Information Retrieval and the Role of the Information Specialist in Producing High Quality Systematic Reviews in the Social, Behavioural, and Education Sciences

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Abstract
The International Campbell Collaboration (C2) prepares, maintains, and disseminates high-quality systematic reviews in the social, behavioural and educational sciences. As part of its effort to ensure that systematic reviews are based on a set of systematic, transparent and replicable procedures, C2 has produced a set of policy briefs. One of these, the C2 Information Retrieval Policy Brief proposes policies for searching the literature for C2 reviews, addresses key issues and challenges faced by C2 reviewers, and recommends working with an Information Specialist (IS). This article illustrates how the information retrieval issues raised in the Brief have been addressed by one C2 review team, through the inclusion of an IS as an integral member of their review team. This unique approach recognises that information retrieval is a continuous and important process, requiring the ongoing expertise of a professional. Cost implications for the provision of ongoing support by an IS are briefly addressed, along with various alternative approaches.

Introduction
Policy and practice decisions alike are increasingly informed by high quality systematic reviews of evidence. Chalmers (2005), a strong supporter of evidence-informed decision making, states that “…up-to-date, reliable systematic reviews of research evidence, or a demonstration that no relevant research exists, should…be regarded as desirable and often essential for informing policy and practice.” (p. 236).

A systematic review can be defined as the application of precise, transparent, and replicable procedures that limit bias in the collection, critical appraisal, summary, and analysis of all relevant studies on a topic (Chalmers, Hedges, and Cooper, 2001; Boruch and Petrosino, 2004). Meta-analysis, on the other hand, is the statistical synthesis of different but comparable studies resulting in a quantitative summary of pooled results (Chalmers, Hedges, and Cooper, 2001;
Meta-analysis is considered to be a subset of a field more broadly defined as systematic reviews or research synthesis (Chalmers, Hedges, and Cooper, 2001).

Criticisms of meta-analysis during its formative years were construed as problems with meta-analysis itself, but many of these criticisms related to the lack of systematic procedures that preceded it such as unsystematic or narrowly defined literature searches, poorly defined inclusion/exclusion criteria for studies, or lack of sensitivity to study quality (Eysenck, 1995). Chalmers and Altman (1995) published one of the first guides on how to apply a set of systematic procedures that preceded a statistical synthesis of the data. Throughout this article, we use the term systematic review, but consider it conceptually interchangeable with the term research synthesis.

**International organisations that produce systematic reviews**

The Campbell Collaboration (C2) is a non-profit organisation comprising an international network of professionals who endeavour to assist policy makers and practitioners make well-informed decisions about the effects of interventions in the social, behavioural and educational sciences. Established in 2000, C2’s primary mission is to prepare, maintain, and disseminate systematic reviews of studies of interventions (Boruch, Soydan, and de Moya, 2004).

Other organisations include the EPPI Centre at the Institute of Education, University of London that produces systematic reviews within the social sciences, and the Cochrane Collaboration, based in the UK, which produces systematic reviews within the health sciences. All of these entities aim to produce high-quality reviews based on a set of clearly articulated, systematic, transparent, replicable procedures.
How to conduct a systematic review

High quality systematic reviews generally proceed through eight main stages (additional information about each stage is presented in Appendix I):

(1) Defining the research question to be reviewed;
(2) Developing inclusion/exclusion criteria for studies;
(3) Performing literature searches and documenting information retrieval;
(4) Selecting studies based on Stage 2;
(5) Extracting effect sizes using a coding guide;
(6) Coding study features;
(7) Analysing the data (meta-analysis is used if appropriate); and
(8) Interpreting and writing up the results and conclusions.

The eight stages are neither mutually exclusive nor distinct. Rather, they should be viewed as the key stages that form part of a continuous and iterative process, each preceding stage gradually blending into the subsequent stage (Bernard et al, 2005). The entire systematic review process can take anywhere from six months to several years, depending on the nature, complexity, and scope of the research question(s) being addressed.

Whether a systematic review includes a statistical synthesis or a narrative synthesis, the integrity of the review and the validity of its conclusions rest firmly on the quality of information retrieval (Bernard et al, 2005). Yet few resources are dedicated to the information retrieval phase of a systematic review in the social sciences. The following section highlights C2’s work in this area. Interested readers may consult the Cochrane Collaboration (http://www.cochrane.org), Campbell’s sister organisation, for guidance related to information retrieval in the health sector.
The C2 Information retrieval policy brief

The C2 Information retrieval policy brief was authored by Rothstein, Turner, and Lavenberg (2004) who are members of the C2 Information Retrieval Methods Group (IRMG). The Brief is a summary of C2’s policy on the information retrieval phase of systematic reviews. The Brief was vetted by information specialists from the Centre for Reviews and Dissemination (CRD) and the UK Cochrane Centre, and by other external reviewers with expertise in systematic reviews. C2’s governing body, the international Steering Group, ultimately approved the Brief, which is designed to:

- Identify the key issues that are confronted by C2 systematic reviewers; attempting to gather information relevant to the questions posed by their review;
- Propose policies to direct the activities of C2 reviewers during the various stages within the information retrieval phase of their review;
- Provide exemplars to demonstrate the implementation of these policies; and
- Describe the ways in which the reviewers can contribute to the goals of C2.

This document is meant to provide general guidance to reviewers and to establish minimum standards for key information retrieval tasks. Although the Brief speaks specifically to individuals planning to conduct a C2 review, the policies, procedures and guidelines are applicable to anyone interested in implementing information retrieval methods that maximise coverage and minimise bias during the information retrieval process.

The Brief’s fundamental premise is that information retrieval is an essential component of the systematic review process, analogous to the data collection phase of a primary research study, and requires the expertise of an information specialist (IS) or librarian. A thorough and unbiased compilation of all potentially
relevant studies is one of the key characteristics of a systematic review and if the
literature located is unrepresentative of the population of completed studies, the
remainder of the review process will be compromised (Hopewell, McDonald,
Clarke, & Egger, 2002).

Given the diverse nature of the research questions addressed in the social,
behavioural and educational sciences, potentially relevant studies are likely to be
widely distributed and unreliably categorised. While retrieval of information from
the literature is a critical concern for any systematic reviewer, retrieval of
information about complex social, behavioural and educational interventions is
likely to be particularly challenging.

**Implications of naïve information retrieval strategies**

As early as 1994, White expressed his concern over naïve information
retrieval and stated that although systematic reviewers generally conduct more
informed searches than the typical literature searcher, “they still seem blinkered,
exhibiting a kind of tunnel vision towards sources. That is, their search strategies
are not wrong (they are efficient and effective as far as they go) but partial: They
miss sources that a professional searcher would not miss.” (p 44).

Naïve information retrieval strategies can result in a systematic review that
has limited generalisability or, even worse, biased results. Potential biases include
but are not limited to:

- language bias—a tendency to include only those studies published in
  English;
- cultural bias – a tendency to search databases from one’s own country of
  origin;
- availability and cost bias—a tendency to include only those studies that
  are easily accessible and free or at low cost;
- database bias –a tendency to search only databases that are available at
one’s own institution;

• familiarity bias—a tendency to include studies only from one’s own discipline;

• reference bias—a tendency to preferentially cite studies supporting one’s own views; and

• publication bias—a tendency to include only published material, thereby potentially missing studies that did not result in an effect.

The operation of these biases is not hypothetical, nor without consequences. They have been demonstrated to occur in systematic reviews in both health and social sciences, and have led to the approval or adoption of ineffective, and even dangerous, treatments. The interested reader can refer to a recently released edited volume by Rothstein, Sutton and Borenstein (2005) for more information.

Moving beyond naïve information retrieval strategies

For systematic reviewers to move beyond naïve information retrieval strategies, they must anticipate questions likely to be confronted during the information retrieval phase of a systematic review. To assist systematic reviewers in this effort, pertinent questions raised and addressed in the C2 Information Retrieval Policy Brief are summarised below.

C2 policy states that reviewers are required to use a variety of strategies and sources to identify studies, and to have a systematic approach for the selection of studies for inclusion in the review. To ensure a high quality review, identification and retrieval of studies must extend beyond electronic searches of bibliographic databases. In doing so, there is an increased cost in terms of time and resources; therefore, search and retrieval activities must be budgeted for and documented.

Planning a comprehensive search of the literature

In no case is identification and retrieval of studies solely through electronic searching of bibliographic databases sufficient for a high-quality systematic
review. Furthermore, such reviews should not be limited to a search of sources that are free, low cost, easily accessible, or only in English. Systematic reviewers must make an honest attempt to identify and search all major sources of information that are potentially relevant to their review. This is necessary both to reduce the risk of bias and to increase the likelihood that most of the extant relevant data, both published and unpublished, is included in a review.

There are diminishing returns from this process, however, and there comes a point where the rewards of further searching may not be worth the effort required. The decision as to how much to invest in the search process depends on the question a review addresses, as well as the resources that are available, and should be made by the review team in consultation with an IS. Related to this, systematic reviewers should be aware that effective electronic searches of bibliographic databases and effective hand searches of primary sources require thoughtful planning up-front. Each type of search must be approached using different strategies because the organisation of information will differ, as will the terminology used within the different fields.

Developing an electronic search strategy is an iterative process in which the terms that are used are modified, based on what has already been retrieved. It is hoped that in the future, resources will be sufficient to allow each C2 review group to hire a Trials Search Coordinator who will be responsible for coordinating this activity. Until this occurs, however, it is important for the review group to work closely with an IS in deciding which sources to search and what search terms to use.

**Preparing search strategies**

A comprehensive search strategy will involve searching for multiple terms that describe the condition, intervention, and target population of interest. Since many, if not most, of the databases containing studies of interest to C2 reviewers do not index by study design, it is generally recommended to avoid searching with methodological terms (for example, ‘randomised controlled trial’) at this point.
Language and other potentially biasing limitations should, as far as possible, be avoided.

Once a substantive search strategy has been refined to the satisfaction of both the search coordinator or IS, and the reviewers, it should be executed, and the retrieved records downloaded into bibliographic management software such as ProCite, Reference Manager, Endnote or Refworks. Only after the reviewers are certain that the topic-based search strategy has yielded an appropriately high number of relevant studies can they attempt to filter studies for research design.

Consulting the grey literature

C2 policy states that reviewers must attempt to include unpublished as well as published studies in their reviews. In addition to a search of C2’s own database (C2-SPECTR), they should consult other general and specialised databases, journal articles, reference lists, the internet, conference proceedings, government documents, and other sources as appropriate.

Studies that are published informally, distributed through limited channels, or are difficult to retrieve through conventional channels (such as a library) are defined as grey literature (Cooper, 1998). These items include conference papers, research reports and policy documents. Locating and searching this literature is an important step in producing a systematic review, and C2 reviewers are expected, in consultation with the IS, to search systematically for such material. Ideally, reviewers should devise a search protocol to uncover and target the grey literature sources most likely to yield the highest number of studies to include in a review.

Hand searching

C2 policy states that the Coordinating group editorial team will decide when to include hand searching as part of a review, and will ensure that hand searchers are trained before they begin their work.
Electronic search strategies alone are inadequate for identifying primary studies and the more labour-intensive and time-consuming task of manually examining issues of a journal is necessary to identify the complete set of relevant primary studies in the literature.

There are a number of circumstances that determine whether a high-quality systematic review merits a hand search, including the review topic and available resources (time and money). It is the responsibility of the individuals undertaking the review to use their collective expertise and professional judgment, to decide whether to undertake a hand search. However, the decision calculus of systematic reviewers should include the finding from an unpublished study which showed that when it comes to identifying randomised controlled trials, an electronic search misses about two-thirds of the known RCTs identified by a hand search (Turner et al, 2003).

**Recommendations**

To summarise the main points of this section, the C2 Information retrieval policy brief advises C2 systematic reviewers, and others interested in producing high-quality systematic reviews, to plan for the implementation of a comprehensive search of both published and unpublished sources. It is, however, recognised that exhaustiveness, in the sense of locating every single potentially relevant study, is an unrealistic goal. The objective of this stage is to conduct a thorough search, to the extent possible given the resources of the project, with an emphasis on a core checklist of major databases and resources suitable to the given topic. Consulting the list of these sources within the Brief is a good starting point. The purpose of this advice is to maximise search coverage and minimise search bias such that as many as possible potentially relevant studies on a review topic are identified. The conceptual framework for a thorough and comprehensive literature search is depicted in Figure 1. The Brief strongly recommends that an IS be included as an integral part of the systematic review process, and the extent to
which this occurs depends on a number of factors including costs budgeted for the review.

To illustrate these main points, we turn now to specific examples using the actual information retrieval process for high-quality systematic reviews that are completed or in progress.

**The role of an IS within a review team: an example**

The Centre for the Study of Learning and Performance (CSLP) is a provincially funded research centre of excellence located in Montreal. Since the late 1980s, CSLP researchers have produced a number of systematic reviews on a variety of topics including computer-based instruction, instructional effectiveness, small group learning with technology, student ratings, within-class grouping and, recently, distance education. They are currently undertaking two large reviews, one on critical thinking and the other related to technology integration in schools. The CSLP’s Director, Philip Abrami, sits on C2’s Steering Committee, and both he and Robert Bernard (Professor, CSLP) are co-chairs of the C2 Education Coordinating Group. The CSLP’s IS acts as the Information Retrieval Methods Group liaison within the Education Coordinating Group.

In all CSLP reviews, the IS has been a key member of the review team, and this section of the paper explores how and why an IS enhances the quality of a systematic review in general, and a C2 review in particular. We elaborate on why the IS adds value to the review team, illustrating his or her role in the implementation of a review. Excerpts from both a CSLP review and a C2 protocol (or review plan) are used to provide examples of the specific points being addressed in this paper.

**The CSLP review team**

The CSLP review team is composed of faculty, graduate students, an IS and a
Library Assistant. The consideration of the IS as a review team member rather than as an external source of assistance reveals the level of importance that has been placed on information retrieval by this group, in keeping with the suggestion by White (1994). This approach is rarely taken by reviewers, who generally start to consider the issue of conducting searches after the research question and inclusion/exclusion criteria have been defined, and who often assign searching to a graduate student without adequate expertise or experience.

Conversely, at the CSLP, the IS attends all bi-weekly meetings and participates in the often lengthy discussions related to definitions, inclusion/exclusion criteria, methodology and other matters, with the goal of learning about the subject area. The IS provides input as necessary, suggesting, for example, which terms can be used in the searches, what differences exist in terminology among the different fields, what limits can be used to eliminate false hits, and so on. Additionally, these discussions provide the necessary context for the IS, so that when she or he conducts the searches, there is a thorough understanding of the key concepts and an effective strategy can be planned. The Library Assistant (an undergraduate student with experience in information retrieval) is also an important member of the team, responsible for managing and organising the search results within a bibliographic database. The Library Assistant also attends the bi-weekly meetings and communicates regularly with reviewers to keep them abreast of document retrieval activities.

**The information retrieval process**

As the review team works through the various stages of a systematic review, three phases of information retrieval also occur: preliminary searches; main searches; and final searches. These phases are viewed as an iterative process, which each serving to inform the review team differently. Accurate and complete documentation of the steps taken by the IS at each stage is necessary for two main reasons: (1) the documentation serves as a reference tool for the team by itemising the sources and strategies used as the review unfolds; and (2) this documentation
becomes part of the Search History component of the review’s codebook to enable future replication of the review.

**Phase one: preliminary searches**

At the beginning of the review process, as researchers define their key concepts and research question, the IS performs general searches in standard reference tools such as subject encyclopedias and subject thesauri as well as subject-specialised databases such as ERIC and PsycINFO to locate other reviews on the topic area that will help guide and inform the eventual decisions that are made.

The purpose of these preliminary searches is twofold. Firstly, they are investigative insofar as they serve to inform the eventual review question by taking a quick scan of the literature, and secondly they help to articulate the research question to be reviewed, thus providing guidance for the main searches to be performed at the next stage. For the investigative aspect of the preliminary search, previous systematic and literature reviews may be retrieved that will inform the review team about the state of the field on a particular topic, along with primary studies by key researchers in the field. Citation searches may also be performed to learn who has cited the key researchers in the topic area. All of these searches help the team learn what reviews on this topic have been done to date, when the last review was completed and whether there are the gaps in the research. They also provide an estimate of the number of primary studies that have been completed on the particular topic of interest.

For articulating the research question, a search through subject reference sources will help to define key terms within the research question, such as the independent and dependent variables. This process is critical as successful information retrieval depends upon the existence of a well-defined and clearly articulated review question (Rothstein, Turner and Lavenberg, 2004). For example, reviewers at the CSLP are in the second year of a review that addresses
the following research question: what instructional interventions, to what extent, and under what particular circumstances, impact on the development and effective use of learners’ critical thinking skills and dispositions? The team has spent a considerable amount of time grappling with the inclusion and exclusion criteria, given the difficulty of defining both the independent (treatment) variables and dependent (outcome) measures. Box 1, which is an excerpt from their codebook, provides a list of some of the sources consulted to aid in this endeavour.

**Box 1: Excerpt from critical thinking search history**

<table>
<thead>
<tr>
<th>Reference Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose:</strong> To obtain definitions for the terms; creativity, critical thinking, decision making, divergent thinking, convergent thinking, problem solving, reasoning, and higher order thinking.</td>
</tr>
<tr>
<td><strong>Sources consulted:</strong></td>
</tr>
</tbody>
</table>

The results of these preliminary, investigative searches will have a direct impact on the terminology that is to be used in the main searches.
Phase two: main searches

The main search phase is designed to locate all potentially relevant primary studies on the research topic, and is the most extensive, challenging, and time-consuming. It is during this phase that the IS must consult with the team on which information retrieval tools (including print, online and web-based) should be accessed, in which fields (including all relevant related fields), for which geographical regions (American, Canadian, British and so on) and for which time period. This is an especially difficult task within the social sciences, given the multi-disciplinary nature of most research questions. A review on a topic related to distance education for example, would require a scan of literatures in education, educational technology, psychology, applied science and technology, communication studies, business, sociology, and medicine.

It is vital to document and justify the decisions made at this stage so that the review’s stakeholders understand why certain retrieval tools or search strategies were used to locate the primary studies. A recent paper by Boaz, Solesbury, and Sullivan (2004) analysed 28 published reviews (narrative through to systematic) conducted in the UK from 2000-04 in an attempt to look at such issues as design, methods and reporting. Their findings revealed wide disparities in the reporting of decisions made in relation to search tools and strategies used, with some authors stating that “uncovering relevant material through searching is not straightforward (p 12)”. Some of the decisions made during the main search stage of the CSLP review are examined more fully below.

Selection of retrieval tools

The majority of primary studies will be located through the use of bibliographic databases, which contain a citation and an abstract for a record, or in full-text databases. Through consultation with the CSLP review team, the IS is responsible for deciding which databases should be consulted. The decisions taken will be guided by the nature of the research question (determining the
subject fields to be searched), the accessibility of databases at the institution, the scope of the review (for example, English-only versus inclusion of foreign language material), and the type of material to be included (for example, journal articles, dissertations, unpublished reports and other grey literature, and so on.). The use of key bibliographic databases in the social sciences such as ERIC (Education Resources Information Center), PsycINFO or Sociological Abstracts is critical as they provide the widest (although, in no case, comprehensive) coverage of different types of literature in their fields. For example, the majority include foreign language and non-journal material (such as theses and dissertations, conference proceedings, and books) and older material (for example PsycINFO indexes material from 1887 onward). Some databases, such as ERIC, also cover unpublished (grey) literature (such as conference papers, and reports). Strategies will need to be planned for each database to be searched given the differences in vocabulary across fields, and the search software used by different database suppliers.

**Preparation of database search strategies**

Once a list of databases has been compiled, sophisticated search strategies must be prepared. At this stage, the IS is faced with a number of challenges given the desire for yielding high precision and high recall in the search results.

White (1994) discusses the inverse relationship that typically exists between precision (the ratio of documents retrieved and judged relevant to all those actually retrieved) and recall (the ratio of relevant documents retrieved to all those in a collection that should be retrieved). Whereas most searchers want high precision with low recall, conscientious reviewers want both high precision and high recall to ensure thorough searches, with minimal bias (Rothstein, Turner and Lavenberg, 2004). Achieving this balance can be challenging and requires considerable expertise with database searching and experience with the search software used by different database suppliers. Search strategies need to be carefully constructed using a mixture of the controlled vocabulary (or thesaurus)
terms used to index documents and natural language (or free text) keywords that appear in titles and abstracts. The process will vary depending on the databases being searched. It should be noted that even given well-constructed search strategies, reviewers may often be faced with high recall and very low precision, resulting in the need to scan thousands of references to locate relevant items. This is due to weaknesses related to the indexing and abstracting of social science literature. For example, the controlled vocabulary may be used inconsistently within a database or it may not be well-developed; or the type of methodology used is not coded for by the database supplier, thus a searcher cannot retrieve a particular type of study such as a randomized controlled trial.

Some of the key decisions to be made at this stage are related to the following questions:

- What are the key concepts to be searched?
- How are these key concepts represented in each field?
- What are the related terms for these key concepts?
- How are these key concepts represented in the controlled vocabulary within each database?

To help answer some of these questions, the IS must consult the subject thesauri for each database to be searched in order to learn the specific vocabulary used to describe the subject content of the documents it includes. To help illustrate this process, the following example draws on a C2 protocol (or research plan) that Nye, Schwartz and Turner (2005) recently completed as a precursor to their review in progress on parental involvement. The purpose of this review is to assess the effects of parental involvement on the academic performance of elementary school age children. Box 2 presents an example of the terminology used for their ERIC search. Note that a mixture of controlled vocabulary and natural language terms is listed, with the use of a truncation symbol (the asterisk) to pick up variants of some terms (parent, parental, for example).
Box 2: ERIC example on parent involvement

Selecting Keywords and Descriptors for ERIC

- **Descriptors**: Parent Involvement See: Parent participation
- **Related descriptors**: Family involvement, Parent-school relationship, Parent-student relationship, Parent role, Parents as teachers
- **Related keywords**: parent* involvement, parent* effectiveness, parent* support, family support, family participation
- **Descriptors**: Academic Performance See: Academic achievement
- **Related descriptors**: Science achievement, Reading achievement, Literacy Achievement, Writing achievement, Achievement gains
- **Descriptors**: Elementary school children See: Elementary school students
- **Related descriptors**: Elementary education, Primary education, Kindergarten

A similar strategy would be used for every database consulted, but would need to be customised according to the controlled vocabulary used within each of them. Box 3 presents an example of the terminology used for the PsycINFO search. Note that, in this database (and in others) certain key concepts may also be represented in fields other than those for controlled vocabulary index terms, and natural language titles or abstracts. In this example, Key Concepts, Classification Code, or Age Group are fields within PsycINFO that contain relevant concepts.

Box 3: PsycINFO example on parent involvement

Selecting Keywords and Descriptors for PsycINFO

- **Descriptors**: Parent involvement See: Parent-school relationship
- **Related descriptors**: Parenting style; Parental role; Parents; Involvement; Participation
- **Key Concepts**: parental involvement; parenting practices; parental behaviors
- **Descriptors**: Academic performance See: Academic achievement
A constant dialogue between members of the review team is essential as search strategies and terms are adjusted on the basis of decisions that are made following the review of potential studies. For example, in the CSLP review on critical thinking, a broad search strategy that used related terms (such as decision making, problem solving, higher-order thinking and creativity) yielded too many false hits (low precision), resulting in the need to carefully define ‘critical thinking’ and subsequently narrow the search strategy.

Lack of consideration or poor decisions, or both, on these issues will weaken the pool of studies, as they will be unrepresentative of the population of completed studies, thereby resulting in a biased review (Rothstein, Turner and Lavenberg, 2004). Thus, there is a strong need for thoroughness and comprehensiveness at this stage, and the expertise of an IS is essential. Simply put, the use of incorrect terminology within a field can miss many relevant hits (low recall). For example, the concept of ‘distance education’ may be referred to in quite different ways in the fields of education, psychology, communication studies and business: potential variants include distance learning, e-learning, virtual learning, tele-learning, open learning, online learning, computer mediated communication, web-based learning, web-based instruction, open universities or virtual universities, and so on. By not identifying the correct terms within each field, one risks missing relevant studies.

Similarly, a common error by novice searchers is the use of redundant terminology within a given field and this may yield many unwanted hits (low precision). For example, using ‘education’ as a keyword within an education database such as ERIC, or ‘psychology’ as a keyword within PsycINFO, is likely
to produce many unnecessary records.

The IS’s experience using databases also relates to how a term is entered to ensure picking up all variant forms of the term. For example, a search for elearn* using the asterisk as a truncation character to retrieve ‘elearn’, ‘elearners’ or ‘elearning’ only yielded 37 records as shown in Box 4. An experienced searcher would not be satisfied with this result, knowing that there are bound to be more items within ERIC pertaining to this topic. In this example, the searcher also had to use a proximity operator, ‘near1’, to pick up the hyphenated term ‘e-learning’. Yet this still did not retrieve all the relevant records. Upon closer examination of the results and a scan of the subject fields, the Identifier ‘electronic learning’ was found (consultation of the ERIC thesaurus did not reveal this subject term because Identifiers are new terms, not yet listed in the thesaurus). The final set of retrieved records numbered 536. These advanced search strategies are lessons learned through extensive experience with database searching.

**Box 4: ERIC example for the term ‘e-learning’**

<table>
<thead>
<tr>
<th>Locating the Correct Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. elearn* (37 records)</td>
</tr>
<tr>
<td>2. e near1 learn* (459 records)</td>
</tr>
<tr>
<td>AU: Holstrom,-Lisa</td>
</tr>
<tr>
<td>TI: Eliminating Barriers for All E-Learners.</td>
</tr>
<tr>
<td>DE: *Access-to-Education; *Distance-Education</td>
</tr>
<tr>
<td>DE: Feedback--; Higher-Education; Literacy--; Low-Income-Groups; Skill-Development</td>
</tr>
<tr>
<td>IDM: *Barriers-to-Participation; *Electronic-Learning</td>
</tr>
<tr>
<td>IDR: Educational-Media-Use; University-of-Cincinnati-OH</td>
</tr>
<tr>
<td>3. (electronic learning) in DEM,DER,IDM,IDR (104 records)</td>
</tr>
</tbody>
</table>

**Final search statement:** ((electronic learning) in DEM, DER, IDM, IDR) or (e near1 learn*) or (elearn*) (536 records)
Construction of search statements

Some of the key decisions to be taken when formulating the search statements are related to the following questions:

- Which terms should be searched as controlled vocabulary or as natural language?
- What Boolean operators should be used and how should they be logically arranged?
- What limiting features are available to target primary studies only (for example, use of Document Type codes)?
- What time period should be searched?
- Will the search be limited by language?

Box 5 provides an example of some search statements for use in the ERIC database used in the review on parent participation. Note that a combination of descriptors (or controlled vocabulary) and free text (or natural language) terms have been used.

**Box 5: Searching within ERIC**

<table>
<thead>
<tr>
<th>Using Boolean Operators and Limiting Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 (Parent participation OR Family involvement OR Parent-school relationship OR Parent-student relationship OR Parent role OR Parents as teachers) in DE</td>
</tr>
<tr>
<td>#2 Parent* NEAR2 involvement OR Parent* NEAR2 effectiveness OR Parent* NEAR2 support OR Famil* NEAR2 support or Family NEAR2 participation</td>
</tr>
<tr>
<td>#3 #1 OR #2</td>
</tr>
<tr>
<td>#4 (Academic achievement OR Science achievement OR Reading achievement OR Literacy Achievement OR Achievement gains) in DE</td>
</tr>
<tr>
<td>#5 (Elementary school students OR elementary education OR primary education OR kindergarten) in DE</td>
</tr>
<tr>
<td>#6 #3 AND #4 AND #5</td>
</tr>
</tbody>
</table>

**Limiting commands:** Research reports (DTC=143)
In the majority of cases, search strategies will require the use of Boolean operators such as AND, OR, NOT; proximity operators such as phrase, NEAR, ADJ; truncation characters using a wild card character such as the asterisk (*) to search on a stem word; and limiting commands that restrict by date, language, publication type or document type. Consulting the Help features within each database will ensure the correct use of these operators. For example, truncation characters may differ across databases, proximity operators may not be recognised or may be entered differently, and so on.

Box 6 shows an example of how one search has been documented within the CSLP’s codebook for their review on critical thinking. Information includes dates (for example, coverage dates for the database, date the search was conducted), the reason why the search was performed, the number of items included from the total number retrieved, the code that was applied to records from this ERIC search within the in-house ProCite database, and the original search strategy.

**Box 6: Excerpt from critical thinking search history**

<table>
<thead>
<tr>
<th>ERIC search</th>
</tr>
</thead>
</table>
| **Database:** ERIC Database (1966-2003, June)  
Date search conducted: September 21, 2003; AW) | **Purpose:** To retrieve the first set of abstracts to be reviewed according to the current inclusion/exclusion criteria. |
| **Result:** Hit rate of 514/1520 | **Source code in ProCite:** ERIC1 |
| **Searches Strategy** |
| #5 #3 and #4 (1520 records) |
| #4 DTC = 142 or DTC = 143 or control group* (322893 records) |
| #3 #1 or #2 (7718 records) |
| #2 critical thinking in DE,ID (7562 records) |
| #1 thinking skills in DE and critical thinking (1269 records) |
**Non-database searches**

Once electronic searches have been conducted for each subject-specific and multidisciplinary database, secondary retrieval tools must be accessed to locate studies that were not picked up through the traditional methods (see Box 7). These methods include the following: searching some of the social sciences databases accessible from the Evidence Network website\textsuperscript{iv}, using web search engines to retrieve unpublished (or grey) literature that has been posted to the web, the scanning of bibliographies from other relevant review articles, conducting hand searches of key journals in the field or of conference proceedings, and consulting the C2 databases. Once again, careful documentation of the strategies and decisions taken are critical. For example, when hand searching, the IS should document what journals were consulted, for which dates, and what decisions were used to select relevant items. Similarly, search strategies and dates must be carefully documented for each search engine used when searching the web.

**Box 7: Consulting other sources**

<table>
<thead>
<tr>
<th>Secondary Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Database and web searches for grey or fugitive literature</td>
</tr>
<tr>
<td>• Scanning the reference section of review articles;</td>
</tr>
<tr>
<td>• Hand searches of the Table of Contents of key journals and conference proceedings;</td>
</tr>
<tr>
<td>• Personal contact: contact of key researchers in the field; and</td>
</tr>
<tr>
<td>• Consulting the C2 resources (e.g. SPECTR, RIPE)</td>
</tr>
</tbody>
</table>

**Phase three: final searches**

As minor revisions are made to the inclusion/exclusion criteria, or new keywords are discovered as the codebook is being developed, revised searches may have to be performed. Search strategies using Boolean operators may be used to eliminate hits from the previous search results, to avoid duplication of hits and the inefficient use of the review team’s time in scanning previously read abstracts.
For example, original search strategies can be saved within a database, a new search may be run and, through the use of the Boolean operator NOT, records from the original strategy may be excluded from the final set.

In addition, because the review process can take months, if not years, initial searches in all the databases will need to be run again to ensure currency of the review. Again, a systematic approach must be taken to avoid retrieving duplicate records from the previous search results. The careful documentation of the dates the last searches were performed serves to reduce redundancy in the updated search results.

These final searches usually occur as team members are extracting effect sizes and coding studies. Analysis of the results only occurs once all the searches have been completed.

As the primary studies are retrieved, they are forwarded to the review team for extraction of effect sizes and coding. The results of the coding are then transferred into a statistical analysis software package for further analysis. At all stages, the review team is in constant dialogue through bi-weekly and informal meetings. The status of the work by all members is conveyed, along with any challenges that have arisen. This coordinated and systematic approach by the entire review team has taken years to develop. Expertise in each of the various areas has been developed by the team members – and each CSLP review gets better each time. Most importantly, all members, including the IS, are seen to play a critical role in ensuring that a high quality review is accomplished.

**Other models for including the IS**

Another approach to information retrieval has been developed by the Cochrane Collaboration, whereby Trials Search Coordinators (TSCs) are hired to support the entire review process, either on a part-time or full-time basis, within
each of the fifty or so review groups. TSCs are trained information specialists. As discussed in the *Guide for Trials Search Coordinators* (Dooley and Herman, 2004), the responsibilities of the TSC may be divided into four categories:

1. **Support reviewers**: they assist reviewers with designing search strategies, providing advice about which databases to search, or they conduct the actual searches;
2. **Electronic searching**: the TSC identifies, collects and codes the primary studies through searches of databases in the health care sector;
3. **Hand searching**: the TSC organises the hand searches of journals, conference proceedings and other sources, to be conducted by volunteers or paid hand searchers; and
4. **Specialised register**: the TSC manages the group’s register of primary studies and transfers them each quarter to the CENTRAL database.

For those review groups with limited funding, the hiring of a full-time IS may not be feasible. The *C2 Information retrieval policy brief* states that at a minimum, review teams should collaborate with an IS or librarian to act as a resource during the main search phase. Each review group should also keep the Information Retrieval Methods Group (IRMG) apprised of their activities to ensure that they are heading along the correct path. Finally, each review group should designate one of its members as a liaison to the IRMG. Currently, the Education Coordinating Group (ECG) includes an IRMG liaison who participates in ECG training workshops at scholarly conferences, reviews the information retrieval component of review protocols, and attends bi-weekly ECG teleconferences.

**Financial considerations**

**Costs of systematic reviews**

The financial costs of a systematic review vary depending on the review’s
purpose, which can be driven by the interests of the researchers or by the interests and requirements of the client. The complexity of the research question being addressed will also be a factor. Although financial costs are an important arbiter of how thoroughly and comprehensively the reviews steps are implemented, there are very few concrete cost estimates reported in the literature. For reviews that address questions in biomedicine, Petrosino’s (as quoted in Rothstein, Turner, and Lavenberg, 2004), 1999 survey of a convenience sample of 21 Cochrane reviewers found the range of estimates to be between $500 and $78,155 UK.

For reviews that address questions in the educational, social, and behavioural sciences, the Nordic Campbell Center estimates that the eight stages in a C2 review require approximately 909 person hours for the review team and 228 persons hour of research assistant support. The cost of the review can thus be estimated using the billing rate of the review team members and the research assistants (Konnerup, personal communication, 2004).

Using the CSLP as another example, researchers from this body may be interested in conducting a review to answer a broad research question such as ‘What is the impact of technology use on student learning?’ Funds are then requested from a granting agency, typically for a three- to four-year research project, with an estimated CAN$150,000-$200,000 (UK£69,600-£92,800) budget. Often, the project involves the completion of a systematic review, along with a primary study designed to address an area revealed by the review to need further investigation. The review may take anywhere from two to three years to complete at a cost of approximately CAN$100,000 (UK£46,400).

**Costs of an IS**

The financial costs associated with the inclusion of an IS within a review team can be high given the need to hire a professional for the entire length of the project. Because all CSLP’s research projects (including systematic reviews) as well as infrastructure costs, are externally funded through granting agencies, the
cost of the IS has been incorporated in the Centre’s funding proposals. The salary of an experienced, full-time IS ranges from CAN$50,000-$75,000 (UK£23,200-$34,800) so review teams using this model for information retrieval may need to allocate a significant portion of the budget for this purpose.

From these few examples, one can easily see that including an IS as a member of a review team represents a considerable financial investment. However, two important issues should be pointed out. First, two or more reviews may be going on concurrently, thereby reducing the cost of an IS per review. Second, the quality of the reviews is significantly related to the comprehensiveness and completeness of the information retrieval process.

It is clear that international organisations such as the Campbell Collaboration and the Cochrane Collaboration, recognise the importance and value of consulting with an IS during the (un)systematic information retrieval stage of the review process. As Rothstein, Turner and Lavenberg (2004) recommend: “Shoestring-budget information retrieval is likely to introduce bias, and should be avoided.” (p. 11). If the recommended investment in an IS is not made, the costs to the field of scholarship may be even higher, with the potential for policy decisions based on evidence from these reviews being compromised or, even worse, being wrong.
References


Figure 1. Locating Evidence for a Campbell Collaboration Systematic Review: A Conceptual Framework

Note: C2- PROT is the Campbell Collaboration’s register of trials that are newly initiated or in progress.
# Appendix 1: The Eight Stages in a C2 Systematic Review

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Formulate review questions</td>
</tr>
</tbody>
</table>
| 2.    | Define inclusion and exclusion criteria  
  - Participants  
  - Interventions and comparisons  
  - Outcomes  
  - Study designs and methodological quality |
| 3.    | Locate studies – Develop search strategy considering the following sources  
  - The Campbell Sociological, Psychological, Educational, and Criminological Trials Register (C2-SPECTR)  
  - Electronic databases and trials registers not covered by C2-SPECTR  
  - Checking reference lists  
  - Hand searching of key journals  
  - Personal communication with experts in the field |
| 4.    | Select studies  
  - Have eligibility checked by more than one observer  
  - Develop strategy to resolve disagreements  
  - Keep log of excluded studies, with reasons for exclusions |
| 5.    | Assess study quality  
  - Consider assessment by more than one observer  
  - Use simple checklists rather than quality scales  
  - Handling of attrition  
  - Consider blinding assessors to authors, institutions and journals  
  - Assess randomization and power |
| 6.    | Extract Data  
  - Design and pilot data extraction form  
  - Consider data extraction by more than one extractor  
  - Consider blinding of extractors to authors, institutions, and journals |
| 7.    | Analyze and present results  
  - Tabulate results from individuals studies  
  - Examine plots  
  - Explore possible sources of heterogeneity  
  - Consider meta-analysis of all trials or subgroups of trials  
  - Perform sensitivity analyses, examine funnel plots  
  - Make list of excluded studies available to interested readers  
  - Examine process/implementation of interventions |
| 8.    | Interpret results  
  - Consider limitations, including publication and related biases  
  - Consider strength of evidence  
  - Consider applicability  
  - Consider statistical power  
  - Consider economic implications  
  - Consider implications for future research |
Notes

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1 To learn more about C2, visit the website at http://www.campbellcollaboration.org
2 C2-SPECTR is C2’s web-accessible Sociological, Psychological, Educational, and Criminological Trials Register, and houses completed trials, or possible trials, in these areas of inquiry.
3 The C2 Hand search manual will soon be made available on the C2 website.
4 See Evidence Network website at http://www.evidencenetwork.org