Evidence Based Library and Information Practice

Article

Effective Methods for Teaching Information Literacy Skills to Undergraduate Students: A Systematic Review and Meta-Analysis

Denise Koufogiannakis
Collections and Acquisitions Coordinator
University of Alberta Libraries
Edmonton, Alberta, Canada
E-mail: denise.koufogiannakis@ualberta.ca

Natasha Wiebe
Research Associate/Statistician
University of Alberta
Edmonton, Alberta, Canada
E-mail: natasha.wiebe@ualberta.ca

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Structured Abstract

Objective - The objective of this systematic review was to assess which library instruction methods are most effective for improving the information skills of students at an introductory, undergraduate level, using cognitive outcomes (measuring changes in knowledge). The study sought to address the following questions:

1) What is the overall state of research on this topic?
2) Which teaching methods are more effective?

Methods - This project utilised systematic review methodology. Researchers searched fifteen databases and retrieved 4,356 potentially relevant citations. They reviewed the titles and abstracts for relevance, and of those, 257 complete articles were considered in-depth using a predetermined inclusion/exclusion form. There were 122 unique studies that met the inclusion criteria and were subjected to an extensive data extraction and critical appraisal process. Of these studies, 55 met author-defined quality criteria to provide information on the effectiveness of different teaching methods. From this review there was

a final group of 16 studies with sufficient information to enable meta-analyses and calculations of standardized mean differences.

Results - The overwhelming majority of studies were conducted in the United States (88%). Experimental or quasi-experimental research methods were used in 79 studies (65%). Teaching methods used in the studies varied, with the majority focused on traditional methods of teaching, followed by computer assisted instruction (CAI), and self-directed independent learning (SDIL). Studies measured outcomes that correlated with Bloom's lower levels of learning ('Remember', 'Understand', 'Apply').

Sixteen studies compared traditional instruction (TI) with no instruction, and twelve of those found a positive outcome. Meta-analysis of the data from 4 of these studies agreed with the positive conclusions favouring TI. Fourteen studies compared CAI with traditional instruction (TI), and 9 of these showed a neutral result. Meta-analysis of 8 of these studies agreed with this neutral result. Another group of 6 studies compared SDIL with no instruction, and meta-analysis of 5 of these agreed that the result was positive in favour of SDIL.

Conclusion - Based on the results of the meta-analysis, there is sufficient evidence to suggest that CAI is as effective as TI. Evidence also suggests that both TI and SDIL are more effective than no instruction. Additional comparative research needs to be done across different teaching methods. Studies comparing active learning (AL), CAI, and SDIL would greatly enrich the research literature. Further studies utilizing appropriate methodologies and validated research tools would enrich our evidence base, and contribute to the growth of knowledge about effectiveness of particular teaching methods.

Introduction

Information literacy is a topic of great interest in the field of library and information studies, particularly among academic librarians, who view teaching as an important role (Baruchson-Arbib and Bronstein; Godwin; Peacock). The National Forum on Information Literacy defines information literacy as "the ability to know when there is a need for information, to be able to identify, locate, evaluate, and effectively use that information for the issue or problem at hand." Librarians are constantly looking to improve the methods by which they teach information skills to undergraduate students, in order to increase the students' competencies in this area. The professional literature is populated with articles on the topic, ranging from research studies, new innovations, and tales of implementation in various settings. Most librarians have their own stories of teaching successes and failures which they pass on to others. However, while there have been attempts to systematically appraise the literature as it pertains to health professionals (Brettle; Garg and Turtle), the general library research literature of this field has not been gathered or summarized in a systematic way that would facilitate an evidence based approach towards undergraduate level instruction (i.e., using evidence to inform and support information literacy initiatives). This study was an attempt to sort through the published literature and move beyond conjecture surrounding the most effective methods of teaching information literacy skills, via a systematic review of the library research literature relating to undergraduate teaching.

The objective of this review was to assess which library instruction methods are most

effective for improving the information skills of students at an introductory, undergraduate level, using cognitive outcomes (measuring changes in knowledge). Cognitive outcomes may be at varying levels, from simply remembering facts, to applying what was taught in a new situation, to creating new content. It should be noted that cognitive outcomes are only one aspect that may be considered when determining the success of an information literacy program. Behavioural (measuring changes in actions) and affective (measuring changes in attitudes or values) outcomes are other aspects that may be considered. This review, however, did not attempt to encompass all areas of research, and focused solely on cognitive outcomes.

The study sought to address the following questions:

1) What is the overall state of research on this topic?
2) Which teaching methods are more effective?

In addition, the following hypotheses were postulated:

1) Instruction that is taught by a librarian face-to-face is more effective than instruction that is computer-based.
2) Instruction that encourages active participation from students is more effective than passive instructional modes, such as lectures and demonstrations.
3) Using Bloom's taxonomy, the higher the level of learning outcomes measured, the more difficult it will be to link effectiveness directly to library instruction, and the less likely it is that the library instruction will result in a positive outcome.

In terms of evidence based library and information practice, the goal of conducting this systematic review was to find evidence on information literacy instructional methods that may have a direct impact on the way academic librarians approach information literacy instruction for undergraduate students.

Methods

The research methodology used was a systematic review, including an extensive literature search, an inclusion and exclusion process for potential studies, extraction of data from the included studies, and analysis of that data.

Once the study objectives and hypotheses had been determined, inclusion and exclusion criteria were developed. Categories of data required to address the review objectives and hypotheses were also noted for future data extraction. These predetermined criteria helped frame the search process.

Fifteen databases (*LISA*, *Library Literature*, *ERIC*, *Inspec*, *Academic Search Premier*, *Educational Research Abstracts*, *CINAHL*, *Web of Science*, *Dissertation Abstracts*, *Conference Papers Index*, *SIGLE*, *CERUK*, *Education-Line*, *British Education Index*, and *Australian Education Index*) were searched for relevant articles in the Fall of 2004. The searches (Appendix A) were updated in May 2005, and results combined in a single bibliography. Researchers also checked related bibliographies, literature reviews, and references cited in these articles.

For a study to be included in the systematic review, it had to meet the following criteria:

- Instruction had to be led by a librarian or library assistant (or with librarians as part of the instruction team) for a class or stand-alone session utilising any instruction method.

- Study subjects had to be undergraduate students at a post-secondary academic institution.
- The research study had to have an evaluative component that measured the cognitive outcome effect of instruction on student learning via some test of information literacy (e.g., pre- and post-tests, graded papers, or bibliographies).

Included studies were not limited by publication date, but were limited to the English language. Studies were not excluded on the basis of quality or study methodology.

As is shown in Figure 1, 4,356 potentially relevant citations were retrieved from the literature search, and titles and abstracts were reviewed for significance. Of those, 257 complete articles were considered in-depth using a predetermined inclusion/exclusion form, with 108 meeting inclusion criteria. Another 17 articles that met inclusion criteria were identified by checking reference lists and review articles on the topic.

After eliminating three studies where articles had been reported in two source publications, there were 122 unique studies that met the inclusion criteria and underwent an extensive data extraction and critical appraisal process. Appendix B contains the list of studies reviewed. Researchers entered data extraction elements (Appendix C) in an Excel® spreadsheet.

Categories for data extraction were tested on a subset of 8 articles included in the systematic review. Studies were critically appraised using the checklist developed by Morrison et al. (891). The checklist consists of nine questions, focused on the validity and applicability of the study being appraised. The 122 studies were used to present the results relating to the first objective, namely the overall state of research on the topic.

Following the data extraction and critical appraisal process undertaken by DK, a methodological quality filter was applied to all 122 studies. Those that had a comparative study design and compared two different teaching methods, and whose outcomes were based on tests of statistical significance (n=55) were analyzed to determine the results of effectiveness for different teaching methods. A meta-analysis was conducted, by NW, on 16 of these studies to substantiate the findings relating to the effectiveness of different teaching methods. The meta-analysis section of this paper describes this approach in more detail.

Results

The results are presented in three parts. The first part addresses the first research objective: to provide an overview of the state of research on this topic with a description of the studies included. Part two provides further analysis on a subsection of the results of those studies to examine the second study objective and determine which teaching methods are most effective. Part three details the meta-analysis on specific aspects of effectiveness, where the data enabled this method to be used.

I. Status of Research

Description of Included Studies

The majority (78%, 97/125) of the studies were published as journal articles (Table 1), with large numbers coming from three main journals, *College & Research Libraries*, *Research Strategies*, and *Journal of Academic Librarianship*. Publications were spread over a time period spanning from 1963 to 2005, with most publications (35%, 44/125) coming from the current decade. The 1980s

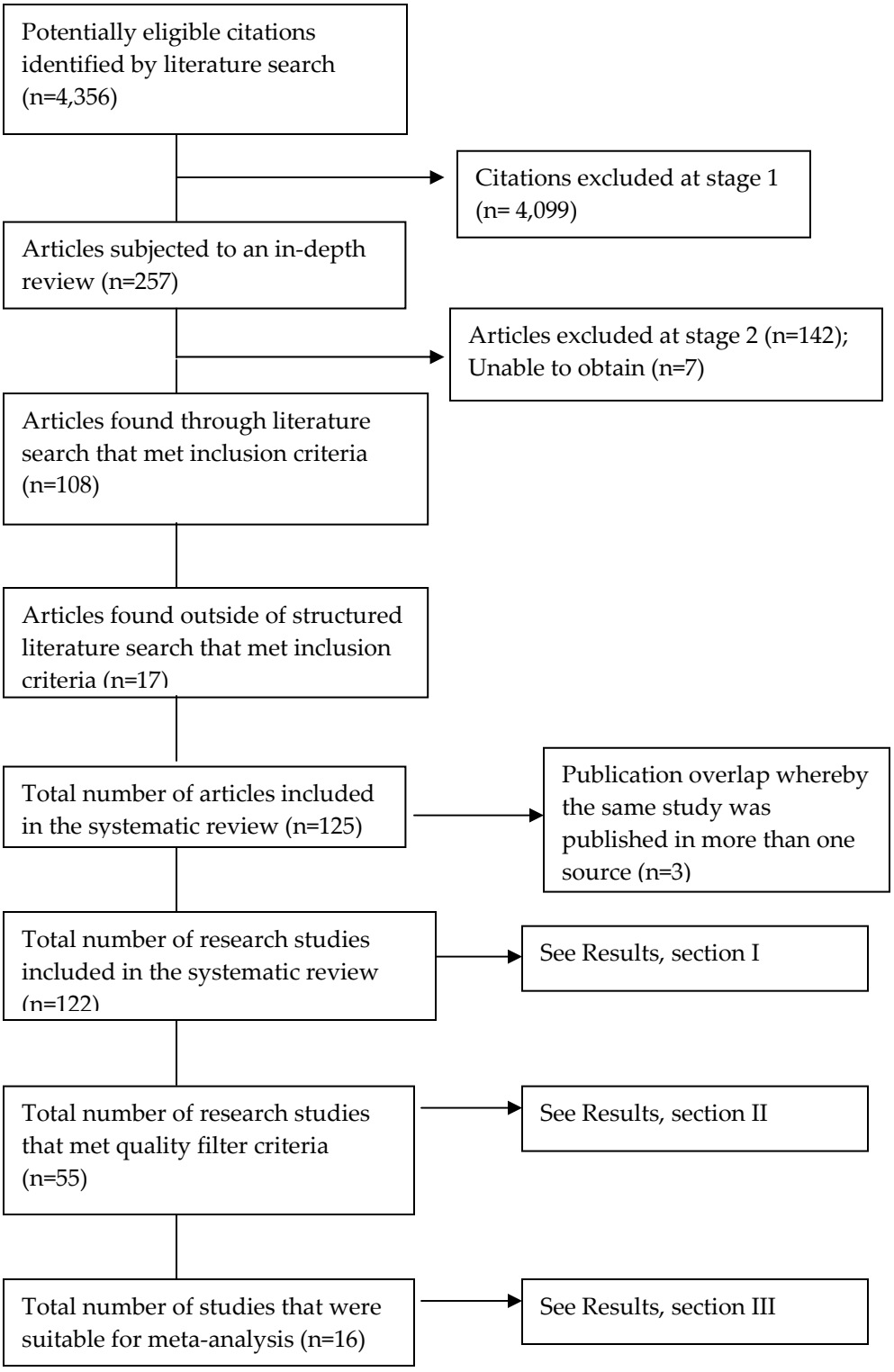

Figure 1: Flow Diagram of the Systematic Review Process

Type of publication		**Number**
Journal articles		97
College & Research Libraries	(20)	
Research Strategies	(14)	
Journal of Academic Librarianship	(11)	
Other journals	(52)	
ERIC documents		19
Dissertations		8
Book Chapters		1
Total Publications		**125**

Table 1: Publication Types

produced nearly the same amount of research on the topic (33%, 41/125). In the 1990s the numbers declined (21%, 26/125), but there was a resurgence in the present decade.

The vast majority (88%) of studies (107/122) were conducted in the United States. Other countries included were Canada (6.5%, 8/122) studies and Australia (4%, 5/122). The UK, and Trinidad and Tobago each contributed one study. The dominance of studies from the United States is overwhelming. Certainly other countries, such as the United Kingdom and Australia, have strong academic information literacy programs operating. This may indicate that the focus of research on the topic of information literacy has been different in other countries, and that the specific focus of this systematic review has been dominated by U.S. researchers. Perhaps researchers in other countries have focused on more qualitative aspects, rather than trying to measure effectiveness based on cognitive outcomes.

Study types

The research studies in this systematic review all used quantitative research methods to measure cognitive outcomes. Some studies also employed qualitative methods to measure other types of outcomes, but those are outside the scope of this review. Figure 2 provides a general breakdown of study types. Most studies were quasi-experimental, employing a controlled study design, but without randomising the students to teaching groups. Fifty-nine of the 122 (48%) studies fit into this categorization, including controlled before-and-after studies, as well as studies that were post-intervention, single time point with a control group. Twenty (16%) of the studies were experimental, employing randomisation and a control group. The majority of these used cluster randomisation, since educational groups were often pre-formed, and the randomisation of individuals was beyond the researcher's control. Some studies were pre-experimental, since they did not have a comparison or control group and focused on exploring the change in one group of students, using a pre- and post-test (i.e., before-and-after study). Nine studies (7%) were observational, including longitudinal and cross-sectional studies. The single 'other' study was large and multidimensional in nature, which could not be classified into any of the other categories.

The studies had varying evaluation periods, with the majority (51%, 62/122) covering a time period of one semester.

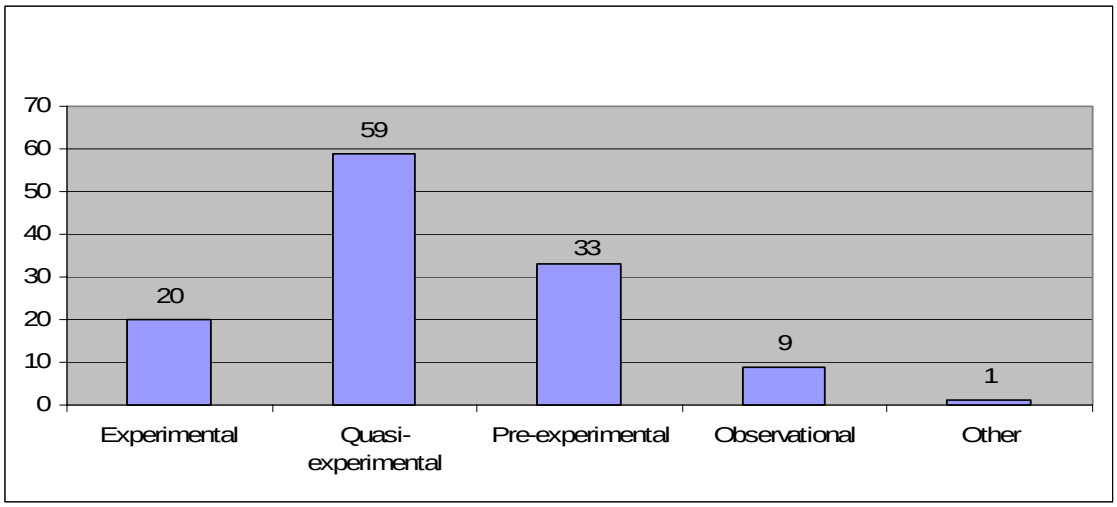

Figure 2: Study Types

One group (7.4%, 9/122) of studies took place over the course of one year, and a further 8/122 (6.6%) took place over 2 semesters. The remaining studies' evaluation periods ranged from 1 day to 6 years. Studies varied with respect to when learning outcomes were measured. The largest number (28%, 34/122) tested learning outcomes at the end of the semester. Another group of studies (25%, 30/122) tested immediately following an instruction session. The remainder ranged from the next class following instruction, to several weeks after instruction, to 3 years after the course was completed. There were 17 studies (14%) that did not report this variable.

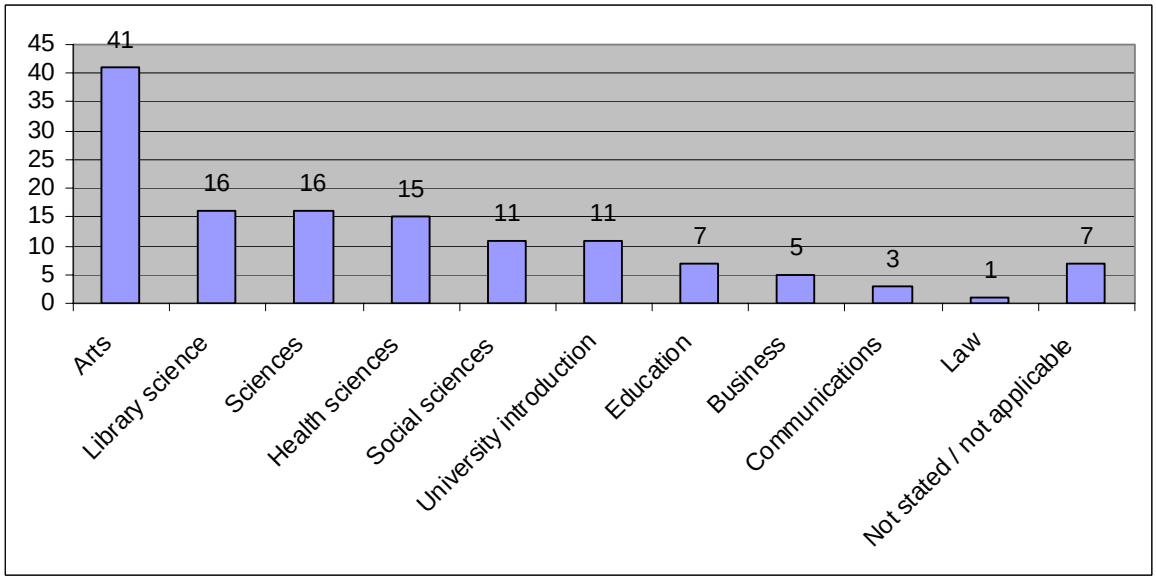

Figure 3: Subject Areas Covered

Teaching Methods	
Active Learning	Students are actively engaged in their own learning, with the instructor taking on a facilitation role.
Computer Assisted Instruction	A computer is used to deliver the instruction directly to the student.
Learner-centred instruction	Focus is on the individual student's unique learning needs.
Self directed, independent learning	Learning in which the individual has primary responsibility for his or her education.
Traditional instruction	Instructional material is transmitted to students from teachers, and is a passive method of learning for students.

Table 2: Definitions of Teaching Methods

Academic subject areas covered
The 122 studies represented a wide range of undergraduate subject areas. Most covered a single subject area, but others included more than one discipline. The highest percentage of studies came from instruction related to courses in English (30%, 37/122), included in the Arts category. Another subject area with many studies was Library Science, which were mainly courses devoted to library skills and taught by librarians for credit (13%, 16/122). Figure 3 shows the number of studies arranged by broad subject discipline.

Teaching methods
Most studies compared two or more teaching methods. Of the 122 studies, 88 (72%) were comparative, while the remaining 34 (28%) studies did not have a comparison group. These non-comparative studies were generally evaluating the effectiveness of a single teaching method to determine whether students' scores improved following the instruction.

The teaching methods (Table 2) used in the studies varied, with the majority focused on traditional methods of teaching (e.g., lecture, demonstration). Other studies dealt with computer-assisted instruction (CAI) (e.g., Web-based tutorials); self-directed, independent learning (SDIL) (e.g., workbooks); active learning (AL) (e.g., problem based learning); and learner-centred instruction (LCI) (e.g., individual term paper counselling). While many teaching methods included a combination of methods, for the purposes of this review they were grouped according to the primary teaching method used (Figure 4). Further details of the studies meeting the quality filter are in Appendix D.

Total librarian contact time with students ranged from 15 minutes to 3 hours per week over the course of a semester. Information on the amount of instructional contact time was lacking in 27% (33/122) of the studies.

Instructional topics varied among studies, although many common themes were identified. The most common areas for instruction were conducting library research and research strategies (33%, 40/122), using the catalogue (28%, 34/122), using reference tools (27%, 33/122), an overview of the library and its resources (21%, 26/122 studies), literature searching (20%, 24/122), and using computerized or electronic resources (19%, 23/122).

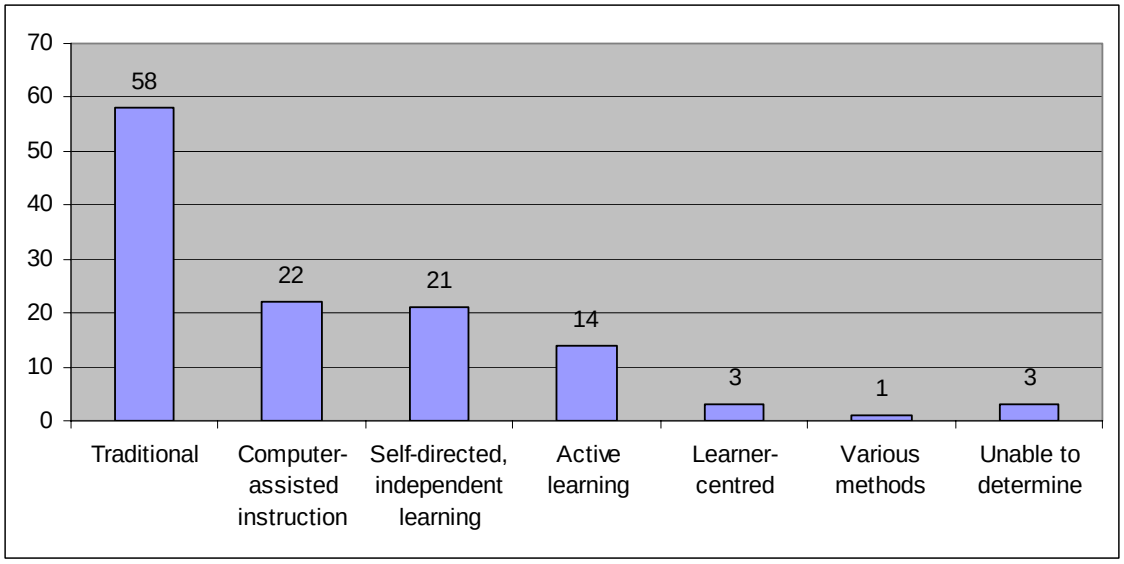

Figure 4: Primary Teaching Methods Used

Outcome measures

The vast majority of studies measured cognitive outcomes via student scores on a post-test (79%, 96/122). Other outcome measures included the graded quality of the students' bibliographies (7%,9/122), an assessment of search tasks (6.5%,8/122), assignment scores (5%,6/122), scores on term papers or essays (3%, 4/122), and scores on a general library skills survey (3%, 4/122). Some studies used more than one cognitive outcome measure.

Bloom's taxonomy of educational objectives (as revised by Anderson and Krathwohl) was used to determine the level of cognitive learning outcomes measured for the 122 included studies. The Anderson and Krathwohl revision was used because it provides an important update of Bloom's 1956 taxonomy and incorporates new knowledge into the framework. Anderson and Krathwohl note the following structure of the cognitive process, covering six levels of learning:

1.0 Remember – Retrieve relevant knowledge from long-term memory.
    1.1 Recognizing
    1.2 Recalling
2.0 Understand – Construct meaning from instructional messages, including oral, written, and graphic communication.
    2.1 Interpreting
    2.2 Exemplifying
    2.3 Classifying
    2.4 Summarizing
    2.5 Inferring
    2.6 Comparing
    2.7 Explaining
3.0 Apply – Carry out or use a procedure in a given situation.
    3.1 Executing
    3.2 Implementing
4.0 Analyze – Break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose.
    4.1 Differentiating
    4.2 Organizing

4.3 Attributing
5.0 Evaluate – Make judgements based on criteria and standards.
5.1 Checking
5.2 Critiquing
6.0 Create – Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure.
6.1 Generating
6.2 Planning
6.3 Producing
(Anderson and Krathwohl 31)

Figure 5 shows the levels of learning outcomes measured by the 122 studies in this review. More than one level of learning was often assessed within a single study, with 'Remember' being the most commonly assessed area. Most studies focused on one of the three more basic levels of learning outcomes. There is an evident lack of cognitive assessment research in the higher order areas -- 'Analyze', 'Evaluate', and 'Create'. Also of note is that 23 studies (18%) did not provide enough information about what they were testing to determine what learning outcomes were being measured. The research hypothesis for this study anticipated that the higher the level of learning outcomes measured (using Bloom's taxonomy), the more difficult it will be to link effectiveness directly to library instruction, and the less likely it is that the library instruction will result in a positive outcome. Results of this systematic review indicate the hypothesis is partially supported. The higher levels of learning outcomes were less frequently measured, suggesting a possible difficulty in testing these areas. Furthermore, the results in the studies that did measure higher level outcomes varied widely, with a greater percentage of those studies having mixed results. The levels 'Remember', 'Understand', and 'Apply' seem to be easier to measure in terms of cognitive outcomes, while 'Analyze', 'Evaluate', and 'Create' are more complex concepts that do not lend themselves as well to quantitative measurement. As a result, the focus of outcome measures is more evident in areas where demonstrable outcomes can be achieved.

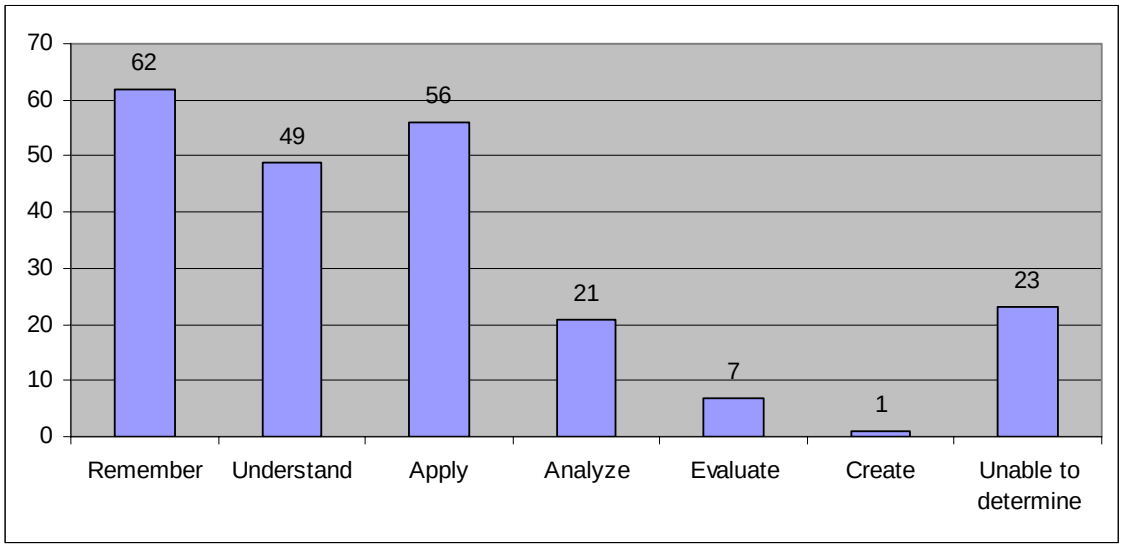

Figure 5: Number of Studies Assessing the Bloom (revised) Levels of Learning Outcomes

In the areas of 'Analyze', 'Evaluate', and 'Create' there are more variables that cannot easily be separated and tested, so it is more difficult for students' learning to be attributed directly to the library-led instruction they received.

II. Effectiveness of Different Teaching Methods

Reported outcomes by teaching method

The second objective of this review was to determine effective teaching methods. In order to do this, studies were categorised and reviewed with a quality filter. Based on the primary teaching method, studies were categorised into five teaching methods: active learning (AL), computer assisted instruction (CAI), learner-centred (LC), self-directed independent learning (SDIL), and traditional instruction (TI). Four studies could not be classified according to teaching method.

Study results were recorded to indicate if the intervention had a positive, negative, neutral, or mixed result, based upon the outcomes measured. Studies were subjected to two quality filters. The first determined whether the study was comparative (a design whereby the intervention is compared to another teaching method or control). The second quality filter determined whether the study outcome as noted by the authors was based on data assessed for statistical significance. These quality filters were selected to remove bias due to confounding (control groups should be similar in every respect to the experimental group except for the variable being tested) and to account for differences due to chance (statistical significance). A total of 73 studies met these two criteria. One additional study (Ridgeway), while not using tests of statistical significance, did have enough information for such tests to be calculated, so it was included as well, bringing the total to 74. However, 19 of these compared different modes of delivery or other aspects within the same overall teaching method, so they were removed from the analysis, since they did not compare different teaching methods.

The 55 remaining studies compared the main teaching intervention to a different teaching method, or to no instruction, and those 55 studies form the basis of the following review and meta-analysis in order to draw conclusions about the effectiveness of different teaching methods. Selected characteristics of the 55 studies are noted in Appendix D.

Traditional instruction

The traditional method of instruction (TI) was the main intervention for the highest number of studies in general (n=58). However, only 18 of these met the aforementioned quality criteria. Table 3 provides the number of study outcomes for TI, with a specific breakdown by the comparison teaching method.

Traditional Instruction (n=18)

Comparison	Positive	Neutral	Negative	Mixed	Total
No instruction (NI)	12	3	0	1	16
CAI	0	0	0	1	1
Placebo	0	0	0	1	1

Table 3: Study Outcomes for Traditional Instruction

Computer Assisted Instruction (n=17)					
Comparison	**Positive**	**Neutral**	**Negative**	**Mixed**	**Total**
Traditional	3	9	2	0	14
Self-directed	0	2	0	0	2
No instruction	0	1	0	0	1

Table 4: Study Outcomes for Computer Assisted Instruction

The single study comparing TI against a placebo (an inactive treatment given instead of the treatment being evaluated, in this case a non-instructional film), had a mixed result. Although TI accounts for much of the research literature, there is a lack of comparative research to determine effectiveness versus other teaching methods. Where the comparison is versus no instruction, the studies reviewed here show a mainly positive result, with 12 of the 16 reporting an affirmative outcome in favour of TI, suggesting that this instructional method is more effective than no instruction. Within this subset of data, there was sufficient information in 4 studies comparing TI with no instruction, to perform meta-analysis and further substantiate this finding, as explained in Section III.

Computer Assisted Instruction

There were 22 studies for which computer assisted instruction (CAI) was the main intervention. Of these, 17 met the study criteria (see Table 4), including 14 comparing CAI against TI, 2 comparing CAI against SDIL, and 1 where CAI was compared to no instruction. The group of 14 studies comparing CAI with TI is the largest single grouping of studies found in this systematic review. Based on the reported outcomes of these CAI studies, the overall neutral result points toward CAI being just as effective as traditional teaching methods. Eight of these were selected for meta-analysis (see Section III).

Self Directed, Independent Learning

A total of 21 studies focused on SDIL as the main intervention, with 13 meeting the aforementioned criteria; 7 studies comparing SDIL with TI and 6 comparing SDIL with NI (see Table 5). The overall positive and neutral outcomes suggest that SDIL is as effective as TI and more effective than NI. Four of the studies comparing SDIL to no instruction met the study criteria for the meta-analysis, discussed in Section III.

Self-Directed Independent Learning (n=13)					
Comparison	**Positive**	**Neutral**	**Negative**	**Mixed**	**Total**
Traditional	2	5	0	0	7
No instruction	5	1	0	0	6

Table 5: Study Outcomes for Self-directed, Independent Learning

Active Learning (n=5)					
Comparison	**Positive**	**Neutral**	**Negative**	**Mixed**	**Total**
Traditional	1	1	1	0	3
No instruction	1	0	0	1	2

Table 6: Study Outcomes for Active learning

Active Learning
Fourteen studies focused on active learning (AL). Of those, 5 met the criteria for further analysis -- 3 compared AL with TI, and 2 compared AL with NI (see Table 6). Results varied widely and indicate the studies pertaining to AL are not conclusive and require further research. The hypothesis, "Instruction that encourages active participation from students is more effective than instructional modes that are passive, such as lecture and demonstration," could not be addressed and meta-analysis could not be performed.

Learner Centred Instruction
Finally, three studies focused on learner-centred instruction (LCI) as the main intervention. Two met the criteria for further analysis; one comparing LCI to TI and the other to no instruction, both with a neutral result (see Table 7). The small numbers of research studies in this area prevent further analysis. Further research is required to build the evidence base with respect to effectiveness of LCI.

III. Meta-analysis of comparative studies

A meta-analysis is the pooling of estimates of effect from individual studies asking the same basic question. Meta-analysis provides an estimate of overall effect as well as measuring the variability between these studies. Additionally, the meta-analysis will weight the estimates based on how many subjects each study tested and on how much between-subject variability existed. The purpose of meta-analysis is to provide some guidance (ruling out chance and as much bias as possible) around discrepant studies and amongst small studies with indeterminate results. Further information about conducting meta-analysis can be found in Chalmers et al, Cooper and Hedges, and Egger et al. Meta-analysis was performed on 16 studies for these comparisons:

- Traditional instruction vs. no instruction (n=4)
- Computer assisted instruction vs. traditional instruction (n=8)
- Self-directed independent learning vs. no instruction (n=4)

Learner-centred instruction (n=2)					
Comparison	**Positive**	**Neutral**	**Negative**	**Mixed**	**Total**
Traditional	0	1	0	0	1
No instruction	0	1	0	0	1

Table 7: Study Outcomes for Learner-centred Instruction

These three comparisons were selected because the studies in these areas reported enough information to calculate a standardized mean difference (SMD), a measure by which the studies could be compared directly despite the use of different measurement tools. SMD is the difference in means of the two groups being compared, divided by an estimate of standard deviation (SD). The number of participants in both the intervention and control groups, the mean score for each group, and the standard deviation was used to calculate SMD.

The meta-analysis allows for a visual representation of the research data in a meta-graph using RevMan software (see Figures 6, 7, and 8). Each row in the meta-graph constitutes one study. This includes the raw data (here, the sample size, mean, and standard deviation for each teaching method) as well as the estimate of effect (here, the SMD and the confidence intervals). The best estimate of effect for each study is represented by the square, and the horizontal line running through the square represents the confidence interval. The vertical zero line is the line of no effect. If the confidence interval crosses this line, the estimate of effect is not significant. The diamond at the bottom of the graph represents the overall pooled estimate. Its centre is the best estimate of effect, and its width represents the pooled confidence intervals.

This meta-analysis used standardized mean difference (SMD), the difference in means of the two groups being compared, divided by an estimate of standard deviation (SD). The pooled SD from both instructional groups was used. The SMD is in units of SD. For example, as shown in Figure 7, the SMD for Alexander's study is 0.27 SDs. Therefore, Alexander found a difference of 0.27 SDs between the two groups, favouring CAI. However, this result was not statistically significant, since the 95% confidence interval (-0.15 to 0.69 SDs) includes zero. This means that although the best estimate is 0.27 SDs, the true difference may lie anywhere between -0.15 and 0.69 SDs, including zero, the estimate of no effect. An SMD of 0.2 is said to be small, 0.5 to be moderate, and 0.8 to be large (Cohen 25).

The three meta-analyses show the individual estimates of each study plus the overall pooled result. There are different statistical methods for pooling. We chose a method that accounts for random effects between individual studies. This means that not only did we expect subject-to-subject variation, but also study-to-study variation, such as differences due to type of computer programs, teaching styles, evaluation periods, and so on. Including random effects in the overall estimate of effect widens the confidence intervals, thereby increasing the uncertainty of the estimate.

Traditional vs. No Instruction

Of the studies comparing TI to no instruction, 4 provided sufficient information to calculate SMD. Three of the four studies (Cooper Moore, Lechner, and Toifel) provided multiple TI vs. NI comparison groups within their studies, and these were included in the meta-analysis as separate comparisons. This information is summarized in the meta-graph in Figure 6. The meta-graph shows that for this group of studies, there is a statistically significant difference between the TI and no instruction groups, suggesting that the TI method is more effective than no instruction. Additionally, since the confidence interval stretches from 0.14 to 0.48, we would conclude that the size of effect would be somewhere between small and moderate, using Cohen's guidelines.

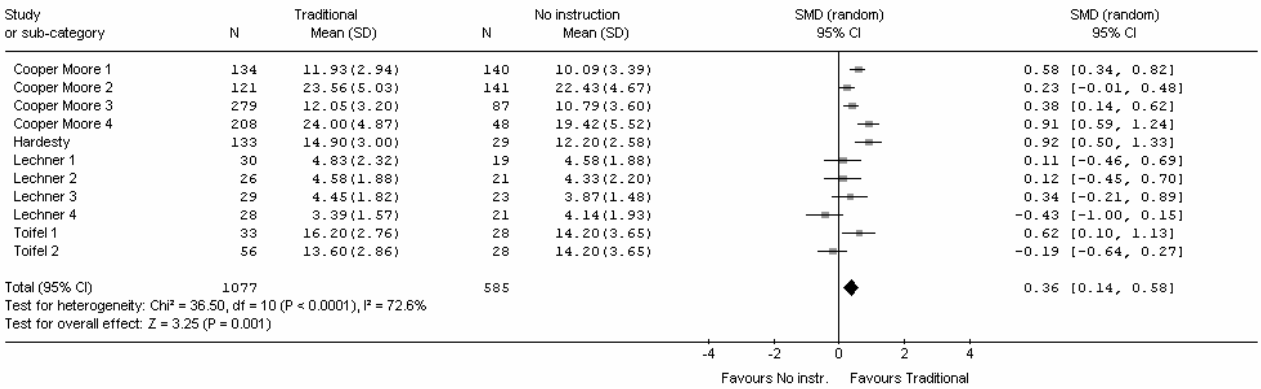

Figure 6: Standardized Mean Difference of Traditional Instruction vs. No Instruction

Computer Assisted Instruction vs. Traditional Instruction

The CAI subset of data included 8 studies that were able to be compared using meta-analysis, since all 8 compared CAI with TI, and they provided sufficient information to calculate the standardized mean difference (SMD). This information is summarized in Figure 7. The pooled SMD estimate is -0.09 SDs, and the 95% confidence intervals, -0.47 to 0.29 SDs, cross the zero line, allowing for the possibility of no difference between groups. Note also that our best estimate, -0.09 SDs, is very small. Thus, provided that these studies are representative (of typical and quality instruction methods), we can say there is no evidence to support any difference between CAI and TI methods. However, we cannot say that there is absolutely no possibility of a true difference, since the confidence limits include estimates (e.g. -0.47, 0.29) that Cohen (25) and other researchers would consider important.

The meta-graph shows that for this group of studies, there is no difference between CAI and TI, suggesting that CAI is just as effective as traditional teaching methods. Results of this research did not support the hypothesis that, "Instruction that is taught by a librarian face-to-face is more effective than instruction that is computer-based".

Self-Directed, Independent Learning vs. No Instruction

There were 4 studies comparing SDIL to no instruction and provided enough data to calculate SMD. The meta-graph in Figure 8

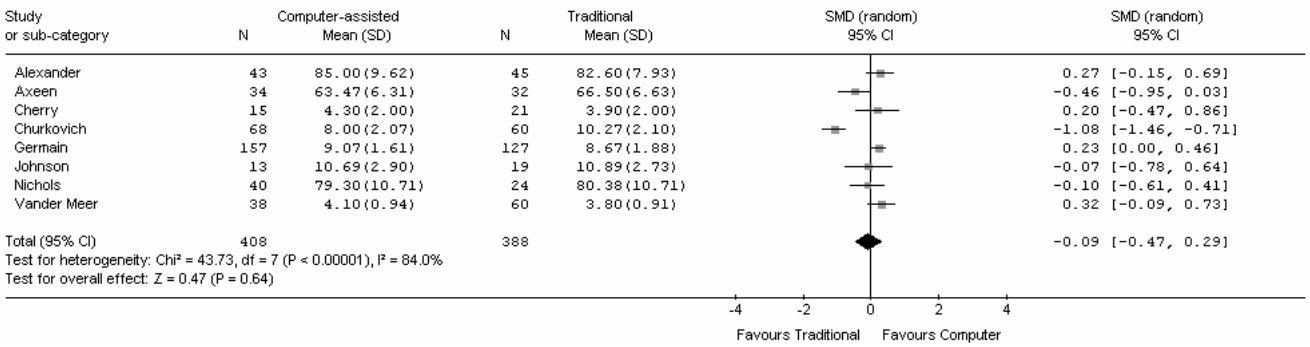

Figure 7: Standardized Mean Difference of CAI vs. Traditional studies

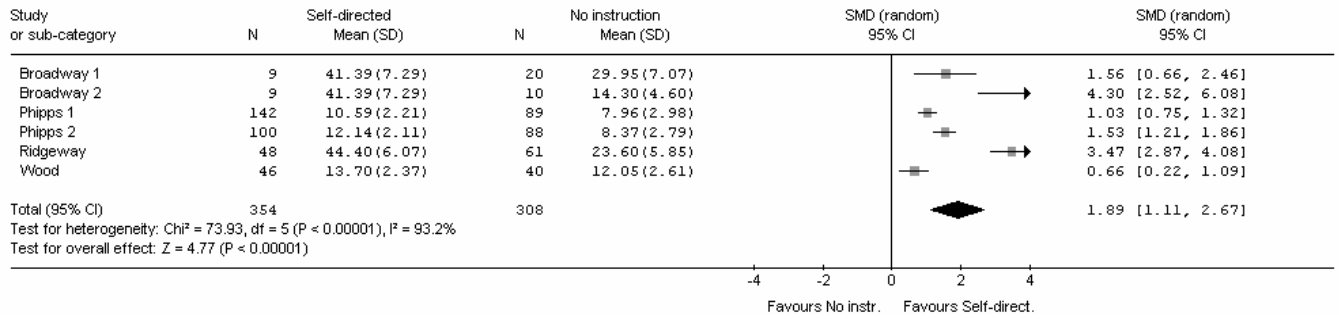

Figure 8. Standardized Mean Difference of Self-Directed Independent Learning vs. No Instruction.

shows the result of these studies. Note that Broadway studied 1 SDIL group and 2 NI groups. We divided Broadway's SDIL group (halving the sample size, so that each of the no instruction groups could be included in the meta-analysis as a separate study. Phipps and Dickstein studied 4 instruction groups (2 were self-directed, and 2 had no instruction). The studies were included in the meta-analysis as 2 separate studies. As the graph shows, the data in these studies qualitatively favours SDIL over no instruction, and all the studies individually favour self-directed teaching over no instruction. However, since the size of effect is heterogeneous (the confidence intervals are non-overlapping), we cannot conclude a precise estimate of effect. Size of benefit will vary based on the specific content of self-directed instruction. We can, however, conclude that SDIL is more effective than no instruction, since all studies are statistically significant in favour of SDIL. Additionally, since the lower overall confidence limit is greater than 0.8 (as are most of the lower confidence limits for the individual studies), we can expect that SDIL will confer a larger benefit compared to no instruction.

Discussion

The 122 studies included in this review provide a broad picture of the state of the research pertaining to effective library instruction methods for improving the information skills of students at an introductory, undergraduate level, using cognitive outcomes.

Most studies have been conducted on traditional modes of instruction, however these varied in terms of quality, and the studies often lacked a comparison group. When there was a comparison, it was usually to 'No Instruction'. The next most frequent teaching area was 'Computer Assisted Instruction'. This group of studies largely focused on a comparison with 'Traditional Instruction', perhaps an indication of the way in which that type of instruction has sought to prove its worth against face-to-face teaching. 'Self-Directed, Independent Learning' had a number of positive outcomes as a whole when compared to either 'No Instruction' or 'Traditional Instruction' methods. Neither 'Active Learning' nor 'Learner-Centred' instruction yielded enough studies to make any meaningful comparisons.

Looking at the studies as a whole, there were a variety of research methods used, some more rigorous than others. Of the 122, 79 (65%) were experimental or quasi-experimental studies. In trying to measure effectiveness, such studies indicate more reliable methods, if those studies are conducted properly.

There were several issues with methodology and gaps in the information reported. One apparent area was the lack of validated research instruments. Of the 122, Only 9 (7%) studies gave a detailed description of how the research instrument was validated. A validated research tool increases the strength of the study, allowing us to trust that the questions actually measure what they intended to measure. A further 22 (18%) studies indicated some attempt to pilot test the instrument. The remaining studies did not touch upon the importance of the research instrument at all.

Sample size ranged in size from those with less than 100 participants to very large with more than 600 participants throughout the 122 studies. In 8 (6.5%) studies the sample size was not mentioned, and in another group of 5 (4%) studies the number of participants was stated in only approximate numbers. There were 37 (30%) studies with 100 or fewer participants, 35 (29%) studies had 101-200 participants, 22 (18%) studies had 201-600 participants, and 9 (7%) studies had more than 600 participants.
More than 25 (20%) of the 122 studies did not perform any statistical analysis of the data they collected. A further 12 (10%) noted that statistical tests were performed, but did not report their data. Other methodological issues with the studies were the lack of reporting of loss to follow-up between pre-test and post-test, and biases that were introduced, most noticeably selection bias of participants.

Gaps in reporting were often a problem. In many cases, it was difficult to determine what a study was trying to measure, since there was no clear description of the research instrument or the learning outcomes being measured. Sometimes there was no description of what was being taught or the learning environment. Such elements are important to give the reader a complete picture, in order to determine whether the study may be applicable to the reader's own situation. With regard to Bloom's levels of learning, many studies did not report sufficient information to determine the outcomes being measured. For the studies that could be measured, focus rested on levels of learning that were lower and easier to measure.

The 16 studies (13%) that met the criteria for meta-analysis were of higher quality, and the meta-analysis method accounted for differences between studies. This analysis suggests three key points, which could affect practice:

- Computer assisted instruction is as effective as traditional instruction.
- Traditional instruction is more effective than no instruction.
- Self-directed, independent learning is more effective than no instruction.

The current research in our field does not highlight any particular teaching method as being more effective than any other teaching method. While individual studies have compared different teaching methods directly, not enough of them have compared those teaching methods in a meaningful way. The only direct comparison between two teaching methods that could be made statistically using meta-analysis was with computer assisted instruction vs. traditional instruction.

The neutral result showing that CAI is just as effective as TI indicates that decisions to implement CAI should not be disregarded because of the belief that in-person instruction is more beneficial to the students. As the research points to equal outcomes, other factors such as time, costs, staffing, and ability to reach greater numbers of students need to be weighed in the decision of using one teaching method over another. Qualitative research designs may have more to add to the discussion of which method

may be preferable, based upon other factors such as user preference.

The result showing that TI is more effective than no instruction, provides a measure of the worth of library instruction as it has most commonly been performed in the past. Teaching seems to provide some benefit, over and above not teaching at all. While this is positive, more research is needed to determine whether or not TI is the best method of instruction. Studies comparing traditional teaching methods to AL and to SDIL, for example, should be considered, so that we can more fully understand the effectiveness of the ways in which we teach information literacy skills.

The positive results for SDIL versus no instruction, should not be overlooked. As with CAI, this method of instruction provides a solution that does not require instruction to be face-to-face. It is a possible solution for those wanting to implement information literacy initiatives but not having the resources to teach in person. Again, more research is required to test this teaching method against other methods, including traditional instruction and CAI.

Active learning and learner-centred instruction did not have enough studies to reach any conclusions about their effectiveness. These areas require further research to create a body of studies comparing these teaching methods to other more established methods, such as traditional and computer assisted instruction.

Possible confounders of this systematic review and meta-analysis include the dominance of U.S. studies in the evidence base, which may impact transferability of these results. Another factor is that only studies reported in the English language were included; results may not be able to be generalized to practice in other countries.

The authors relied on study design as a measure of quality, but study design in and of itself does not constitute a good study. Just because a study has a design that should be more rigorous, does not mean that it has been well conducted. However, for the questions of effectiveness that the authors were attempting to answer, the comparative study design was an appropriate filter. Finally, results were not compared across subject areas, so results may not necessarily be transferable from one subject area to another. Readers should look at the detail provided in Appendix D for studies that apply specifically to their subject areas.

Conclusion

The goal of conducting this systematic review was to find evidence about information literacy instructional methods that may have a direct impact on the way academic librarians approach teaching information literacy to undergraduate students. This review provides a general picture of the research that has been done in this area, highlights some of the better research, draws together current evidence on what teaching methods are most effective, highlights problems with this body of research, and outlines what we can learn from the current evidence base.

To determine effectiveness of teaching methods, more comparative research needs to be done across different teaching methods using sound research methodologies and validated research tools. Careful consideration should be given to the most appropriate research method, and researchers should determine possible areas of comparison before beginning the study. The norm is to compare with no instruction, or to the standard traditional methods. Studies comparing to active learning, computer assisted instruction, and self-directed independent learning would

greatly enrich the research literature. Building upon existing studies with good methodologies and validated research tools would enrich our evidence base and contribute to the growth of knowledge about effectiveness of particular teaching methods.

This systematic review of the literature provides librarians who teach information literacy skills with an overview of the research literature in this area. Despite certain flaws in the studies which have been outlined, this review provides pragmatic evidence of the effectiveness of several methods of teaching information literacy. The lack of comparative studies, however, does not allow us to conclude anything about the effectiveness of teaching methods in areas such as active learning and learner-centred instruction. In the areas of traditional instruction, CAI, and self-directed independent learning, only three conclusions could be made. The systematic method of arriving at those conclusions provides us with clear evidence in those specific areas. However, there is not enough evidence to determine which teaching method is best. We should approach information literacy grounded in this knowledge, and move forward to build upon it, contributing to the evidence base in the future.

Nevertheless, this systematic review will aid librarians teaching information literacy skills to undergraduate students to be more informed about the teaching methods they use. While there is not enough current evidence to persuade instructional librarians to change their teaching practices from one method to another, librarians should know that the evidence base for effectiveness based on cognitive outcomes is weak, and make their decisions with that in mind. This systematic review should be a call for those involved with information literacy instruction to contribute to the research knowledge base in their field of interest, so that better decisions can be made in the future. Researchers, particularly those in countries other than the U.S., should continue to build upon the research results summarised here to provide more research evidence of effective library instruction methods.

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Appendix A: Literature Search Process

Searches were conducted between September and November, 2004 and updated in May, 2005.

1. **LISA (CSA)** 1969 - present
Search strategy:
((de=(user training) or (information literacy) or (computer assisted instruction) or (information literacy tutorial) or (education activities)) or "library instruct*" or "library educat*" or "librar* teach*" or "user train*" or "user educat*" or "online tutor*" or "library skill*" or "information skill*") and (de=students or undergrad* or "first year" or bachelor* or "post secondary")
Number of documents retrieved: 1,443.

2. **Library Literature (Silverplatter)** 1984 - present
Search strategy:
#1 bibliographic-instruction-college-and-university-students in DE (1,285 records)
#2 bibliographic-instruction-junior-and-community-college-students in DE (47 records)
#3 #1 or #2 (1,332 records)
#4 computer-assisted-instruction in DE (909 records)
#5 end-user-searching-teaching in DE (750 records)
#6 bibliographic-instruction in DE (207 records)
#7 internet-teaching in DE (398 records)
#8 information literacy (593 records)
#9 library instruct* (535 records)
#10 librar* teach* (2,351 records)
#11 user train* (41 records)
#12 user educat* (213 records)
#13 online tutor* (16 records)
#14 library skill* (159 records)
#15 information skill* (206 records)
#16 #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 (5,708 records)
#17 undergrad* (508 records)
#18 first year (77 records)
#19 bachelor* (9 records)
#20 post secondary (8 records)
#21 postsecondary (12 records)
#22 #17 or #18 or #19 or #20 or #21 (605 records)
#23 #16 and #22 (108 records)
#24 #3 or #23 (1,383 records)
Number of documents retrieved: 1,383.

3. **ERIC (OVID**) 1966 - July 2004
Search Strategy:
1 exp Information Literacy/ (984)
2 exp Course Integrated Library Instruction/ (409)
3 exp Library Instruction/ (3,082)
4 exp Information Skills/ (1,950)
5 exp Library Skills/ (1,542)
6 library instruct$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (3,231)
7 library educat$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (3,133)
8 librar$ teach$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (1,068)

9 user train$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (255)
10 user educat$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (224)
11 information literacy.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (1,274)
12 online tutor$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (55)
13 library skill$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (1,749)
14 information skill$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (1,114)
15 or/1-14 (9,234)
16 exp Undergraduate Students/ (5,855)
17 exp College Freshmen/ (5,672)
18 exp college freshmen/ or exp college juniors/ or exp college seniors/ or exp college sophomores/ (6,057)
19 undergrad$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (27,073)
20 (postsecondary or post-secondary or post secondary).mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (38,914)
21 bibliographic instruct$.mp. (632)
22 15 or 21 (9,278)
23 bachelor$.mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (3,905)
24 (first year or first-year).mp. [mp=abstract, title, headings word, identifiers, eric digests full text] (8,997)
25 or/16-20 (70,037)
26 or/23-25 (79,802)
27 26 and 22 (885)
28 exp Undergraduate Study/ (7,066)
29 26 or 28 (79,802)
30 29 and 22 (885)
31 from 30 keep 1-885 (885)
Number of documents retrieved: 885

4. **Inspec (Axiom/IOP)** 1968 – present
Search Strategy:
((information literacy or information instruction or information searching skills or library instruct* or library educat* or librar* teach* or user train* or user educat* or online tutor* or library skill* or information skill* or bibliographic instruct*) and (undergrad* or first year or bachelor* or post secondary or freshman or academic librar*)) <in> (TI,AB,CI,UI)
Number of documents retrieved: 232

5. **Academic Search Premier (EBSCO)** 1975 -present
Search Strategy:

S1	SU (information literacy or library education or information services - user education or computer-assisted instruction or user education)	5,366
S2	(bibliographic instruct* or library instruct* or library educat* or librar* teach* or user train* or user educat* or online tutor* or library skill* or information skill*)	2,868
S3	(undergrad* or first year or bachelor* or postsecondary or academic librar*)	35,765

S4	(S2 Or S1)	8,071
S5	(S4 And S3)	767

Number of documents retrieved: 767

6. **Educational Research Abstracts** 1995-present
Search Strategy:
((keywords/"library instruct*" or keywords/"bibliographic instruct*" or keywords/"information literacy" or keywords/"user train*" or keywords/"library educat*" or keywords/"library teach*" or keywords/"online tutor*" or keywords/"library skill*" or keywords/"information skill*") and (keywords/undergrad* or keywords/"first year" or keywords/bachelor* or keywords/postsecondary or keywords/"post secondary" or keywords/"academic librar*"))
Number of documents retrieved: 6

7. **CINAHL (OVID)** 1982 – present
Search Strategy:
1 exp Library User Education/ (357)
2 (library instruct$ or library educat$ or librar$ teach$ or information literacy or library skill$ or information skill$).mp. [mp=title, cinahl subject headings, abstract, instrumentation] (205)
3 1 or 2 (473)
4 exp Students, College/ (2,911)
5 (undergrad$ or first year or bachelor$ or postsecondary or post secondary).mp. [mp=title, cinahl subject headings, abstract, instrumentation] (4,314)
6 exp Libraries, Academic/ (928)
7 or/4-6 (7,719)
8 3 and 7 (124)
9 from 8 keep 1-124 (124)
Number of documents retrieved: 124

8. **Web of Science** (all sections) 1945-present
Search Strategy:

#1	1,665	TS=(librar* instruct* OR bibliographic instruct* OR library educat* OR librar* teach* OR user train* OR user educat* OR information literacy OR online tutor* OR library skill* OR information skill*) DocType=All document types; Language=All languages; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=1945-2004
#2	56,264	TS=(undergrad* OR first year OR first-year OR bachelor* OR postsecondary OR post-secondary OR academic librar* OR university student* OR college student*) DocType=All document types; Language=All languages; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=1945-2004
#3	185	#1 AND #2 DocType=All document types; Language=All languages; Databases=SCI-EXPANDED, SSCI, A&HCI; Timespan=1945-2004

Number of documents retrieved: 185

9. **Dissertation Abstracts / Digital Dissertations** (ProQuest)
Search Strategy:

1	KEY(library instruction) or KEY(bibliographic instruction) or KEY(information literacy)	138
2	KEY(library education) OR KEY(user education) OR KEY(library skill?) OR KEY(information skill?)	171
3	#2 or #1	296
4	KEY(undergrad?) OR KEY(first year) OR KEY(first-year) OR KEY(bachelor?) OR KEY(postsecondary) OR KEY(post-secondary) OR KEY(academic librar?) OR KEY(university student?) OR KEY(college student?)	40,957
5	#3 and #4	70

Number of documents retrieved: 70

10. **Conference Papers Index** (CSA)
Search Strategy:
("information literacy" or "library instruct*" or "library educat*" or "librar* teach*" or "user train*" or "user educat*" or "online tutor*" or "library skill*" or "information skill*") and (undergrad* or "first year" or bachelor* or "post secondary" or academic librar*)
Number of documents retrieved: 2

11. **SIGLE** (System for Information on Grey Literature in Europe)) 1980-present
Search Strategy:
(LIBRAR? INSTRUCT? OR BIBLIOGRAPHIC INSTRUCT? OR LIBRARY EDUCAT? OR LIBRAR? (3A)TEACH? OR USER TRAIN? OR USER EDUCAT? OR INFORMATION LITERACY OR ONLINE TUTOR? OR LIBRARY SKILL? OR INFORMATION SKILL?) AND (UNDERGRAD? OR FIRST YEAR OR FIRST-YEAR OR BACHELOR? OR POSTSECONDARY OR POST-SECONDARY OR ACADEMIC LIBRAR? OR UNIVERSITY STUDENT? OR COLLEGE STUDENT?)
Number of documents retrieved: 0

12. CERUK: Current Education Research in the UK
Browsed keyword terms: Librarians; Library and information services; Information skills
Number of documents retrieved: 15

13. Education-*Line* <http://www.leeds.ac.uk/educol>
Query: ("LIBRARY INSTRUCT$" OR "BIBLIOGRAPHIC INSTRUCT$" OR "LIBRARY EDUCAT$" OR "LIBRAR$ TEACH$" OR "USER TRAIN$" OR "USER EDUCAT$" OR "INFORMATION LITERACY" OR "ONLINE TUTOR$" OR "LIBRARY SKILL$" OR "INFORMATION SKILL$") AND (UNDERGRAD$ OR "FIRST YEAR" OR "FIRST-YEAR" OR BACHELOR$ OR POSTSECONDARY OR "POST-SECONDARY" OR "UNIVERSITY STUDENT$" OR "COLLEGE STUDENT$" OR "ACADEMIC LIBRAR$")
Number of documents retrieved: 11

14. British Education Index (Dialog)
Number of documents retrieved: 16

15. Australian Education Index (Dialog)
Number of documents retrieved: 30

Appendix B: Studies Included

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Appendix C: Data Extraction Elements

Author – names of authors on paper

Date – date paper was published

Country and Institution – country and institution where research took place

Study Objective – the stated objective of the study, as relayed by the authors

Subject area – at the departmental level (i.e., Sociology, Medicine, Biology)

Participants – number of participants in study, other factors that are known about the participants (university level of students, average age, prior educational level)

Evaluation Period – duration of the research project (i.e., 4 years, 6 weeks)

Learning Objectives – aims of teaching related to information literacy

Faculty Collaboration – Was the instruction based on a partnership between librarians and faculty (collaboration/partnership/consultation), or was it solely librarian initiated. (yes/no) Did the librarian and faculty member work together?

Integrated or Independent – Was the instruction integrated as part of an existing subject-based course, or was it an independent course or session? (integrated/independent)

Tie to student need – Was the instruction tied directly to student need, wherein the instruction had a direct tie to a student assignment; or was the instruction indirectly tied to student need, wherein the instruction gave examples and assignments that were similar to what they would be expecting in their course; or was the instruction not tied to student need, using examples and assignments which were of supposed interest to the student for future need. (direct/indirect/no tie)

Contact time -- number of hours of instruction included within the study

Teaching method used – way of presenting instructional materials or conducting instructional activities

Mode of Delivery – specific elements regarding how the instruction was carried out (i.e., lecture, small-group, study guide, computer lab exercises, face-to-face, WebCT module, online tutorial)

Instructional Topic – specific focus of the instruction (i.e., library orientation, using bibliographic databases, doing research for a term paper)

Research methods used – type of study design. Also note details of the research methodology.

Learning Outcomes Measured – information literacy learning outcomes the researchers were testing (i.e., improved ability to search online database, increased knowledge of appropriate

information resources, and improved understanding of where to search for information). List the outcomes stated and their categories, based on Bloom's revised taxonomy (Anderson and Krathwohl) of educational objectives for the Cognitive domain ('Remember', 'Understand', 'Apply', 'Analyze', 'Evaluate', 'Create').

ACRL Information Literacy Standard / Performance Indicator – cite the Standard and Performance Indicator numbers as given in the ALA document: Information Literacy Competency Standards for Higher Education <http://www.ala.org/ala/acrl/acrlstandards/standards.pdf>.

Point at which Learning Outcomes were Measured – when the test of learning outcomes took place (i.e., immediately following instruction, 1 week after instruction, 2 years after instruction)

Results – results of research (include all numerical data)

Reported Outcome – outcome of research (Positive, Mixed, Neutral, or Negative), as reported by authors (i.e., students using X method of instruction had higher test scores).

Implications of research – as suggested by the authors (i.e., X method of teaching should be used; more research needs to be done on X).

Critical Appraisal Elements – using the Glasgow checklist (Morrison et al. 891).

Appendix D: Characteristics of studies meeting quality filter

Quality filter: 1) comparative studies, 2) compared 2 different teaching methods, 3) outcomes based on data assessed for statistical significance.

***Shaded rows are studies included in meta-analysis*

Abbreviations

AL = Active Learning
CAI = Computer-Assisted Instruction
SDIL = Self-Directed Independent Learning
TI = Traditional Learning

Study	Teaching Method Used	Subject Area	Research methods used	Outcome Measure	Study Outcome	Sample size
Active Learning						
Bren 1998	AL vs. TI	English Literature	Post-intervention, single time point, with control group.	Score on post-test	Positive	86
Cudiner 2001	AL vs. TI with an AL component	First Year Experience	Controlled before-and-after.	Score on post-test	Negative	13
Frasca 1992	AL with a TI component vs. No instruction	Medicine	Post-intervention, single time point, with control group.	Score on post-test	Positive	92
Koufogiannakis 2005	AL vs. no instruction	Medicine and Dentistry	Randomized controlled trial (before-and-after).	Score on post-test; score on final exam	Mixed	164
Prorak 1994	AL vs. TI	English Composition	Controlled before-and-after.	Score on post-test	Neutral	246
Computer Assisted Learning						
Alexander 2000 & 2001	CAI vs. TI	Library Science	Post-intervention, single time point, with control group.	Final exam grade	Neutral	88
Axeen 1967	CAI vs. TI	Library Science	Controlled before-and-after.	Score on post-test	Neutral	66
Cherry 1991	CAI vs. TI vs. No instruction	English	Controlled before-and-after.	Score on post-test search tasks	Positive	53
Cherry 1994	CAI vs. No instruction.	N/A	Randomized controlled trial (before-and-after).	Score on post-test search tasks	Neutral	30
Churkovich 2002	CAI vs. CAI with mediation vs. TI with an AL component	Sociology	Randomized controlled trial (before-and-after).	Score on post-test	Negative	174
Germain 2000	CAI vs. TI with an AL component	First Year Experience	Controlled before-and-after.	Score on post-test	Neutral	303

Gutierrez 2001	CAI with a TI component vs. SDIL with a TI component.	Not stated	Randomized controlled trial (before-and-after).	Score on post-test	Neutral	134
Holman 2000	CAI vs. TI vs. No instruction	English Composition	Controlled before-and-after.	Score on post-test	Neutral	125
Hooks 1986	CAI vs. TI	Library Science	Post-intervention, single time point, with control group.	Score on post-test	Positive	19
Johnson 1980	CAI vs. TI (2 different modes) vs. No instruction	English	Post-intervention, single time point, with control group.	Score on post-test	Neutral	68
Kaplowitz 1998	CAI with a SDIL component vs. TI with a SDIL component	Biology	Controlled before-and-after with follow-up.	Score on the post-test	Neutral	423
Lawson 1989	CAI vs. TI	English	Controlled before-and-after.	Score on post-test	Positive	172
Madland 1988	CAI vs. TI vs. No instruction	Remedial English	Controlled before-and-after.	Score on post-test	Negative	not stated
Nichols 2003	CAI vs. TI	English composition	Controlled before-and-after.	Score on post-test	Neutral	64
Orme 2004	CAI vs. TI vs. CAI and TI vs. No instruction	Business	Post-intervention, single time point, with control group.	Scores on post-test; searching task; and transcription task	Neutral	128
Schilling 2002	CAI vs. TI	Medicine	Randomized Controlled Trial (before-and-after).	Score on post-test	Neutral	128
Vander Meer 1996	CAI vs. SDIL with a TI component	University 101	Randomized controlled trial (before-and-after).	Score on post-test	Neutral	186
Learner-centred Instruction						
Donegan 1989	Learner-centred vs. TI vs. No instruction	Management	Post-intervention, single time point, with control group.	Score on post-test	Neutral	156
Tabur 2001	Learner-centred vs. No instruction	Medicine	Before-and-after study.	Score on post-test	Neutral	137
Self-directed, Independent Learning						
Broadway 1985	SDIL vs. No instruction	Library science	Controlled before-and-after with follow-up.	Score on post-test	Positive	48

Ellsbury 1981	SDIL vs. No instruction	Agricultural and Biological Engineering, Biological Sciences, Entomology	Controlled before-and-after.	Score on post-test	Positive	155
Holt 1984	SDIL vs. TI vs. No instruction	English Composition	Controlled before-and-after.	Score on post-test	Neutral	approximately 112
Kirk 1971	SDIL vs. TI	Biology	Post-intervention, multiple time points, with control group.	Score on bibliography; essay grades	Neutral	approximately 190
Marcus 2003	SDIL vs. TI	Introduction to College Life	Randomized controlled trial (after-only).	Score on post-test	Neutral	203
Meehan-Black 1981	SDIL vs. TI vs. No instruction	Educational Psychology and Human Development	Controlled before-and-after.	Scores on two post-tests	Positive	50
Phillips 1979	SDIL vs. TI	Communications	Randomized controlled trial (after-only).	Score on post-test	Neutral	161
Phipps 1979	SDIL vs. No instruction	English Composition	Controlled before-and-after.	Score on post-test	Positive	487
Ridgeway 1983	SDIL vs. TI vs. No instruction	Writing	Randomized controlled trial (after-only).	Score on post-test	Neutral	149
Stevens 1974	SDIL, comparing two different modes of delivery vs. No instruction	Psychology	Post-intervention, single time point, with control group.	Score on post-test	Positive	502
Suprenant 1982	SDIL vs. TI vs. No instruction	English	Randomized controlled trial (before-and-after).	Score on post-test	Positive	1,234
Wendt 1963	SDIL vs. TI vs. No instruction	English	Randomized controlled trial (before-and-after).	Score on post-test	Neutral	193
Wood 1984	SDIL with a TI component vs. No instruction	Library Science	Controlled before-and-after.	Score on post-test	Positive	86
Traditional Instruction						
Bolt 1986	TI with an AL component vs. No instruction	Library Science	Longitudinal retrospective cohort with control group.	Grade point average	Neutral	572
Bostian 1990	TI, comparing 3 different modes vs. No instruction	Introduction to the Academic Community; Business	Post-intervention, single time point, with control group.	Assessment of search strategies	Positive	56
Breivik 1977	TI with an AL component vs. TI vs. No instruction	English	Controlled before-and-after.	Score on final term paper	Positive	130

Buchanan 1992	TI vs. No instruction	English Composition	Post-intervention, single time point, with control group.	Score on searching exercises	Positive	137
Cooper Moore 2001	TI with an AL component vs. No instruction	English courses accounted for 75% of the sample.	Controlled before-and-after.	Score on post-test and bibliography assessment	Positive	820
Currie 1982	TI (instruction plus compulsory assignment vs. instruction only) vs. No instruction	Biology; Sociology	Post-intervention, single time point, with control group.	Score on post-test	Positive	406
Davis 1993	TI (compares 3 different modes of delivery), vs. CAI	Freshman Orientation; English Composition; Education	Randomized controlled trial (after-only).	Score on post-test	Mixed	220
Dodgen 2003	TI with an AL component vs. No instruction	Sociology	Controlled before-and-after.	Score on post-test	Mixed	294
Eyman 1977	TI vs. No instruction	Library Science	Controlled before-and-after.	Score on post-test	Neutral	242
Fox 1996	TI with an AL component vs. No instruction	Nursing	Multidimensional program evaluation.	Scores on post-tests; graded assignments	Positive	A) not stated; B) 276; C) 112
Hardesty 1979	TI with a SDIL component vs. No instruction	English Composition	Controlled before-and-after.	Score on post-test	Positive	162
Hardesty 1982	TI with a SDIL component vs. No instruction	English Composition	Longitudinal cohort with control group.	Scores on skills tests	Positive	403
Lechner 1989	TI with a SDIL component vs. No instruction	Education	Randomized controlled trial.	Score on post-test; score on performance test	Neutral	199
Nielsen 1987	TI with a SDIL component, comparing the order in which the modes of delivery were given, vs. Placebo	N/A	Randomized controlled trial (before-and-after).	Score on post-test	Mixed	90
Robinson 2004	TI comparing different motivations for an assignment vs. No instruction	Political Science	Post-intervention, single time point, with control group.	Analysis of bibliography citations	Positive	84
Selegean 1983	TI with an AL component vs. No instruction	Library Science	Longitudinal cohort study with control group.	Grade point average; student persistence; and	Positive	468

				graduation rates		
Toifel 1999	TI and AL vs. TI with an AL component vs. No instruction	Education	Controlled before-and-after.	Score on post-test	Positive	145
Wallace 2000	TI with an AL component vs. No instruction	Nursing	Controlled before-and-after.	Score on post-test	Positive	127