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Effects of Hypermedia on Students' Achievement: A Meta-Analysis

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A meta-analysis was performed to synthesize existing research comparing the effects of hypermedia verse nonhypermedia instruction (e.g., CAI, text, traditional, videotape instruction) on students' achievement. Forty-six studies were located from three sources, and their quantitative data were transformed into Effect Size (ES). The overall grand mean of the study-weighted ES for all 46 studies was 0.41. The results suggest that hypermedia instruction is more effective when there is no instruction for the comparison group or when the comparison group used videotape instruction. However, CAI and text instructions are slightly more effective than hypermedia instruction. As a whole, the results of this analysis suggest that the effects of hypermedia instruction on students' achievement are mixed, depends on what type of instruction it compares to. In addition, four of the seventeen variables selected for this study (i.e., instrumentation, type of research design, type of delivery system, and comparison group) had a statistically significant impact on the mean ES.

The results from this study suggest that the effects of using hypermedia in instruction are positive over non-hypermedia instruction as a whole. The results of this study also provide to classroom teachers an accumulated research-based evidence for using technology in instruction.

Media comparison studies were the primary focus of most research on media in education from 1920s through the 1960s. Yet, during this period many researchers found problems in the nature of media comparison studies. Problems included faulty theoretical assumptions, deficient experimental designs, and lack of consistently significant findings (for details see Thompson, Simonson, & Hargrave, 1992). In 1983, Richard Clark evoked considerable controversy in the field of educational technology with the publication of his article, "Reconsidering Research on Learning From Media," in the Review of Educational Research. (Ross, 1994). After reviewing the results of reviews and meta-analyses of research comparing the learning advantage of various media, Clark (1983) claimed that there are no learning benefits to be gained from employing any specific medium to deliver instruction . According to Clark, the results of those studies that appear to favor one medium over another are not due to medium but due to the method or content that is introduced along with the medium. Clark (1983) concludes that "...media do not influence learning under any conditions" (p.445). Kozma (1994) challenged Clark's claims by reframing the question from "Do media influence learning?" to "Will media influence learning?" Komza analyzed the results of two significant and effective instructional environments (i.e., ThinkerTools, and The Jasper Woodbury Series) to identify causal mechanisms by which media may have influenced learning. He argued that "...Clark's separation of media from method creates an unnecessary and undesirable schism between the two. Medium and method should have a more integral relationship. Both are part of the instructional design" (p.16). Clark and Kozma may be both right, based on their own definitions of "media" and "method." However, from an instructional designer's point of view, Clark might overlook the fact that certain media attributes make certain methods possible, particularly when new technology, such as hypermedia, is used as the delivery system.

Hypermedia as a new technology is basically a most recent forms of computer-based instruction (CBI), which has been widely used in America for about two decades. The current notion of hypermedia is formed by two different fields: one is multimedia and the other is hypertext (for details see Burton, Moore, & Holmes, 1995). Because of this, the definition of hypermedia is sometimes confused. The terms multimedia, interactive video, and hypermedia are often used synonymously in much of the literature. For example, Gayeski (1993) defined hypermedia as "...a classification of software programs which consist of networks of related text, graphics, audio files, and/or video clips through which users navigate using icons or search strategies" (p.5). Schwier and Misanchuk (1993) defined interactive multimedia as "...an instructional program which includes a variety of integrated sources in the instruction. The program is intentionally designed in segments, and viewer responses to structured opportunities influence the sequence, size, content, and shape of the program" (p.324). In one sense, these two definitions are much alike; they all consist of two fundamental concepts: one is multiple representations of information, and the other is interactivities between users and this information. Burton, Moore, and Holmes (1995) suggest a broader definition of hypermedia which includes both interactive video and multimedia.

Hypermedia has become "...the hottest thing to happen to education since the arrival of the microcomputer" (Moore, 1994, p.5). Researchers and educators have noted the potential of hypermedia in education. Trotter (1989), for example, indicates that hypermedia employs a strategy that is advantageous to students since the learner is (a) in charge and (b) can use a variety of media to approach the subject. Moore (1994) also points out that many publications and promotions note the advantages of using hypermedia including the addition of combining sound and picture, the interactive opportunities for the learner, the ability to structure one's learning approach, the ability of the system to "remember," the ability to pursue cross-reference, and the increase of the learner's control over the subject matter.

In spite of claims regarding the potential benefits of using hypermedia in education, and the controversial issues about the relationship between media and learning, research results comparing the effects of hypermedia and nonhypermedia instruction are conflicting. For example, Bain, Houghton, Sah, and Carroll (1992), Barnes (1994), Chen (1993), Delclos, and Hartman (1993), Gretes, and Green (1994), Liu, and Reed (1995), Overbaugh (1995), Smith, Jones, and Waugh (1986), and Toro (1995) all report significant gains for hypermedia over nonhypermedia instruction. On the other side, Azevedo, Shaw, and Bret (1995), Barker (1988), D'Alessandro, Galvin, Erkonen, Albanese, Michaelsen, Huntley, McBurney, and Easley (1993), Hess (1994), Kinzie (1993), Leonard (1992), McCoy (1994), Rojewski, Gilbert, and Hoy (1994), Sheldon (1995), and Tabar (1991) have found no significant differences between hypermedia and nonhypermedia instruction. One study (Havice, 1995) even reports significant gains favor nonhypermedia instruction. Recently, a descriptive review of research on hypermedia-based learning (Ayersman, 1996) provides deep discussion about various types of hypermedia studies on students' learning. Yet, owing to the contradictory evidence provided by existing research in the area, it is important to conduct a meta-analysis to clarify the research conclusions. The results of this meta-analysis may also shed light on the debatable issue regarding the relationship between media and learning.

The definition of hypermedia may be varied based on different source of information; however, it is not the intention of this study to discuss the different definitions of hypermedia. For the purpose of the present meta-analysis, studies employed interactive multimedia, multimedia simulators, and level III (or above) (see Alessi & Trollip, 1991, p.415) interactive videodiscs as delivery systems were considered in a broader definition of hypermedia and were included in the synthesis.

PROCEDURE

The research method used in this study is the meta-analytic approach which was similar to that suggested by Kulik, Kulik, and Bangert-Drowns (1985). Their approach requires a reviewer to (a) locate studies through objective and replicable searches; (b) code the studies for salient features; (c) describe outcomes on a common scale; and (d) use statistical methods to relate study features to outcomes (Kulik, Kulik, & Bangert-Drowns, 1985). Their method differs from Glass, McGaw, and Smith (1981) approach is that a single study, defined as the set of results from a single publication, is weighted equally to all other studies, so that aggregate multiple effect sizes from one study can be avoided.

The purpose of this study was to synthesize and analyze the research on effects of two instructional approaches. It is important to define these approaches to provide for proper selection of appropriate studies.

Hypermedia Instruction (HI): classes using computer-based interactive videodiscs (level 3 or above), computer simulators, or interactive multimedia as instructional tools to teach students.

Non-Hypermedia Instruction (NHI): classes or labs not using hypermedia instruction (e.g., traditional instruction, computer assisted instruction, or videotapes) to teach students.

Data Sources: The studies considered for use in this meta-analysis came from three major sources and were published from 1986 to 1998. One large group of studies came from computer searches of Education Resources Information Center (ERIC). A second group of studies came from Comprehensive Dissertation Abstracts. A third group of studies was retrieved by branching from bibliographies in the documents located through review and computer searches.

Forty-seven studies were located through these search procedures; 14 studies came from ERIC, 26 studies were retrieved from published journals, and 7 studies were from Comprehensive Dissertation Abstracts. However, one study reported by Liu and Reed (1995) had an Effect Size (ES) several times higher than mean ES of other studies included in the synthesis (i.e., ES = 6.54 for Liu & Reed's study). The study was therefore considered as outlier and excluded from this meta-analysis.

Several criteria were established for inclusion of studies in the present analysis.

1. Studies had to compare the effects of hypermedia vs. non-hypermedia instruction on students' achievement.
2. Studies had to take place in actual educational settings. There was no restriction on grade level.
3. Studies had to provide quantitative results from both hypermedia and non-hypermedia classes.
4. Studies had to be retrievable from university or college libraries by interlibrary loan or from ERIC, Dissertation Abstracts International, or University Microfiche International.
5. Studies were published between 1986 and 1998.

There were also several criteria for eliminating studies or reports cited by other reviews: (a) studies did not report sufficient quantitative data in order to estimate ESs; (b) studies reported only correlation coefficients¾*r* value or Chi-square value; and (c) studies could not be obtained through interlibrary loans or from standard clearinghouses.

Outcome Measures

The instructional outcome measured most often in the 46 studies was student learning, as indicated on standard or researcher-develop achievement tests at the end of the program of instruction. For statistical analysis, outcomes from a variety of different studies with a variety of different instruments had to be expressed on a common scale. The transformation used for this purpose was the one recommended by Glass et al. (1981) and modified by others (e.g., Hunter, Schmidt, & Jackson, 1982). To reduce measurements to a common scale, each outcome was coded as an ES, defined as the difference between the mean scores of two groups divided by the pooled standard deviation of two groups. For those studies that did not report means and standard deviations, F values, t values, or proportion values were used to estimate the ES; these formulas are presented in Table 1. Also, in studies which used one-group pretest-posttest design, in which a control group did not exist, an alternative approach suggested by Andrews, Guitar, and Howie (1980) was used. In their approach, the ES is estimated by comparing the posttreatment mean with the pretreatment mean, and dividing by the pooled standard deviation.

Table 1

Formulas Used in Calculating Effect Size

Type of statistics	Formula
Mean and standard deviation	ES = (M1 - M2)/SDpooled
t - value	ES =
F - Value	ES =
Proportion	ES = P1 - P2

Note.
ES = Effect size. M1 = mean for the experimental group. M2 = mean for the control group. SDpooled = pooled standard deviation of both groups. N1 = number of subjects in the experimental group. N2 = number of subjects in the control group. P1 = proportion value for the experimental group. P2 = proportion value for the control group.

In most cases, the application of the formula given by Glass and his colleagues was quite straightforward. But in some cases, when more than one value was available for use in the formula of ES, the value that measured outcomes most correctly was selected. For example, some studies reported both differences on posttest measures and differences in pre-post gains, and some studies reported both raw-score differences between groups and covariance-adjusted differences between groups. In such cases, pre-post gains and covariance-adjusted differences were selected for estimating ES.

In addition, when studies used more than one type of control group (e.g., HI vs. traditional instruction and HI vs. CAI), each of the comparison related to the present meta-analysis was estimated for ES separately. In other cases, several subscales and subgroups were used in measuring a single outcome (e.g., those that reported separate data by gender or grade). In such cases, each comparison was weighted in inverse proportion to the number of comparisons within the study (i.e., $1/n$, where n = number of comparisons in the study) so that the overweighing of ES of a study could be avoided (see, e g., Waxman, Wang, Anderson, & Walberg, 1985, p. 230).

Variables Studied

Seventeen variables were coded for each study in the present synthesis. These variables are listed in Table 2. Each of these variables was placed in one of the following sets of characteristics: (a) study characteristics, (b) methodological characteristics, and (c) program characteristics. The first two variables in the study characteristics were coded because it is important to know how effects are related to sources of information over time. The other two variables (i.e., subject area and grade level) in the study characteristics were coded so that potential different effects for subjects with different backgrounds could be detected. Seven variables placed in the methodological characteristics were coded so that effects related to characteristics of research procedures could be detected. The last six variables in the program characteristics were coded because it is critical to know how effects are related to nature and design of the primary research. Each variable was employed as a factor in an analysis of variance (ANOVA) to investigate whether there were significant differences within each variable on the ES.

Table 2
The Assignments of Studied Variables in Each Characteristic

Characteristics	Variables
Study Characteristics	Type of Publication Year of Publication Subject Area Grade Level
Methodology Characteristics	Sample Size Instructor Bias Instrumentation Reliability of Measure Statistical Power Statistics Type of Research Design
Program Characteristics	Type of Application Type of Delivery System Comparison group Type of Instruction for Treatment Implementation of Innovation Duration of Treatment

Coder Reliability

To obtain more reliable outcomes from coding, two investigators coded the studies. One investigator coded each of the studies on each of the independent variables. As a check for accuracy, a second investigator coded three studies independently. The intercoder agreement for the studies coded by both of the investigators was 89%. In addition, the different codings on each of the studies between two investigators were discussed.

RESULTS

The number of comparisons and the study-weighted ESs are reported in Table 3. Of the 46 studies included in the present synthesis, 28 (61%) of the study-weighted ESs were positive and favored the HI group, while 17 (37%) of them were negative and favored the NHI group. Only 1 (2%) of them showed no difference between HI and NHI groups. The range of the study-weighted ESs was from -0.91 to 3.13. The overall grand mean for all 46 study-weighted ESs was 0.41. When this mean ES was converted to percentiles, the percentiles on students' achievement were 66 for the HI group and 50 for the NHI group. The overall grand median for all 46 study-weighted ESs was 0.15, suggesting that percentiles on students' achievement were 56 for the HI group and 50 for the NHI group. The standard deviation of 0.87 reflects the great variability of ESs across studies.

Among the 143 ESs included in the present synthesis, 86 (60%) were positive and favored the HI group, while 53 (37%) were negative and favored the NHI group. Only 4 (3%) of the ESs indicated no difference between HI and NHI groups. The range of the ESs was from -0.85 to 3.13.

The ESs for the 143 comparisons showed that despite several large effects, most of the ESs were small to moderate in magnitude. About 90% of ESs lie between -0.5 and 0.5, while less than 7% of the ESs were greater than 0.5.

Table 3
Number of Comparisons and Study-weighted Effect Sizes

Author(s)	Year	No of Comparisons	ES
Azevedo et al.	1995	6	-0.559
Bain et al.	1992	2	0.864
Barker	1988	2	0.612
Barnes	1994	1	0.456
Boone, & Higginsa	1993	4	-0.015
Boone, & Higgins	1993	6	-0.004
Boone, & Higgins	1993	4	-0.006
Boone et al.	1996	3	0.019
Bowdish et al.	1998	6	-0.049
Branch et al.	1987	1	0.108
Chen	1993	1	1.677
D'Alessandro et al.	1993	1	0.313
Delclos, & Hartman	1993	1	0.438
DeNardo, & Pyzdrowski	1992	1	3.130
Goodson	1992	4	0.469
Gretes, & Greenb	1994	3	0.894
Gretes, & Green	1994	1	0.977
Havice	1995	1	-0.852
Hess	1994	1	0.000
Higgins, & Boone	1990	12	0.035
Johnson, & Merrill	1997	2	0.559
Kim, & Young	1991	3	1.325
Kinzie et al.	1993	5	1.056
Leonard	1992	5	-0.037
Levin	1991	2	-0.223
Matthew	1996	2	0.113
Mayfield-Stewart et al.	1994	2	0.763
McCoy	1994	1	-0.522
Moore	1993	2	-0.266
Moore-Hart	1995	6	0.309
Overbaugh	1995	2	0.793
Quade	1993	1	-0.505
Rickelman et al.	1988	1	2.887
Rojewski et al.	1994	4	-0.055
Sheldon	1995	1	0.182
Shore	1997	6	1.030
Smith et al.	1986	2	1.153
Soltani	1995	6	0.767
Standish	1992	1	-0.311
Tabar	1991	1	0.257
Tiaden, & Martin	1997	10	-0.115
Toro	1995	1	2.643
Van Omer	1992	6	-0.502
Wang	1994	6	-0.191
Weathers	1987	2	-0.908
Wilson, & Koury	1997	2	0.050

Table 3 (continued)

Author(s)	Year	No of Comparisons	ES
Overall grand mean			0.408
Overall grand median			0.147
Overall grand SD			0.874

Note.Total N of studies = 46. Total N of comparisons = 143
aTwo Separated studies reported in one article.
b Three Separated studies reported in one article.

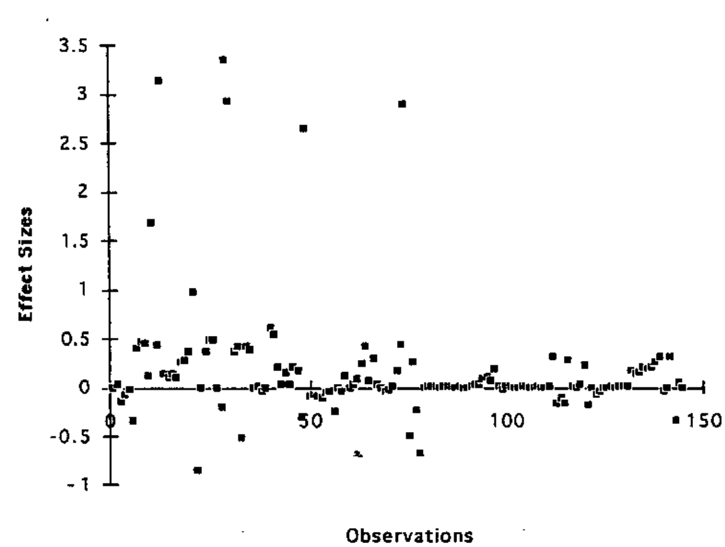

Figure 1. The Scatter Diagram of Effect sizes

Table 4 lists the *F* values for the 17 variables for all study-weighted ESs in the study. Descriptive statistics for the 17 variables are presented in Table 5. Four variables, instrumentation, type of research design, type of delivery system, and comparison group showed statistically significant impact. For each of these variables, a post hoc (Fisher? Protected LSD) test was performed.

Table 4
Results of ANOVAs for Coded Variables

Variables	*df*	*F*	*p*
Study Characteristics			
Type of Publication	2, 43	1.472	0.2407
Year of Publication	5, 40	0.232	0.9463
Subject Area	5, 40	0.409	0.8396
Grade Level	3, 42	1.749	0.1717
Methodology Characteristics			
Sample Size	2, 43	2.391	0.1036
Instructor Bias	3, 46	1.518	0.2224
Instrumentation	2, 43	3.241	0.0489*
Reliability of Measure	2, 43	0.521	0.5975
Statistical Power	2, 43	2.142	0.1298
Statistics	3, 42	1.860	0.1511
Type of Research Design	3, 42	6.998	0.0006***
Program Characteristics			
Type of Application	3, 42	2.421	0.0794
Type of Delivery System	2, 43	3.951	0.0266*
Comparison Group	5, 48	4.876	0.0011**
Type of Instruction for Treatment	4, 42	1.269	0.2975
Implementation of Innovation	2, 47	0.379	0.6865
Duration of Treatment	6, 39	1.308	0.2766

* $p<.05$ **$p<.01$ ***$P<.001$

The post hoc test for instrumentation, ($F(2,43) = 3.241, p<.05$), showed that the mean comparison of studies in which the instrumentation was coded as unspecified was higher than the studies employed local or standardized instruments. There were no significant differences found between the mean comparison of studies using local instruments and standardized instruments.

The post hoc test for type of research design, ($F(3,42) = 6.998$, $p<.001$), showed that the mean comparison of studies coded as one group repeated measure was significantly higher than studies coded as pretest-posttest control group, nonequivalent control group, or posttest only control group designs. There were no significant differences found among the mean comparison of studies coded as pretest-posttest control group, nonequivalent control group, and posttest only control group designs.

Table 5
Means and Standard Deviations of Study-weighted ESs for Coded Variables

Variables	N	%	ES	SD
Study Characteristics				
Type of Publication				
Journal article	25	54.3	0.551	0.849
Dissertation/thesis	7	15.2	-0.084	0.666
ERIC	14	30.5	0.399	0.969
Year of Publication				
1986 - 1991	9	19.6	0.583	1.101
1992	6	13.0	0.602	1.337
1993	9	19.6	0.299	0.684
1994	8	17.4	0.290	0.558
1995	7	15.2	0.469	1.142
1996 - 1998	7	15.2	0.230	0.415
Subject Area				
Art/music	3	6.5	-0.146	0.700
Langugae/reading/writing	13	28.3	0.492	0.758
Medicine	8	17.4	0.413	1.063
Science	9	19.6	0.478	1.216
Social Science/Education	8	17.4	0.571	0.735
Math/Other	5	10.9	0.125	0.571
Grade Level				
K - 6th	10	21.7	0.220	0.376
7th - 12th	7	15.2	-0.079	0.615
College	20	43.5	0.705	1.086
Other	9	19.6	0.335	0.760
Methodological Characteristics				
Sample Size				
10 - 40	12	26.1	0.621	1.179
40 - 80	18	39.1	0.598	0.842
Over 80	16	34.8	0.033	0.490
Instructor Bias				
Same	14[a]	28.0	0.620	1.090
Different	18	36.0	0.047	0.524
No instructor	10	20.0	0.524	0.922
Unspecified	8	16.0	0.484	0.704
Instrumentation				
Local	35	76.1	0.354	0.857
Standard	9	19.6	0.292	0.469
Unspecified	2	4.3	1.871	1.780

Table 5 (continued)

Variables	***N***	**%**	***ES***	***SD***
Reliability of Measure				
Actual reliability figure	12	26.1	0.379	1.022
Adequate indication	14	30.4	0.234	0.332
Unspecified or inadequate	20	43.5	0.546	1.042
Statistical Power				
Adequately minimized	36	78.3	0.275	0.726
Probably threat9	19.6	0.835	1.475	
Unspecified or inadequate	1	2.2	1.325	0.000
Statistics				
Mean & Standard deviation	30	65.2	0.458	0.892
t - value	5	10.9	1.036	1.201
F - value	6	13.0	-0.034	0.545
Proportion value	5	10.9	0.006	0.021
Type of Research Design				
One group repeated measure	5	10.9	1.827	1.040
Pretest-posttest control group	19	41.3	0.269	0.474
Nonequivalent control group	11	23.9	0.277	1.056
Posttest-only control group	11	23.9	0.134	0.583
Program Characteristics				
Type of Application				
Tutorial	26	56.5	0.308	0.722
Simulation	9	19.6	1.057	1.261
Other	7	15.2	0.160	0.559
Unspecified	4	8.7	0.025	0.747
Type of Delivery System				
Cmputer-based Interactive Videodisc	13	28.3	0.586	0.951
Computer simulator	3	6.5	1.538	1.665
Interactive multimedia	30	65.2	0.217	0.661
Comaprison Group				
Traditional instruction	30[a]	55.6	0.169	0.497
CAI	5	9.3	-0.200	0.368
Text	3	5.6	-0.141	0.224
Videotape	5	9.3	0.736	1.234
Other	2	3.7	0.176	0.096
No comparison group	9	16.7	1.263	1.048

Table 5 (continued)

Variables	N	%	ES	SD
Type of Instruction for Treatment				
Large group	5[a]	10.6	0.296	0.841
Small group (less than 5 persons in a group)	12	25.2	0.209	0.723
Individual	24	51.1	0.398	0.854
Mixed	2	4.3	0.108	0.467
Unspecified	4	8.5	1.274	1.319
Implementation of Innovation				
Replacement for usual instruction	26[a]	52.0	0.293	0.736
Supplement to instruction	23	46.0	0.481	0.946
Unspecified	1	2.0	0.050	0.000
Duration of Treatment				
Less than 1 week	9[a]	19.6	0.726	0.997
1 - 4 weeks	13	28.3	0.156	0.509
1 - 4 months	12	26.1	0.605	1.205
Over 4 months	6	13.0	-0.043	0.282
Unspecified	6	13.0	0.532	0.831

Note. [a] Some sudies reported more than one comparison groups.

For type of delivery system, ($F(2, 43) = 3.951$, $p<.05$), the post hoc test showed that the mean comparison of studies in which simulators were employed was significantly higher than studies in which interactive multimedia were employed as delivery systems. There were no significant differences found between the mean comparison of studies in which computer-based interactive videodisc and interactive multimedia were used. In addition, no significant differences were found between the mean comparison of studies in which simulators and computer-based interactive videodiscs were employed.

Finally, the post hoc test for comparison group, ($F(5, 48) = 4.876$, $p<.01$), showed that the mean comparison of studies with no comparison group (i.e., one group repeated measure) was significantly higher than studies in which the comparison groups using traditional instruction, CAI, textbooks only, or other types of instruction (e.g., audiotapes). In addition, the mean comparison of studies in which the comparison group using videotapes was significantly higher than the studies in which the comparison groups using CAI.

DISCUSSION

The results of this meta-analysis indicate that hypermedia instruction has moderately positive effects on student achievement over the non-hypermedia instruction. An effect is said to be medium when ES = 0.5 and large when ES = 0.8 (Cohen, 1977). Sixty-one percent of positive study-weighted ES values and 60% of positive ESs overall also confirm the effectiveness of hypermedia instruction. The moderateness of the effect must be keep in mind, however; the overall study-weighted mean ES of 0.41 only indicates 16 percentile scores higher than the NHI group. The percentile scores for the overall grand mean and median were 66 and 56, respectively. The difference of 10 percentile points between them was possibly attributed to the large overall grand standard deviation (0.87). The analysis of studied variables suggests some interesting trends in the accumulated research base and is discussed in the following sections.

Study Characteristics

Source of studies in a meta-analysis is always an important factor to be examined. The fact that more than half of studies were located from journal articles indicates that the majority of studies included in the synthesis have been critically reviewed by journal reviewers. The smallest ES associated with Dissertation/thesis is not surprising; usually the larger ES associated with published articles is typical in meta-analysis (Glass, et al., 1981, p. 227).

The year of publication variable in the meta-analysis allows an assessment of the effect of hypermedia over time. About two-thirds of studies located were published after 1993 suggesting hypermedia studies have just become more popular recently; it is expected that more studies will be published soon.

Hypermedia studies conducted to measure students' achievement tend to focus on specific subject areas. Studies included in the present meta-analysis were spread in a wide range of subject areas. About 37% studies examined the effects of hypermedia for teaching medicine or science. Another 28% of studies concentrated on the teaching of language, reading, or writing. Although no significant differences on ES were found among subject areas, the various subjects examined seem to suggest that hypermedia has the potential to implement in many different subject areas. However, there was one subject area (i.e., art/music) that showed negative mean ES, suggesting the effects of hypermedia may vary for different subject areas.

For the grade-level variable, there was no significant difference of mean ES. However, the smallness of the ES associated with secondary school subjects may have been due to the fact that different instructional approaches were used for these students as compare to other students. More studies need to be conducted to clarify this variable.

Methodological Characteristics

The sample size for a study may significantly affect the statistical power of the study; in general, the larger the sample size, the better the statistical power. The sample sizes for about 65% of studies included in the synthesis were less than 80, and the mean ES for these studies was about 0.6. For studies in which the sample size went beyond 80, the mean ES dramatically dropped to 0.033. This seems to suggest that the effects of hypermedia on students' achievement may only work for small to medium sample size. How to retain the positive effects of hypermedia for a larger sample size will be a critical question for researchers and educators as well.

After reviewing several meta-analysis of media research, Clark (1983) suggested that the positive effects of media seemed to be the uncontrolled effects of instructional method or content differences between treatments that were compared; he concluded that effects more or less disappeared when the same instructor delivered all treatments. The results of the present meta-analysis show that studies using the same instructors and no instructor for treatments had higher ES than studies using different instructors. The finding clearly indicates that the positive effects of hypermedia instruction over nonhypermedia instruction should not be confused with the uncontrolled effects of instructional method noted by Clark.

For instrumentation, over 75% of studies used researcher-develop instruments, and only less than 20% used standardized instruments. This is possibly because hypermedia is still a new field in educational research and there are not many published instruments available. Although a significant higher ES was found for studies coded unspecified, there were only 2 studies in this category; this result may be considered tentative.

For type of research design, studies which employed repeated measures had significantly higher ES than other types of designs. In general, repeated measure design is considered as methodologically weaker than other designs. This result along with the results of analyses of sample size, reliability of measure and statistical power suggests that studies which employ weaker research designs may obtain higher ES.

Program Characteristics

Type of application is always a critical concern for hypermedia studies. About 76% of the hypermedia programs used in the 46 studies were tutorials or simulators and obtained higher ES, suggesting that these two types of applications may be more appropriate for hypermedia instruction than others.

For type of delivery system, the greater ES was associated with studies using computer simulators possibly because simulators may provide more vivid situations for learning and that may enhance students' achievement. However, since there were only 3 studies that used simulators, this result may be considered tentative.

For comparison group, it is quite obvious that the overall grand study-weighted mean ES of 0.41 was mostly contributed by studies compared to no comparison group (ES = 1.048) and studies compared to videotape instruction (ES = 0.736). This result suggests that hypermedia instruction becomes more effective when there is no instruction for the comparison group (i.e., one-group repeated measure design) or when the comparison group used videotape instruction. However, the negative ESs associated with CAI and text (e.g., textbooks or handouts) instructions suggest these two types of instructions are slightly more effective to students' achievement than hypermedia instruction. The effects of hypermedia instruction over traditional instruction are trivial. As a whole, the results of this analysis suggest that the effects of hypermedia instruction on students' achievement are mixed, depends on the type of instruction it compares to. It is possible that different media attributes may provide different learning environments that influence students' achievement.

Of the 46 studies included, 24 (51%) studies employed individual instruction for the hypermedia classes; 12 (25%) studies were for small group instruction; only 5 (11%) studies were for large group instruction. Although the differences of mean ES among studies used individual, small group, and large group instruction were trivial, the observable differences in number of studies among these groups suggest that hypermedia instruction may be more preferable if it is implemented in individual or small group settings.

It is usually difficult for teachers to decide whether use a new innovation as a replacement for usual instruction or as a supplement to instruction. In most cases, the decision depends on which approach can provide more effective outcomes. Although no significant main effect was found, the mean ES for supplement group was 0.18 higher than the replacement group, suggesting hypermedia may be more effective when used as a supplement to traditional instruction.

Duration of treatment is usually a critical variable in meta-analysis. Clark (1983), after reviewing several meta-analyses of CAI, suggested that the effects of new media to instruction were due to a novelty effect, because the ES was reduced when treatment lasted for longer period of time. Liao and Bright (1991) also reported this novelty effect in their meta-analysis of programming on students' cognitive abilities. Although no significant difference was found for this variable, the results of this synthesis do not quite support the previous viewpoint of novelty effect. The mean ESs for studies lasting 1-4 months or less than 1 week were higher, while the mean ESs for studies lasting 1-4 weeks or over 4 months were lower. There may be some unknown effects related to the duration of treatment that influence students' outcomes from hypermedia instruction. Or, there may be different instructional features among hypermedia, CAI, and programming that result in the distinct outcomes from their perspective meta-analyses.

CONCLUSION

The results from this study suggest that the effects of using hypermedia in instruction are positive over nonhypermedia instruction as a whole, however, the effects may be varied depending on what type of instruction that hypermedia compares to. The results of this study also provide some evidences which disagree with Clark's viewpoint about the relationship between media and learning. While many educators devote tremendous efforts with great expectation that technology will dramatically increase students' academic achievement, the results of this study provide to classroom teachers an accumulated research-based evidence for using technology in instruction. Left unanswered is the question of what factors truly affect the diverse outcomes for different types of instructions. Studies of this question will require further clarification of the distinct attributes between hypermedia and various types of instructions, and their relationships with learning. This meta-analysis points out only that improvements of students' academic achievement are possible. That information by itself is useful.

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Note

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