

The Steps to Doing a Systems Literature Review (SLR)

A systemic empirical approach to literature reviews

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ABSTRACT: Literature reviews are an important part of research as they precede a doctoral dissertation, a master's thesis, a policy paper with recommendations, a single scientific publication, a white paper, a research project of any kind, or just as a stand-alone reconnoitering of a given field or topic with the goal of understanding. Building off of previous efforts of Boote and Biele [1] and PRISMA [2] and applying a systemic approach (DSRP), this paper proposes a new step-wise process and evaluative rubric called Systems Literature Review (SLR). The purpose of SLR is to transform a haphazard and relative (non standardized) process into a more systematic effort that yields a literature review which is, itself, an empirical contribution to any field.

KEYWORDS: literature review | empirical object | systems thinking | systems science | systems literature review | SLR | Keyword | Keyword | Love Reality Loop |

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Why Do A Literature Review?

Literature reviews are an important part of research as they precede a doctoral dissertation, a master's thesis, a policy paper with recommendations, a single scientific publication, a white paper, a research project of any kind, or just as a stand-alone reconnoitering of a given field or topic with the goal of understanding. With the exception of this last option, all of these goals require (in the spirit of science and building upon prior knowledge) future work (knowledge) to be grounded in the past work (knowledge) that has been done. This is the power and promise of a well-executed literature review. Unfortunately, very few literature reviews are executed well. This may be a function of the name: "literature review"—a term that, at best, sounds like a long, painful march through endless texts. The truth is, a literature review should be far more than an "haphazard inventory" of the field which does not constitute an empirical contribution. It should be a deep *analysis* and synthesis of the current state of knowledge in a topic, field, or domain. It must include a representative *sample*, and should be *systematic*, *transparent*, and *replicable*. If done correctly, literature reviews can be empirically grounded, stand alone contributions to the field.

This paper introduces a *Systems Literature Review* or SLR, and outlines the procedural steps and a rubric for applying a systems thinking (DSRP) [3,4] lens to the literature review process. Only when literature reviews are done *systematically*, using mixed methods, and in such a way as to result in a synthesis that summarizes the ‘condition of knowledge’¹ in the field do they reach their potential as an empirical contribution. A Systems literature review moves beyond an inventory of the relevant research, to also highlight the overarching themes, places of substantive disagreement and agreement, the problems, open questions, methodologies applied, significance, disciplinary contributions, and knowledge gaps in a given field. In other words, the systematic literature review can stand on its own as an empirical contribution to a body of knowledge. Additionally, a systematic literature review provides a synthetic snapshot of the condition of knowledge that is foundational to the design of future studies that will contribute to the field. This paper will outline, at the tactical level, the steps in a systematic and mixed method approach to completing a Systems Literature Review (SLR). SLR has four major steps:

- **Coverage:** identify a transparent sample of the literature;
- **Analysis:** identify what the literature says in part;
- **Synthesis:** identify what the literature says as a whole; and,
- **Grounding:** connecting the past literature to future work.

Transparency and the Researcher’s Journal

The first step in the process of any research is to establish a researcher’s journal. Principal in all scientific processes is transparency. A journal captures easily-forgotten decisions that the researcher makes during the process and can be done in any medium from a notebook to an online document. In the examples provided throughout this paper, the authors used a combination of a google document and spreadsheet (with multiple tabs). The research journal enables the researcher to translate their notes, which will be especially helpful during the writing process to explain the decisions they made, criteria selected, and threats to validity, etc.

¹Condition of knowledge is the state of the research and knowledge within a field. It is typically characterized along the Y-axis as stages (Nascent, Intermediate, Advanced) with an orthogonal X-axis that illustrates the types of methods applicable at each stage. [5]

An SLR transforms a traditional literature review to an empirical artifact characterized by transparency and replicability that is as comprehensive as possible given the [transparent] parameters chosen. Notably, an SLR also: includes mixed (quantitative and qualitative) measures of analysis and synthesis; analyzes each element (publication) of the literature individually; and, importantly, arrives at a synthetic and systematic set of conclusions about the existing condition of knowledge on the topic. This synthesis is a foundation on which to build new research, hypothesis, or policy recommendations.

Coverage: A Transparent Sample of the Literature

Coverage establishes a boundary between what is, and is *not*, included in the literature review. Coverage is determined by the type of search (scholarly, public, hasty, AI) conducted, the key search terms used, where the search will take place (databases), and the criteria for inclusion (criteria).

Types of Search

One could argue that search is the most important part of the literature review because the publications that are included shapes the entire analysis and synthesis generated by the researchers about the field. This is why it is recommended that multiple types of search are done in a single SLR. The Systems Literature Review (SLR) outlines three types of searches: scholarly, public, and hasty.

- **Scholarly:** The scholarly search is used to get a sense of the scientific community's perspective on the topic of interest.
- **Public:** The public search is used to understand the general population's perspective on the topic of interest.
- **Hasty:** The hasty search is used to ensure that publications crucial (Seminal or highly cited) to the overall understanding of the topic are not overlooked.

It may seem excessive to do three separate types of search for one topic. However, using only one type of search subsequently limits the inventory of publications that the review or research project includes. This results in an incomplete view of the existing knowledge in a given field. Thus, performing all three types of search, leads to a *more complete* view of the literature. This

leads to the researcher understanding their questions better from new perspectives, and therefore gives the researcher a comprehensive view of the field as a whole.

Create a Search Selection Process

The next step in any literature review is to set up the search which includes (1) identifying the specific search terms relevant to the research question, (2) deciding which databases will be used to find the publications, (3) organizing where papers that will be part of the literature review will be stored, and (4) coming up with the criteria that will be used to narrow the search results.

Selecting Search Terms

Selecting the search terms is an important step in the literature review process, as identifying the right search terms means that the search will provide papers that are relevant to the topic of interest. Depending on the length of the literature review it is recommended to have between 3-8 different search terms to use. Note that selection of search terms is the moment where the boundaries of the research are set forth as both a frame for inquiry; and a boundary drawn of where the search will stop. It is at this stage that the researcher is applying “fropping” rules² - the perspectival frame and the stopping criteria for the literature review. Without this crucial step, the literature review process can become too large and unwieldy. Fropping helps to narrow the focus of the search, and is essential to controlling the breadth and depth of the publications considered for inclusion in the SLR.

The first thing to consider in selecting search terms is the research question(s). For example, a literature review on discovery set forth the following research questions:

1. What is discovery both scientifically and in popular culture?
2. Are there existing mathematical models on discovery?
3. What is the state of the research on discovery?
4. How are discovery and innovation related?

² “Framing Rules + Stopping Rules = Fropping Rules; parallel mental models that govern how your analysis proceeds and when to stop [6].” Fropping rules are a part-whole system (S) of ideas that are used as a perspective (P) (e.g., an S to P jig) on the mapping of any system.

Taking these research questions into consideration, the following search terms were generated, as outlined in Figure 1.

discovery	discovery
discovery research	discovery research
discovery and innovation	discovery and innovation
discovery equations	discovery equations
discovery dynamics	discovery dynamics
mathematics of discovery	mathematics of discovery
innovative discovery	~~innovative discovery~~
what is discovery?	~~what is discovery?~~
discovery math	~~discovery math~~

Figure 1: Initial Search Terms for Discovery and their evolution

Figure 1 shows which terms were and were not useful—as indicated by the red strikethrough. Isolating the terms that don't work often happens after they have been input into a database and yield results that are either minimal or unrelated to the framing question. This is the case for "Innovative Discovery." Once it was put into the database, the publications returned were on innovation, not discovery. So that search term is cut. Note also that typing a research question into most types of databases is not recommended. (There is a specific type of database where it is encouraged to type out the research question which will be discussed later). As a result, "What is Discovery?" is also cut from the list. Lastly, when searching for publications using "Discovery Math" as a search term, the engine returned very few low-quality results.

There are 7 remaining individual search terms that collectively will address the proposed research questions. Keep in mind that transparency is key in an excellent literature review, so keep track of which terms are cut and kept, as it may become a part of the final write-up later.

Select the Databases

The database used to perform the search determines the quality and scope of the publications selected. It also depends on which databases you have access to. Depending on the "fropping" rules of the literature review, one or multiple databases could be used. If possible, an academic (e.g. Cornell Library) database is the best option for the scholarly review. The breakdown of the databases used for the Discovery literature review is shown in Table 1.

Database	Type	Benefit	Recommended Search Type
Google Scholar	Academic/Accessible	Accessible to anyone. A generally high quality collection of publications. Has the ability to search for just literature reviews as well.	Scholarly review Hasty review (most cited)
Cornell Library	Academic	High quality large collection of papers. Gives access to many paywalled journals. Has the ability to filter out only peer-reviewed papers.	Scholarly review Hasty review (most cited)
Elicit	Artificial Intelligence	An AI website that allows you to plug in your research question and it returns highly relevant papers. Should not be used on its own.	Scholarly review
chatGPT	Artificial Intelligence	An AI website that allows you to ask questions and receive answers from an AI with a vast training corpus	Popular review Hasty review
Google (or other search engine)	Search Engine	A popular search engine for resources accessible to the general public	Popular review Hasty review

Table 1: Breakdown of Recommended Databases.

A critical step of the search process is deciding the parameters for databases to use. For example, an often-used parameter for scientific papers is to only include peer-reviewed publications from academic journals. You may want to include a “Popular Search” parameter to explore what the construct of study means in the general public. The parameters chosen depend on the purpose of the literature review (e.g., scientific study? policy analysis? publishable paper?) and the topic of focus (e.g., quantum entanglement may not require a popular review but perceptions of quantum entanglement or leadership does). Additionally, “convenience parameters” can be chosen based on the amount of time available to complete the literature review or the resources available (i.e., an individual on a two-week deadline on a shoestring budget will be quite different from a team of researchers, a 6 month deadline and a \$100,000 budget). These parameters serve to expand or limit the number of papers for consideration. Generally speaking, this stage of the process of literature review will inevitably need to be limited because the databases will likely return millions of papers, and it is not feasible to review them all. This leads to a need for selection criteria for inclusion and exclusion in the literature review.

Set Selection Criteria

The levels of review determine which papers ‘survive’ and are included in the final review. It is essential to keep track of the papers that are cut and at each level of review. This will be included in the final literature review. There are many possible selection criteria, or combinations of selection criteria that can be used. For example, any combination of the following can be used as selection criteria:

- Number of citations meets some threshold (i.e., popular papers);
- Search order (for hasty or public searches);
- Time limitations (number of papers that can be digested in allowable time period);
- Snowball or network sample (i.e., start with highly cited and move to bibliographies);
- Relevance (some criteria for determining relevance of an individual paper (see “levels” below); and/or
- Original sources (for historical, seminal analysis).

An example of the levels of review for relevance are explained in Table 2.

Level of Review	Acceptance Criteria	Exclusion Criteria
Title	The title of the paper is relevant to the research question(s).	The title is not relevant, uninformative, or unclear.
Abstract	The abstract of the paper is relevant to the research question(s).	The abstract is not relevant, explores a different aspect of the topic than intended, or demonstrates insufficient methodology.
Full Text	The full text of the paper is relevant to the research question(s).	The full text is not relevant, explores a different aspect of the topic than intended, or demonstrates insufficient methodology.

Table 2: Breakdown of the Levels of Review.

Regardless of the selection criteria chosen, the most important part is clarity about what the criteria are and being transparent in the literature review of how the sample was selected. Be sure to jot down criteria as they evolve in the researcher's journal so they are captured in the notes used when writing up the paper.

Fropping Rules

The sections above (types of search, search terms, databases, and criteria) provide a set of dropping rules (framing and stopping) for establishing the sample that constitutes "coverage" of the literature. We can think of the collection of these dropping rules as a perspective, based on which items in the literature are included in the sample and items that are not. Using a DSRP [3,4] Systems Map as shown in Figure X, we see the perspectival point (the dropping rules used) and the view (the elements included and not included in the sample as a result).

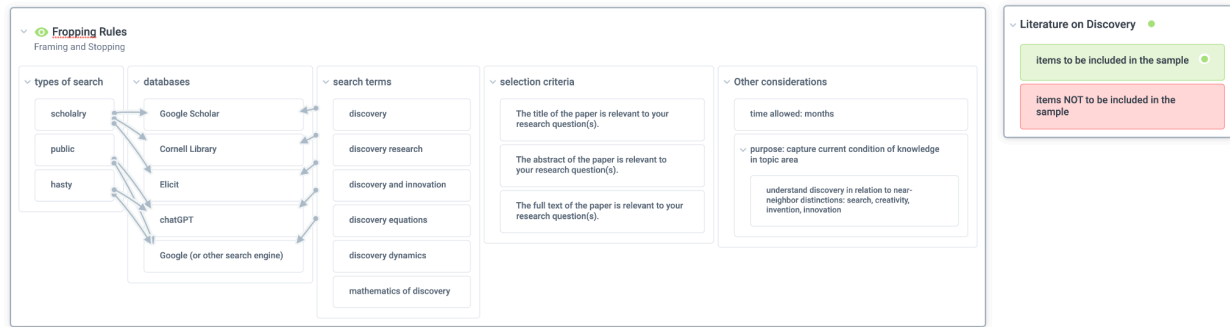


Figure 2: Fropping Rules in DSRP Systems Map

Organization of Publications

The way in which the selected publications are organized may seem unimportant and mundane, but it is not. There will likely be many resources gathered during the search process and it is crucial to this review to organize them in a way that allows one to remember which database they are from and which search term was used. This will be important later. Figure 3 shows an example of how to keep files organized (where each bullet is a Google folder).

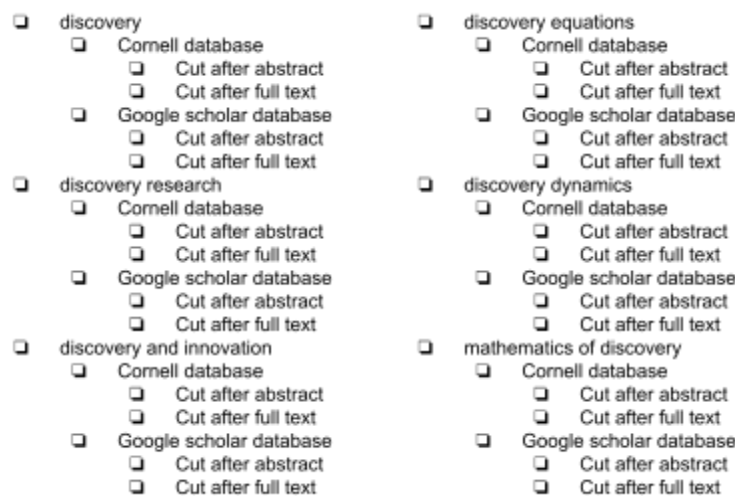


Figure 3: The publications are first organized by search term (in Google folder), then split into databases, lastly, separated by the levels of review³.

³ Note that Elicit and the Hasty Scholar Search are on the top level. They are separate as they used different search terms than Google Scholar and Cornell Library and needed to be organized slightly differently.

Do The Search

Performing the search is where all the above pieces come together. Go to the previously selected database(s) and input the first search term. Download all the papers that pass the first level of review and organize them into their designated folder. Repeat those steps for all of the selected search terms. Then, go through each folder and see which papers pass the second level of review. Then the third. Now all of the sources for the literature review have been selected. Do not get rid of the papers that didn't pass the second and third levels of review. Keep them in a folder for later.

Count the Search

Including a quantitative element in your literature review compliments the qualitative features of the review and increases transparency and replicability. The next step of the SLR utilizes the PRISMA [2] method as part of search and selection. The sources gathered do not have to be read to do this step. All the PRISMA section requires is the documentation of the search process above. This can be done as simply as a table. See Table 3 for an example from the Discovery literature review. This table shows the search data from the Cornell Library database.

Scholarly Search								
Search Term	"discovery"	"mathematics of discovery"	"discovery equations"	"discovery dynamics"	"discovery research"	"discovery science"	"discovery and innovation"	Total
Total Items returned	4,491,379	242,825	580,818	1,305,919	3,281,438	2,985,143	553,987	13,441,509
Top 50	50	50	50	50	50	50	50	350
Articles with Relevant Titles	21	6	13	13	10	17	22	102
Articles with Relevant Abstracts	11	4	7	10	8	17	20	77
Number of Articles Selected for Full Review	3	1	2	1	2	4	3	16

Public Search			
Search Term	discovery	Scientific discovery	Total
Total items returned	2,860,000,000	761,000,000	3,621,000,000
Items Selected based on Top 10 Pages	0	10	10
Items Selected based on Top 10 Books	0	10	10

Hasty Search					
Search Term	Top scholars in discovery	Seminal discovery scholars	Most cited papers in discovery	Discovery Research Labs	Total
Total scholars selected	0	2	2	1	5
Number of Articles Selected from Publications	0	2	2	2	6
Number of Articles Selected from Cited Works	0	0	2	0	2

Table 3: Example PRISMA Table from the Cornell Library Database

Be sure to make one table per database used to increase transparency. Different databases have different numbers and types of publications available, so keeping track of each database separately allows for minimal confusion for both the reader and the researcher. The more transparent one is about the search process the better. It is critical to end the PRISMA section with a paragraph on specifically why publications did or did not make it past certain levels of review.

"The titles that focused on the broader and cognitive aspects of discovery and/or the relationship between discovery and innovation were moved to the next round of review in which the abstracts of the selected articles from the first round of review were considered with a specific focus on the scope and context of the study. For this phase of the review process, the authors specifically looked for an indication that the article focused on the methods used in studying discovery, as well as an interest in the process of discovery, rather than just the impact discovery can have on an environment/stimulus/participant. While some articles on their face presented as being focused on the impact discovery can have on an environment/stimulus/participant, upon reading their full text, there was an underlying focus on the fundamental characteristics of discovery. This led to a few of those publications being included in the review."

Again, transparency is a key part of the Systems Literature Review.

Public Search (Popular)

The next (optional) thing to do is to perform and write up the Popular PRISMA Search. This search identifies the general public's understanding of the research topic of interest. How the public understands a scientific or research topic signifies the state of the research in terms of its value to society as a whole. It is important to get this perspective, as it is often neglected. The Applied PRISMA Search occurs in several steps: first, input the general research topic into a Google query. For the Discovery literature review, this was done by searching for "discovery. in Google. This yielded a significant amount of unrelated results, so the research term was adjusted and then "scientific discovery" was searched in Google. The Top 10 results⁴ should then be put into a table. Next, a search for the top 10 books in the research topic should be done. In this example, the top 10 books in scientific discovery on Google were identified. Those books should be put in the table as well, as shown in Table 4.

⁴ Note to exclude any dictionary websites with definitions of the term.

Rank	Websites	Books
#1	Nobel Turing Challenge: creating the engine for scientific discovery	Science in the Soul: Selected Writings of a Passionate Rationalist - Richard Dawkins
#2	Science News - Latest Scientific Discoveries	Obsessive Genius: The Inner World of Marie Curie - Barbara Goldsmith
#3	The Top Ten Scientific Discoveries of the Decade Science	The Invention of Nature: Alexander Von Humboldt's New World - Andrea Wulf
#4	Seven Scientific Discoveries From 2022 That May Lead to New Inventions	The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars - Dava Sobel
#5	What Are The Greatest Scientific Discoveries Of All Time?	Wonderful Life: The Burgess Shale and the Nature of History - Stephen Jay Gould
#6	Five Inspiring Scientific Breakthroughs From 2022	The Discoveries: Great Breakthroughs in 20th-Century Science, Including the Original Papers - Alan Lightman
#7	Discovery: The spark for science - Understanding Science	The Logic of Scientific Discovery - Karl Popper
#8	10 recent scientific breakthroughs - The Week	What the Future Looks Like: Scientists Predict the Next Great Discoveries—and Reveal How Today's Breakthroughs Are Already Shaping Our World - Jim Al-Khalili
#9	These are the top 20 scientific discoveries of the decade	The Fossil Hunter: Dinosaurs, Evolution, and the Woman Whose Discoveries Changed the World - Shelley Emling
#10	Where Are All The Scientific Breakthroughs? Forget AI, Nuclear Fusion And mRNA Vaccines, Advances In Science And Tech Have Slowed, Major Study Says	A Short History of Nearly Everything - Bill Bryson

Table 4: Example of Public PRISMA on Discovery

Be clear about what resources were included, and why. Then analyze and synthesize what was found. Take this paragraph from the discovery literature review as an example.

"Note that Wikipedia results as well as dictionaries and thesauruses were excluded from the top ten results selected. Additionally, results for the Discovery television network were excluded, as it was not the intended meaning of the word 'discovery.' However, even though this adjustment was made, it is clear that when a member of the general public searches for 'discovery' they do not find resources on the idea of discovery. So, the authors decided to switch their search term to 'scientific discovery.' Once this change was made, the results returned were far more relevant to the topic at hand. These results were primarily about describing scientific discoveries and breakthroughs. There were very few resources on discovery itself or how to discover. To wrap up the Applied PRISMA Search, the top ten books on discovery were found via searching for 'scientific discovery' in Amazon Books and then sorting the list by most reviews. The books are listed in the right column of Table

4. The top ten books focus more on discoveries than discovery itself. Most of the books are rooted in science. The contrast between the applied PRISMA search and the sources found on discovery from just the PRISMA search is stark. This will be easily seen in the Synthesis of the Literature section of this review."

Hasty Search of Scholars

The third type of search needed is a 'hasty' search of the prominent scholars in the field. The 'hasty' search method is adapted from a search and rescue strategy used in natural disasters and traumatic events. In the scholarly and popular search types, the search process is careful and methodical. Both methods share the downside of narrowing the focus and attention of the search process itself. This is where the hasty search method comes in. The hasty search is meant to be quick, rough, and random. By focusing on the related scholars, this search prevents a researcher from diving deeply into relativity and missing Einstein. By doing both a methodical and a hasty search, the researcher ensures that they are getting the fullest picture of the literature of a given topic as is possible. A hasty search is difficult to perform. This is why the search should be timeboxed at no longer than an hour.

A hasty search begins with an online search to find the top 5 (or so) scholars in the area of interest. They can be the most up and coming scholars in the field, the most seminal scholars, or the most popular scholars doing current research in the field of interest. They can be chosen based on the number of citations, people running the most prestigious labs on the topic, and so forth. It is a relatively subjective endeavor when compared to the other search types, so an SLR explains why the scholars were included in the top 5 list. After identifying the scholars, their publications need to be considered and then selected if they would contribute to the literature review.

The final step of the selection process is to examine each scholar's citations of publications and identify any that would also contribute to the literature review. This data is represented in a table for the Discovery literature review, as shown in Table 5.

Scholar	Affiliation	Number of Articles Selected from Publications	Number of Articles Selected from Cited Works
Dr. Gerald Holton	Harvard University	1	0

Dr. Kevin Dunbar	University of Maryland	1	1
Dr. Lorenzo Magnani	University of Pavia	1	1
Dr. Norwood Hanson	Yale University	1	0
Dr. Thomas Nickles	University of Nevada, Reno	2	0

Table 5: Example of Notable Discovery Scholars

Track The Data

Tracking variables of each included publication is a critical step of the SLR process, as this data will be essential to the synthesis of the field later on in the process. The review process of each publication should include tracking a number of variables in a spreadsheet. For the Discovery literature review, the variables that were tracked included:

1. Title;
2. Author;
3. Summary of Text;
4. Discipline;
5. Methodology; and
6. Statistical Significance.

Any other relevant data points can also be included as applicable. It is recommended that 1-6 above are included. Figure 4 provides a sample tracking spreadsheet. In Figure 4, Column C comes from the summary paragraph that is written about each publication that will be discussed later on in this paper.

Publication Title	Authors	Summary of Text	Discipline	Method	Statistical Significance
Causal discovery for fuzzy rule learning	Kunitomo-Jacquelin et al.	Causal discovery is a common method in the discipline of information science. There are three main types of causal discovery. The first is the functionally causal model (FCM), the second is constraint-based (CB), and the last one is score-based (SB).	Mathematics	Modeling	No
Kernel-Based Causal Discovery in Large Time Series Datasets	Liu et al.	Fields such as neuroscience and computer science are becoming increasingly interested in the utility of casual discovery.	Information Science	Modeling	No
The Idea of a Logic of Discovery	Hanson	Discovery can and should be rooted in logic.	History of Science	Theoretical	No
Preregistration of exploratory research: Learning from the golden age of discovery	Dirnagl	Discovery and confirmation are often used interchangeably, when they are not the same thing. Many publications claim to have discovered a concept or mechanism and to have confirmed it within the same publication. This is not possible. One cannot use the same data to discover a thing to confirm it as well.	Biology	Theoretical	No
Inseparability of science history and discovery	Herndon	Through the observation and research of the history of science, patterns emerge that give insight into the discovery process.	History of Science	Theoretical	No
The Methodological Study of Creativity and Discovery -- Some Background	Meheus and Nickles	Explored the history of Discovery research.	History of Science	Theoretical	No
Competition as a Discovery Procedure	Hayek	Competition is a mechanism for discovery. Discovery in science is in the business of discovering facts about the world and reality, whereas discovery in competition is designed to discover temporary situations and solutions to a problem.	Business and Economics	Theoretical	No
Knowledge Discovery in Databases: An Overview	Frawley et al.	The ability to discover new information is crucial for researchers, both scientific and entrepreneurial. The use of various discovery methods in research demonstrates the role discovery plays.	Computer Science	Theoretical	No

Figure 4: Example of spreadsheet tracking the data on each publication included in the Discovery Literature Review.

At this point, a review has been conducted, but the literature included has not yet been analyzed, summarized, or synthesized to indicate the condition of knowledge in the subject of interest. In other words, an inventory of publications may have been created, but it has not yet contributed to the research questions or the scientific community as a whole. To do so, one must complete the next steps in an SLR: to analyze, summarize, and synthesize the literature.

Analysis: What the Literature Says In Part

Now that a set of search parameters have been developed and publications and resources to be included in your review (aka, "Coverage") have been identified, the next step is analysis. Analysis involves carefully reading and reviewing each publication and creating an inventory of each publication's main points, themes, findings, and methods. Each publication is summarized as an element in the inventory of the literature review.

Below is an analytical summary of one publication in the discovery literature as an example. The analyses section would include a description for each included publication in the sample.,

"Ippoliti (2020) [7] researched the progression of insights on scientific discovery over time. Discovery has been related to evolution, logic, methods, and inference. Theories of discovery have been created over time, such as

the evolutionary discovery theory, deductive discovery theory, and the cognitive discovery theory. As time progressed, scientists have found more novel ways to practice the art of discovery. Ippoliti (2020) states that the scientific community is in a “scientific discovery revolution” at the moment, which is, “not only a new way of looking at discovery, but also a construction of tools that can guide us to discover something new [7].” With all of the new materials in discovery, scientists have the opportunity to improve upon the act of discovery itself, the tools used to measure it, and the way the general populace understands discovery. Ippoliti’s research comes from the field of psychology and is hypothetical in nature (that is, it is not empirical, has no research design or methodology, and therefore no statistical findings of significance). (Cabrera et al. 2023)”

Note that the narrative write-up of a particular publication is written using the elements in the row of the spreadsheet for said item, shown in Figure 5.

Publication Title	Authors	Summary of Text	Discipline	Method	Statistical Significance	Category [Main]	Category [Sub]	Relationship(s)?
The Incomplete Guide to the Art of Discovery	Oliver	There is no universal recipe for discovery. There is no guaranteed route to discovery. The scientist who seeks to discover must follow a course that cannot be fully defined or anticipated.	History of Science	Theoretical	No	Discovery Measurement and Research	Definitions/Processes	N/A
Towards an Explanatory and Computational Theory of Scientific Discovery	Chen et al.	Discoveries that described the emergence and evolution of a field in some way tend to be the more high-profile and impactful scientific discoveries.	Computer Science	Mixed Methods	No	Discovery Measurement and Research	State of the Field	N/A
Discovery, invention, and development: Human creative thinking	Simon	The element that distinguishes discovery from creativity is the a-ha moment that a scientist has that leads to a breakthrough. There is an element of surprise or chance involved with discovery.	Psychology	Theoretical	No	Discovery Measurement and Research	Definitions/Processes	Creativity
Scientific Discovery Reloaded	Ippoliti	With all of the new materials in discovery being discovered, scientists have the opportunity to improve upon the act of discovery itself, the tools used to measure it, and the way the general populace understands discovery.	Psychology	Theoretical	No	Discovery Measurement and Research	State of the Field	N/A
How a Scientific Discovery Is Made: A Case History	Holton et al.	More attention should be paid to past discoveries, as they can give vast insight to how to have future scientific discoveries.	History of Science	Theoretical	No	Discovery Measurement and Research	State of the Field	N/A

Figure 5: Using the Spreadsheet as a guide to building the Narrative Synopsis for Each Element.

Synthesis: What the Literature Says As A Whole

After reading the publications as the source material for the literature review, it is time to synthesize all the literature. The synthesis stage of the literature is the author’s original contribution to the field. Up until this stage, the author has collected a sample of publications and stated what each individual publication says (analysis), but not what *they* say as a whole (synthesis). *This synthesis—what the literature on a topic says as a whole—is the crux of a truly excellent literature review that itself is a contribution to the field.*

It is clear from the SLR Rubric that a useful and transformative literature review would receive scores of threes (and one four) when measured against the rubric shown in Table 6.

Systems Literature Review (SLR) Scoring Rubric

Criterion	1	2	3
A. COVERAGE - Justifies sampling			
A1. Justified criteria for inclusion and exclusion from review.	Did not discuss the criteria inclusion or exclusion	Discussed the literature included and excluded	Justified inclusion and exclusion of literature
A2. Utilized diverse set of search types (scholarly, public, hasty) to capture diversity of coverage	Did not use different search types but should have	Used the right search types for the topic	Used the right search types for the topic and justified their use
A3. Justified appropriate databases for search types	Did not justify database choices	Justified database choices	Used the right databases for the topic and justified their use
A4. Justified search terms for different databases	Did not explicate or justify search terms	Search terms are explicit and justified	Search terms are explicit and justified and evolution of choices is explicit
A5. Justified selection selection criteria	Did not explicate or justify selection criteria	Selection criteria are explicit and justified	Selection criteria are explicit and justified and evolution of choices is explicit
A6. Included quantitative metrics (PRISMA) showing search and selection process	Did not use standardized (PRISMA) analysis	Did use standardized (PRISMA) analysis	Did use standardized (PRISMA) analysis and provided explanatory narrative
B. ANALYSIS - accurately details what individuals in sample say			
B1. Provided a clear, concise inventory of each publication's thrust, main points, themes, findings, and methods	Did not cover each individual publication in the inventory	Did cover each individual publication in the inventory	Provided publication's thrust, main points, themes, findings, and methods for each publication in the inventory,
C. SYNTHESIS - accurately details what sample says as a whole			

C1. (Disciplinary Synthesis) If necessary, provided a synthetic view of the disciplines involved in the research.	Did not provide a disciplinary synthesis.	Provided a review of disciplines per publication.	Provide a review of disciplines per publication and a summarizing synthesis of its meaning and implications.
C2. (Methods Synthesis) Identified the main methodologies and research techniques that have been used in the field, and their advantages and disadvantages.	Research methods not discussed	Some discussion of research methods used to produce claims	Critiqued research methods and/or Introduced new methods to address problems with predominant methods
C3. (Variable Synthesis) Articulated important variables and phenomena relevant to the topic.	Key variables and phenomena not discussed	Reviewed relationships among key variables and phenomena	Noted ambiguities in literature and proposed new relationships
C4. (Vocabulary Synthesis) Acquired and enhanced the subject vocabulary.	Key vocabulary not discussed	Key vocabulary defined	Discussed and resolved ambiguities in definitions
C5. (Thematic Coding) Identified themes across literature by systematically coding inventory of publications	Did not perform thematic coding	Provided a thematic coding of aggregate themes.	Provided a thematic coding of aggregate themes and a summarizing synthesis of its meaning and implications.
C6. Synthesized and gained a new perspective on the literature.	Accepted literature at face value	Some critique of literature	Offered new perspective
D. SIGNIFICANCE - places research, policy, or project in context of previous work			
D1. (Historical Context) Placed the research in the historical context of the field and identified seminal works.	History of topic not discussed	Some mention of history of topic	Critically examined history of topic
D2. Placed the topic or problem in the broader scholarly literature.	Topic not placed in broader scholarly literature	Some discussion of broader scholarly literature	Topic clearly situated in the broader scholarly literature
D3. Distinguished what has been done in the field from what needs to be done.	Did not distinguish what has and has not been	Discussed what has and has not	Critically examined the state of the field

	done	been done	
D4. Rationalized the practical significance of the research problem.	Practical significance of research not discussed	Practical significance discussed	Critiqued practical significance of research
D5. Rationalized the scholarly significance of the research problem.	Scholarly significance of research not discussed	Scholarly significance discussed	Critiqued scholarly significance of research
D6. Justified the relationship between current condition of knowledge and methodological choice (K-MMM).	Does not justify the relationship between method and condition of knowledge.	Justifies the relationship between method and condition of knowledge.	Justifies relationship between method and condition of knowledge and is accurate in assessment
E. WRITING - is written well			
E1. Was written with a coherent, clear structure that supported the review.	Poorly conceptualized, haphazard	Some coherent structure	Well developed, coherent

Table 6: Systems Literature Review (SLR) Scoring Rubric (**Adapted from Boote and Biele)

Discipline Synthesis

The next section of an SLR is a specific analysis of the disciplines of the literature selected for the review. This is where the data sheet comes in handy. Using the data collected previously, explicate the breakdown of disciplines in the field, and what that means for the research question(s) overall. It is recommended to make a graph to visually demonstrate the breakdown of the disciplines (see Figure 6).

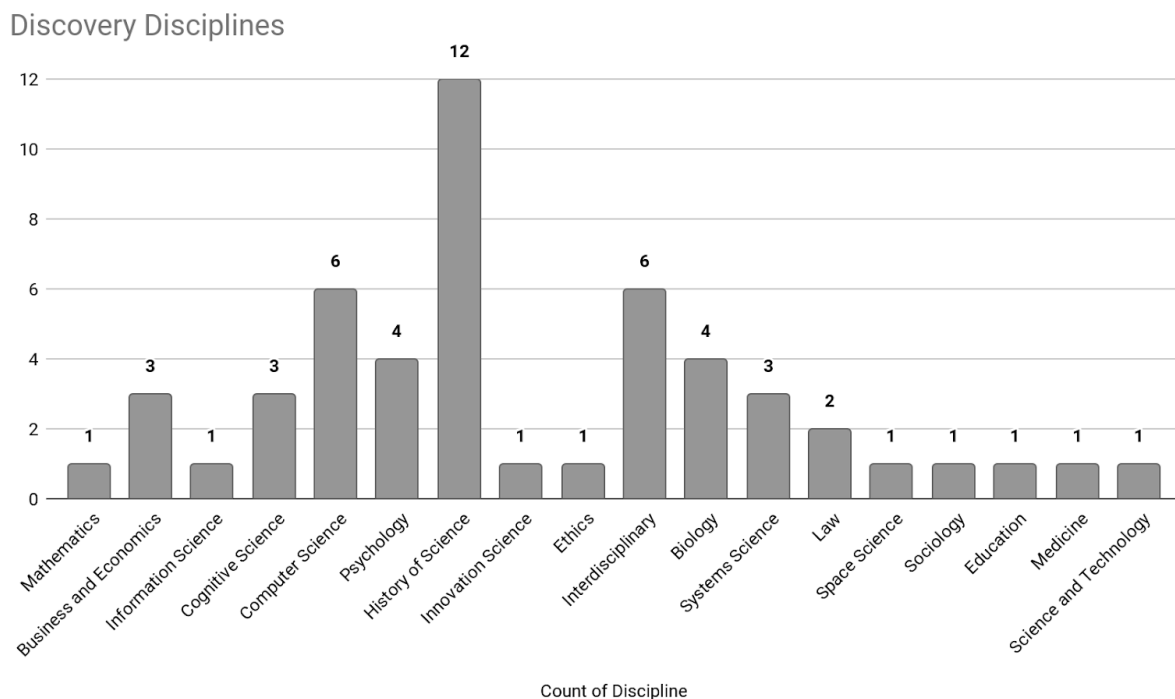


Figure 6: Example of Disciplines Chart

Methods Synthesis

The Methods section has two parts that both use the data sheet assembled while reading the publications. The first part of this step is to summarize and synthesize the *methodologies* used in the publications. Again, the data collected previously can be used to explicate the breakdown

of methodologies in the field, and the implications of the breakdown for the research question(s) overall. Again, make a graph to visually demonstrate the breakdown of the methodologies (see Figure 7).

Discovery Methodologies

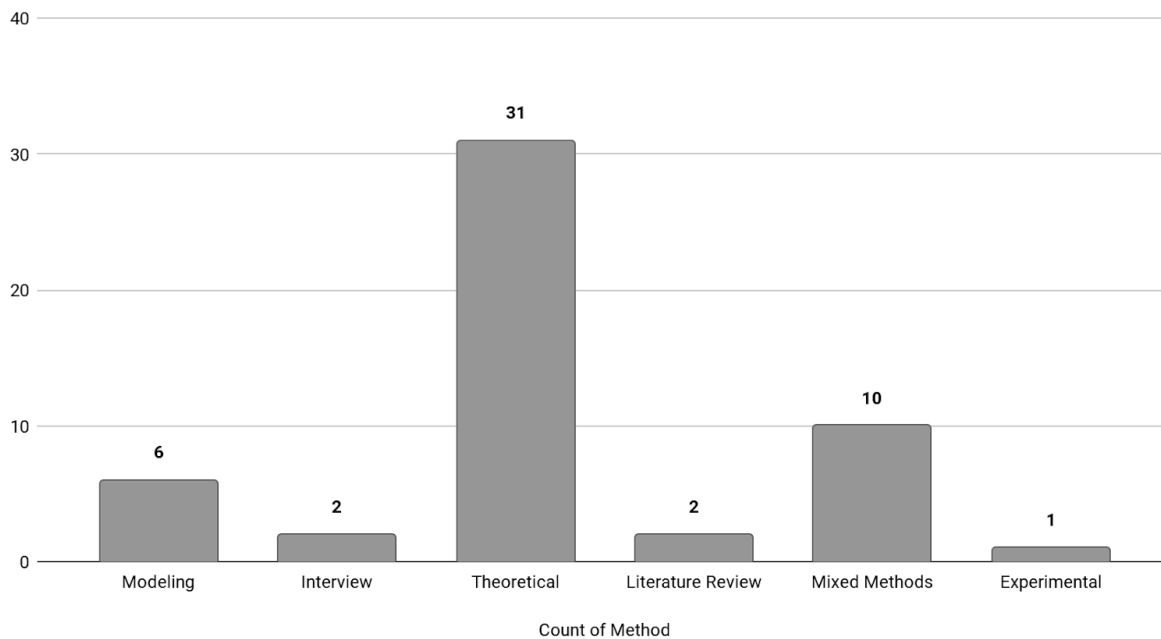


Figure 7: Example of Methods of the Selected Literature

To sort the literature collected by methodology, it is recommended that the Knowledge-Method Matching Matrix [5] is used as a guide (Figure 8).

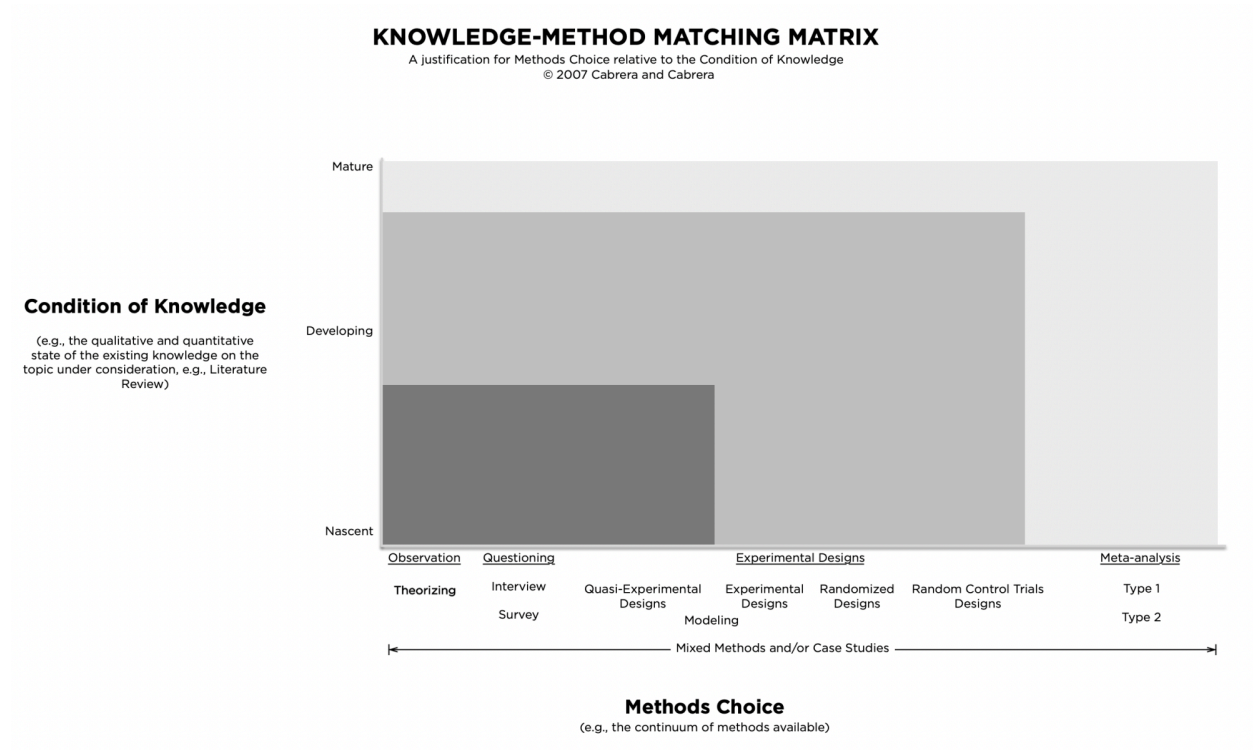


Figure 8: The Knowledge-Method Matching Matrix (from [5])

The second part of this section compiles data on the statistical significance of the findings in the selection of publications for the literature review. This means that one has gone through the papers and noted which papers had statistically significant results. Using this data collected previously, explicate the breakdown of statistical significance in the field, and what that means for the research question(s) and the state of the field overall. Make a graph to visually demonstrate the breakdown of the statistical significance (see Figure 9).

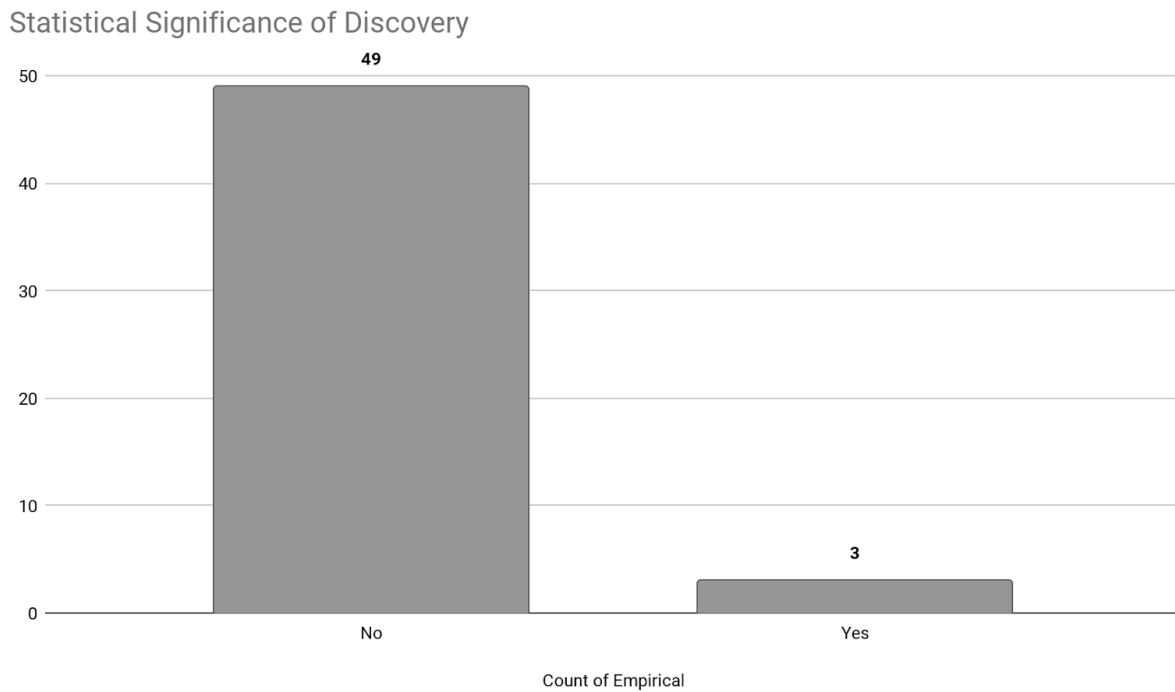


Figure 9: Example of the Statistical Status of the Selected Literature

Variable Synthesis

An analysis of the variables outlined in the selected literature for the review is also needed and can be done in paragraph form or as a table. It is okay to provide only a few examples of different variables as long as the rest of the included variables are described in the summaries of the text later on in the paper. An example of this type of summary is provided below.

“Discovery is not a very well understood phenomena. There are some recurring variables in the current scientific understanding of discovery. The most common variable mentioned throughout the literature is *chance*—also known as serendipity or luck. For example, “Serendipity is another factor that must be considered. Both discoveries and inventions are dependent on ‘chance’ stimulus, meaning that there is an amount of luck involved in the creation of a discovery or invention [8].”

Vocabulary Synthesis

A glossary of important terminology is an important part of the synthesis section of the SLR. This could be provided in narrative form within the literature review or as an appendix. See example below:

“The field of discovery research is broad, but lacks depth. While there are many studies that cross disciplines, a comprehensive and shared scholarly definition of discovery is not apparent. Building shared understanding of the discovery process and a vocabulary of discovery itself would rectify this lack of depth reflected in the literature. Particularly, it would be helpful for the scientific community to branch outside of discovery as a function. For the publications that did define discovery, the definitions are similar but not shared and cohesive. Examples of the definitions provided by the included publications are as follows. Kostoff (2006) defined discovery as, “ascertaining something previously unknown or unrecognized [9].” However, Oliver (1991) defines discovery as, “The finding of something previously unknown [10].” The definitions above are similar, but not cohesive. There is danger of breeding confusion and a lack of construct validity within the field. Without question, the scientific community would greatly benefit from a cohesive and universal definition of discovery.”

Thematic Coding

Thematic coding is a crucial part of the literature review. This process is the way to organize a large amount of material in a way that can be more easily understood by grouping it into common themes across works. In other words thematic coding is a way to synthesize all of the data collected on each publication, with the knowledge gained through reading, writing, and understanding the state of the field. One easy, tactile way to do this is to print out the spreadsheet of information about all the publications (remember one row represents one piece of written work). Cut each row/published work into its own strip. Then lay the strips onto a table or a desk and begin to categorize them. Group similar items together by placing them close to one another (see Figure 10 below). Once they are all sorted, characterize the groups by assigning them to a thematic code. See Figure 10 for visual examples from the Innovation Literature Review.

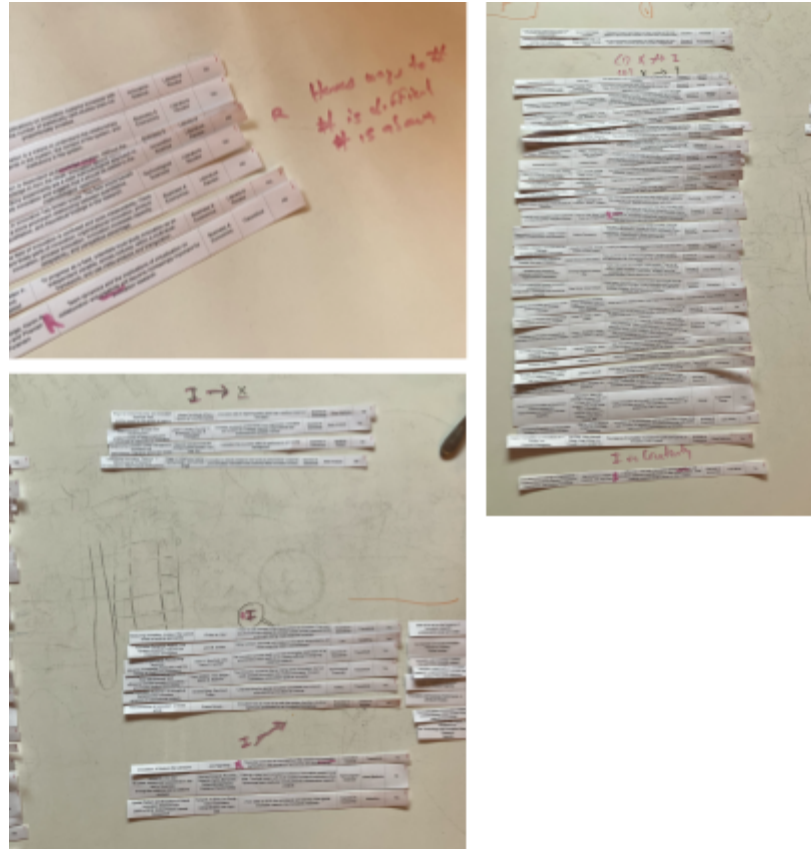


Figure 10: Physical Categories from the Innovation Literature Review

As is shown by Figure 10, physically categorizing the papers this way led to greater insights about the structure of the field that could not have been conceived of by simply reading and analyzing the text of the papers.

This categorization then leads to the restructuring of the paper based on four thematic codes: X relates to Innovation, Innovation relates to X, Innovation Measurement and Research, and Innovation in the Bigger Picture. These categories are then placed into the spreadsheet, shown in Figure 11.

	A	B	C	D	E	F	G
1	Publication Title	Authors	Summary of Text	Discipline	Method	Statistical Significance	Category [Main]
2	Causal discovery for fuzzy rule learning	Kunitomo-Jacquelin et al.	Causal discovery is a common method in the discipline of information science. There are three main types of causal discovery. The first is the functionally causal model (FCM), the second is constraint-based (CB), and the last one is score-based (SB).	Mathematics	Modeling	No	Discovery in the Bigger Picture
3	Kernel-Based Causal Discovery in Large Time Series Datasets	Liu et al.	Fields such as neuroscience and computer science are becoming increasingly interested in the utility of causal discovery.	Information Science	Modeling	No	Discovery in the Bigger Picture
4	The Idea of a Logic of Discovery	Hanson	Discovery can and should be rooted in logic.	History of Science	Theoretical	No	Discovery in the Bigger Picture
5	Preregistration of exploratory research: Learning from the golden age of discovery	Dimagi	Discovery and confirmation are often used interchangeably, when they are not the same thing. Many publications claim to have discovered a concept or mechanism and to have confirmed it within the same publication. This is not possible. One cannot use the same data to discover a thing to confirm it as well.	Biology	Theoretical	No	Discovery in the Bigger Picture
6	Inseparability of science history and discovery	Herndon	Through the observation and research of the history of science, patterns emerge that give insight into the discovery process.	History of Science	Theoretical	No	Discovery in the Bigger Picture
7	The Methodological Study of Creativity and Discovery – Some Background	Meheus and Nickles	Explored the history of Discovery research.	History of Science	Theoretical	No	Discovery in the Bigger Picture
8	Competition as a Discovery Procedure	Hayek	Competition is a mechanism for discovery. Discovery in science is in the business of discovering facts about the world and reality, whereas discovery in competition is designed to discover temporary situations and solutions to a problem.	Business and Economics	Theoretical	No	Discovery Measurement and Research
9	Knowledge Discovery in Databases: An Overview	Frawley et al.	The ability to discover new information is crucial for researchers, both scientific and entrepreneurial. The use of various discovery methods in research demonstrates the role discovery plays.	Computer Science	Theoretical	No	Discovery Measurement and Research

Figure 11: Updated Spreadsheet with the Thematically Coded Categories added

Frequency of items placed in each code will vary. For example, as shown in Figure 10, the majority of research found was coded in the “X relates to Innovation ” category, whereas very few of the papers found focused on “improving the measurement and research practices of the field.” Thus, thematic coding is an excellent way to see the focal areas of preceding research for any given field. This is a significant contribution to understanding any field in and of itself. By following these methods, the traditional literature review becomes a systems literature review (SLR).

This process must be written up in its entirety in the synthesis section of the SLR. It should be clear both how categories were selected, and what each thematic code means. This should be done in the context of both the research question(s) and the larger context of the field. See the example from the Discovery literature review below:

“After summarizing the above literature, the authors organized the publications into a datasheet. This datasheet contained the title, author, summary, methodology, discipline, and empiricism of each publication. This is the datasheet that was used to fill out previous sections of this literature review.

In order to get a better understanding of the state of the discovery science field, the authors thematically coded each publication into four main categories. This was done through printing out the datasheet,

cutting out each individual publication, and physically arranging the pieces of paper into thematic categories. This allowed the authors to physically verify the quantity and relationships between the thematic primary groups.”

The groups were characterized into four primary groups as follows:

1. **X relates to Discovery:** Meaning that some construct was related in some way (increases, decreases, causes, leads to, etc.) to Discovery;
2. **Discovery relates to X:** Meaning that Discovery was related in some way (increases, decreases, causes, leads to, etc.) to some construct (“X”);
3. **Discovery Measurement & Research:** Meaning that the publication’s predominant focus was on the state of research and/or the measurement on Discovery;
4. **Discovery In The Bigger Picture:** Meaning that the publication’s predominant focus was on the bigger picture (e.g., why it is important, macroscale effects, etc.) regarding Discovery.

The selected publications for the discovery literature review were primarily categorized in the ‘Discovery Measurement and Research’ category. These publications were typically focused on various definitions of discovery, methods of discovery, and the discussion of whether or not discovery is a construct that can be understood scientifically. The next highest category was ‘X relates to Discovery.’ These publications discussed the relationship of a stimulus or process to the quality and prevalence of discovery. For example, communication among scientists on their research findings increases overall discovery output in the local scientific community. The ‘Discovery relates to X’ category was dominated by publications that stated that discovery positively increases innovation and overall cognitive output. Finally, the ‘Discovery in the Bigger Picture’ category was typically centered on the use of discovery processes in a wider context (for example, within an organization or in an educational system).

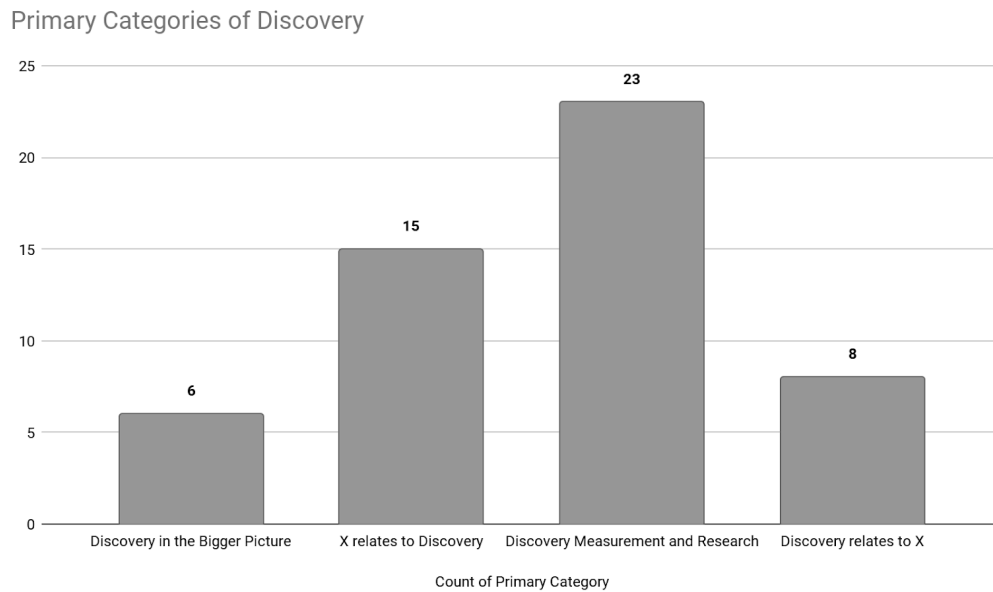


Figure 12: Primary categorization of the Discovery literature included in this review

This seemingly simple process and the data that results shows us the synthetic themes that make up the field. For example:

1. Discovery is related to many larger phenomena that we care about, such as invention, innovation, better technology, economics, and the like. So, as a causal factor, it is a wildly and globally important phenomenon.
2. At the same time that it is important, it is widely misunderstood and notoriously evasive of measurement; problems which must be reconciled if we are to harness its great power.
3. This is perhaps directly undermined by the predominant theme that many researchers attempt to increase the conditions relating to discovery (even when this may contradict fundamental processes).
4. Finally, discovery is correlationally related to a number of other salient phenomena which may form a web of causality for even more important outcomes such as innovation.
5. And, out of all 52 of the publications included in this literature review, under 6% were empirical. Under 2% were experimental.

This paper is not about the field of discovery itself, but we provide these thematic examples as a way of showing the central importance of identifying synthetic themes in the literature and then relating these themes to identify contradictions, gaps, new directions, or promising paths for a given field of knowledge. This is part and parcel of a synthetic view of the literature on any topic—and provides insights into what it says as a whole.

Overall, the SLR is an extremely powerful tool that goes beyond an academic summary of a collection of papers. It can bring insights into the state of a field, it can demonstrate unknown relationships between disciplines, and it can show a path forward to the maturation of a field. The systems literature review transforms the condition of knowledge of any discipline by: systematically searching to create the inventory of literature; analyzing the gathered inventory; using thematic coding the inventory of literature to find relationships, the state of the field, and gaps in the knowledge; summarizing what was found; and finally, taking all of that knowledge built and laying out a path to what is next for any field.

In short, this synthesis allows the researcher to situate his or her efforts (for further research, policy recommendations, etc.) and explain the significance of these new directions based on what we currently know, or don't know.

Grounding: Past Literature as the Foundation for the Future

The reason for conducting a literature review is germane to how it connects to the goal of the project. For example, the literature review may be the predecessor to a doctoral dissertation, a master's thesis, a policy paper with recommendations, a single scientific publication, a white paper, or just as a stand-alone reconnoitering of a given field or topic. Importantly, the SLR grounds the future work needed to address knowledge gaps in the past work knowledge that has been done. The next section of the SLR explains and justifies the significance of future work based on past work. Three assessments (contained in the adapted rubric for SLRs) should be considered: historical context; broader context; and the significance of research question methodological choice.

Historical Context and Seminal Works

A historical analysis of the selected literature examines the oldest publications, seminal works, or any literature reviews found that discuss the history of the field/issue that is being explored. This allows a researcher to explain what is known about the history of the field or the history of the research topic. See below for an example:

"The historical information this review has gathered on discovery came from various publications that span decades. Historically, discovery research has started in methodology science, with it moving towards psychology, and eventually landing (in the last two decades or so) in the field of the history of science. In recent years, creativity has been showing up in the field of discovery science as well. Additionally, the idea of serendipity or chance has been historically linked to major scientific discoveries."

Placing the Literature in the Broader Context

The inventory of literature should also be placed in the broader context of the field. The conclusions that have been drawn could be critical, balanced, or positive based on the publications read. It is in this section that basic suggestions or improvements for the field can be explained.

"Review of the literature suggests that the majority of research on discovery tends to be done as a means to an end... The research questions generated by scholars indicated the desire to understand what discovery is, how to replicate it, and what its parts are. The definition of discovery is written about in length in the literature. However, while there are elements in each paper's definition of discovery that are similar, there is not a single cohesive definition within the whole field, especially when you break the literature down by discipline. There is a wide breadth of research done on discovery. More depth is needed for the field to mature."

Significance of Research Question Methodological Choice

Finally, the completed systems literature review serves as an important grounding foundation and springboard for future work. This work may be a doctoral dissertation, a scientific publication of research, a policy analysis or a set of policy recommendations, or a standalone literature review. Regardless, the next step is built upon prior knowledge and should be *situated within it or distinguished from it*. Analysis of methodological choices in the existing literature

serve as a litmus for suggested improvements in methods chosen in future research e (e.g., the field is ripe for an experimental study as the constructs are validateable).

Conclusion

This paper provides a methodology, called Systems Literature Review (SLR), for building an empirical artifact that transparently codifies and categorizes data on a topic. The steps of SLR can be used for statistical analysis, to compare perspectival differences, synthesize general themes, and suggest knowledge gaps on a topic. SLR solves the problem that literature reviews are often haphazard or require in-group knowledge of who to cite when breaking into a topic, thus making the process of science more political and less egalitarian. To remove subject bias and politics, we need a scientific method for conducting a literature review. An SLR is an empirical artifact that synthesizes published works and establishes the present condition of knowledge about a topic. In turn, this synopsis of the condition of knowledge grounds and informs future efforts. The SLR is a deep *analysis* of previous and current knowledge of a field. More importantly, it is the *synthesis* of the current state of knowledge in a topic, field, or domain. This paper has introduced the SLR as an important method for applying a systems thinking lens to the literature review process. An SLR fulfills its promise as a stand alone contribution because all of its procedural steps are done *systematically* to yield an original synthesis of the current 'condition of knowledge' in the field. Thus, the SLR process is both transparent and reproducible. SLR is a tool to identify knowledge gaps, indicate methodological weaknesses, or to shift focal areas to guide future inquiry in a grounded, meaningful way. This, in turn, can evolve and elevate any field.

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