-2010 ($\chi^2 = 14.9$, $p < .05$). In addition, among the studies that used adults as their samples, technology for general purposes is adopted significantly more often than technology for a specific instructional purpose (AR = 3.1). Although the association between technology adoption and sample group is not significant for the period of 2005-2007, an association is found in the period of 2008-2010 ($\chi^2 = 11.9$, $p < .05$), as shown in Table 4. Specifically, among the studies that used adults as their samples, technologies were more often adopted for general purposes (AR = 2.3) rather than for a specific instructional purpose in the period of 2008-2010. In contrast, among the studies which used high school students as their samples, technology for a specific instructional purpose (AR = 2.2) is adopted significantly more often than technology for general purposes. It seems that high school students have to learn domain-specific learning tasks; as a result, technologies for specific instructional purposes were adopted to assist their learning.

The reason why studies with adults as participants tended to use technology for general purposes is likely to be that adults are more familiar with such technologies. Technologies for general purposes can meet adults' ordinary usage needs, and require less technical competence and assistance.

Table 3. Frequencies and adjusted residual between technology adoption and sample group from Chi-square analysis (2005-2010)

	Elementary School Students	High School Students	Higher Education Students	Adults
	(n, AR)	(n, AR)	(n, AR)	(n, AR)
Technology for general purpose (n=113)	(18, -1.8)	(17, -1.8)	(63, 1.3)	(15, 3.1)
Technology for specific instructional purpose (n=209)	(51, 1.8)	(49, 1.8)	(101, -1.3)	(8, -3.1)
Pearson's Chi-Square	14.94*			

AR: Adjusted residual values (AR with absolute values larger than 1.96 are significant.)
*$p < 0.05$

Table 4. Frequencies and adjusted residual between technology adoption and sample group from Chi-square analysis (2008-2010)

	Elementary School Students	High School Students	Higher Education Students	Adults
	(n, AR)	(n, AR)	(n, AR)	(n, AR)
Technology for general purpose (n=113)	(11, -1.4)	(8, -2.2)	(44, 1.7)	(9, 2.3)
Technology for specific instructional purpose (n=209)	(34, 1.4)	(35, 2.2)	(71, 1.7)	(6, -2.3)
Pearson's Chi-Square	11.90*			

AR: Adjusted residual values (AR with absolute values larger than 1.96 are significant.)
*$p < 0.05$

Technology adoption vs. subject domain

The association between technology adoption and subject domain is shown in Table 5. There is a significant association between technology adoption and subject domain for the period of 2005 to 2010 ($\chi^2 = 14.79$, $p < .05$). For the studies whose subject domain was science, more technologies for a specific instructional purpose (AR = 3.1) were adopted than for general purposes. In contrast, for the studies that focused on the "engineering & computer" domain, more technologies for general purposes were adopted (AR = 2.5) than technology for a specific instructional purpose. It should be noted that, for the studies that focused on the "engineering & computer" domain in the period of 2005-2010, 35 used technology for general purposes while 39 used technology for a specific instructional purpose. However, the total number of studies using technology for general purposes was 113, while 209 used technology for a specific instructional purpose in the period of 2005-2010. Thus, the percentage of studies focusing on the "engineering & computer" domain among those using technology for general purposes is significantly higher than the average. However, the associations are not significant in the two sub groups of 2005-2007 and 2008-2010.

The results indicate an association between technology adoption and subject domain. Regarding science, as mentioned previously, since most scientific concepts are abstract in nature and the scientific methods are complex, specially-designed technology for a specific instructional purpose can better support students to learn related scientific concepts and methods. For example, to enhance students' science learning and application, Fund (2007) used a computerized environment that creates a microworld with problem-solving scaffolding supports to help students conduct simulated-based experiments. In contrast, since most engineering or computer courses are designed for helping students learn basic computer programs or algorithms, technology for general purposes is more likely to be adopted as a basic "tool" for assisting learning.

Table 5. Frequencies and adjusted residual between technology adoption and subject domain from Chi-square analysis (2005-2010)

	Subject domain						
	Science	Math	Arts & Languages	Social Study	Engineering & Computer	Others	Non-Specified
	(n, AR)	(n, AR)	(n, AR)	(n, AR)	(n, AR)	(n, AR)	(n, AR)
Technology for general purpose (n=113)	(22,-3.1)	(9,- 0.7)	(9, -0.5)	(28, 1.3)	(35, 2.5)	(3, 1.0)	(5, 0.3)
Technology for specific instructional purpose (n=209)	(76, 3.1)	(22, 0.7)	(20, 0.5)	(39, -1.3)	(39, -2.5)	(5, -1.0)	(8, -0.3)
Pearson's Chi-Square	14.79*						

AR: Adjusted residual values (AR with absolute values larger than 1.96 are significant.)
*$p < 0.05$

Interpersonal interaction type vs. participant interaction

As shown in Table 2, a total of 199 studies have employed technology-assisted interpersonal interaction. To further understand the association between interaction type and participant interaction in the studies, a Pearson Chi-square test was performed. There is a significant association between interactive types and participant interactions for the studies during 2005 to 2010 (Chi-square = 10.57, $p < 0.05$) as shown in Table 6. In particular, the studies with participant interactions including both student-student and student-teacher had a strong tendency to adopt the blended mode (F2F and TMI) of interpersonal interactions.

To enhance the effects of instruction, various learning activities of technology-assisted interpersonal interactions were designed. For example, in traditional learning environments, the opportunities for peer (i.e., student-student, SS) interaction are relatively limited. Thus, studies in this line may make additional efforts to design various learning activities with technology-mediated interaction (e.g., Gijlers, Saab, van Joolingen, de Jong, & van Hout-Wolters, 2009; Gilbert & Dabbagh, 2005; Schellens & Valcke, 2006). Moreover, the lecture is still a dominant form for student-teacher (ST) interpersonal interaction in a traditional classroom. Thus, extra efforts have been made to develop learning activities with blended interpersonal interaction that may enhance the interaction between students and teachers (e.g., Lim, Reiser, & Olina, 2009; Ozmen, 2008). In addition, the associations between interpersonal interaction types and participant interactions are not significant in the two sub groups of 2005-2007 and 2008-2010.

Table 6. Frequencies and adjusted residual between the interpersonal interaction types and the participant interactions of the studies from Chi-square analysis (2005-2010)

	Student versus Student (SS)	Student versus Teacher(ST)	Both (SS and ST)
	(n, AR)	(n, AR)	(n, AR)
Face To Face (FTF) (n=40)	(23, -0.3)	(7, 1.6)	(10, -0.7)
Technology-Mediated Interaction (TMI) (n=117)	(76, 1.8)	(12, -0.2)	(29, -1.8)
Blended (FTF and TMI) (n=42)	(20, -1.8)	(2, -1.4)	(20, 2.9)
Pearson's Chi-Square	10.57*		

AR: Adjusted residual values (AR with absolute values larger than 1.96 are significant.)
*$p < 0.05$

Conclusions and directions for further research

Pedagogical considerations are crucial for the use of technology in education (Leijen et al., 2008). By reviewing papers published in five important SSCI journals from 2005 to 2010, this study aimed to provide insights into intervention studies on technology-assisted instruction. It should be acknowledged that while the five journals selected are major journals in the field of educational technology, there are many other studies pertaining to education technology published elsewhere. Therefore, the interpretation of the results derived from this study should be made with care. Besides, more journals for educational technology are suggested to be used as the literature source in further research. Or, via certain keyword searching in some electronic databases (e.g., SSCI or Google Scholar), the researchers can collect more articles in various journals or conferences as the literature source for further research. Thus, a more complete picture regarding intervention studies on technology-assisted instruction can be provided.

The major research trends derived from the results of this study are summarized and concluded below. In this study, a remarkable increase in the number of empirical studies on technology-assisted instruction from 2005 to 2010 was found. However, it should also be noted that, among the 4,093 papers published in these five journals from 2005 to 2010, only a total of 322 were identified as intervention studies regarding technology-assisted instruction. This study suggests that more attention should be paid to the role of interventions in technology-assisted instruction in future empirical research. Moreover, this study also found that very few studies have simultaneously addressed achievement, learning process, and affective outcomes. This suggests that further research on technology-assisted instruction may be conducted with various samples, different subject domains, or multiple research foci. Moreover, digital literacy outcomes and metacognitive knowledge have received an increasing amount of attention in recent years (e.g., Jimoyiannis & Gravani, 2011; Topcu & Ubuz, 2008). Future research can also include these outcomes when analyzing the research foci among the reviewed studies.

Regarding technology adoption, this study reveals that, in both the 2005-2007 and 2008-2010 periods, technologies for specific instructional purposes were more frequently adopted than those for general purposes. This study also analyzed interpersonal interactions within empirical research on technology-assisted instruction. It was revealed that technology-mediated interpersonal interactions were relatively commonly utilized in these intervention studies and that these interactions mostly focused on those among peers. Finally, the cross analyses in this study showed that technology for general purposes were frequently used in the reviewed studies with adults as participants.

In sum, the findings derived from the current study provide important insights into the effects and research tendencies of these relatively more informative studies. One may be interested in the specific instructional strategies used in these intervention studies on technology-assisted instruction reviewed in this study. However, when conducting content analyses, we found that the strategies used in some studies were not clearly described; besides, a specific instructional strategy might be introduced using a variety of terminologies in different studies. Therefore, it is very difficult to categorize the strategies (such as scaffolding, inquiry) used in these intervention studies on technology-assisted instruction during the period of 2005 to 2010. This study suggests that further studies regarding technology-assisted instruction should be carried out with specific technology-assisted instructional activities, and that more in-depth data from participants should be collected. Thus, the actual influences of using technology in instructional practices can be further explored.

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