

Using Matrix Analysis to Achieve Traction, Coherence, Progression and Closure in Problem-Solution Oriented Research

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Abstract

In this contribution we propose the use of two types of matrices as conceptual scaffolding at the beginning of a problem-solution oriented research project when solutions to problems under investigation are finite while ignorance about them is more or less infinite. The first type of matrix is the problem-research question alignment matrix used to ensure that the sub-problems that are identified in problem statements are properly aligned with the research questions that the researcher poses to ensure viable empirical results. The second type of matrix is the concept matrix used to present a concept-centric rather than an author-centric literature review, thereby ensuring that one's literature review does not become a subjective process stitching together a patchwork quilt of references, or the unilateral cherry picking of references that supports a preferred point of view. Finally, we would like to point out that the concept-centric approach to literature review that we propose is firmly rooted in epistemological research philosophy.

Keywords: Concept, concept matrix, epistemology, knowledge, literature review, matrix analysis, problem-based research, problem-solution oriented research, problem statement, research question.

Introductory Remarks

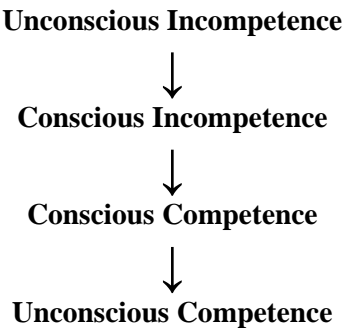
Matrix analysis of one sort or another has for the past century been used in a

variety of disciplines to summarise complex aspects of knowledge generation and to provide an eagle’s eye perspective of them. Examples are formal probability theory (Popper 1959), linguistics (Chomsky & Halle 1968; Quirk *et al.* 1974; Chen & Wang 1975; Lass 1984), psychology (Fox *et al.* 2001) and in communication science (Rugbeer 2004; Reddy 2004). The focus of this article, *the matrix method of literature review*, was popularised as a research tool in the health sciences by Garrard (1999), later reprinted as Garrard (2004). We have adapted Garrard’s method somewhat to extend it to other disciplines and to make it more flexible from an epistemological point of view.

The matrix method of literary review protects the reviewer against ignorant assumptions about the research theme at a stage that s/he is the most vulnerable due to lack of knowledge about the topic under investigation. This of course relates to the conceptual domain of knowledge known as epistemology.

From an epistemological vantage point it is self evident that research mostly begins at a stage of total ignorance about the topic under investigation, progressing to a realisation of the extent of one’s ignorance, to a stage of limited knowledge about it, and if one persists, to a stage of expert knowledge of the topic. All problem-based research therefore begins with ignorance, because conducting research about known subjects would be like reinventing the wheel. We propose the following four-phase knowledge competency continuum:

Figure 1: Levels of competence when completing a conceptual task



- *Unconscious incompetence*: being unaware of something, its relationship to other things, and how it can be used in conjunction with other things.
- *Conscious incompetence*: becoming aware that one does not know what can be known.
- *Conscious competence*: beginning to surmise, envisage and hypothesise the nature of something, its relationship to other things, how it can be used, but not yet being able to use it as intended.
- *Unconscious competence*: achieving an expert level of knowledge of something and its relationship to other things, how it can be used, and having achieved such a level of command of using it, that one can conceptualise it as forming part of newly understood events, and being able to utilise it without consciously focussing one's attention on it, so that one can focus one's attention on the general interrelationship and interaction potentials between that thing and other things.

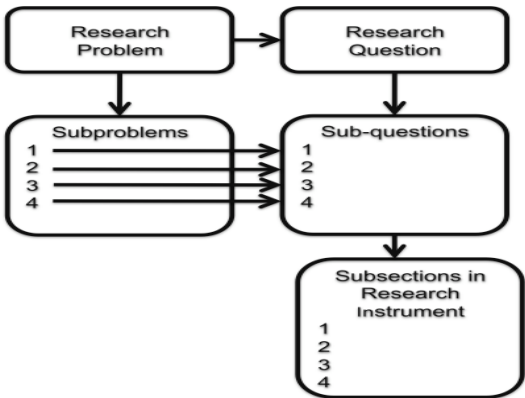
The matrix method of literature review is a powerful and practical research tool that forms the initial scaffolding to help researchers sharpen the focus of their research and to enable them to rapidly progress from the initial state of conscious incompetence to the stage of unconscious competence as outlined above.

Aligning Research Problems, Aims and Research Questions

In the authors' capacities as postgraduate supervisors, external examiners and peer reviewers they regularly encounter research designs in which general problems and research questions are either absent or misaligned. In a well-designed research project the researcher has a clear conceptualisation of what the general problem is that should be solved and the questions one should answer through one's own research to solve the problem.

Once the researcher understands the general problem and research question, s/he has to expound them in greater detail into more specific subproblems and sub-questions as in Figure 2 below:

Figure 2: Flowchart demonstrating the alignment of a general problem and research question, and reconceptualising them in greater detail as properly aligned subproblems and research questions disseminated as Klopper (2009)



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In a well designed research project the researcher will extract a specific number of subproblems from the general problem, as well as the same number of sub-questions from the general research question in such a way that sub-questions and subproblems are properly aligned. If this is done systematically, the answer to a specific research sub-question will provide the solution to its associated subproblem.

Finally, in empirical research the sub-questions of the research design phase will be restated in greater detail in the research instrument – the questionnaire in the case of quantitative research, or the interview schedule in the case of qualitative research.

The Problem-Research Question Alignment Matrix

The flowchart in Figure 2 above shows the alignment of research problems, subproblems and research questions in flowchart format. Figure 3 below presents a table that demonstrates the alignment of an actual general problem and sub-problems with research questions regarding solving problems with plagiarism in present-day academic research:

Figure 3: The problem-research question alignment matrix for solving the problem of plagiarism, adapted from Klopper (2009)

General Problem	Subproblems	Research Questions
The research community does not know which sources and resources plagiarisers use on the Internet, or the methods of analysis that beyond doubt could establish the likelihood of plagiarism.	1 The <i>sources</i> of plagiarised academic material have not yet been identified.	1. <i>Where</i> on the Internet do plagiarists obtain plagiarised sources?
	2. The <i>resources</i> for tracking and eliminating plagiarism have not yet been identified.	2. <i>What resources</i> can be used to track and eliminate plagiarism?
	3. It has not yet been determined how <i>methods of text analysis</i> could serve as forensic tools to assess the quality of ethical academic writing.	3. <i>What methods of text analysis</i> could serve as forensic tools to identify plagiarism on linguistic grounds?
	4. It is not yet known what the criteria for forensic evidence should be to establish plagiarism beyond doubt.	4. What forensic criteria exist to identify plagiarism beyond legal doubt, in order to distinguish between breaches of copyright and true authorship?

The above matrix can be further extended to align the research questions and the questionnaire questions. The approach would allow the researcher to demonstrate that s/he has proved that all processes have been thought through.

Figure 4: The research-question questionnaire alignment matrix for ensuring data collected help solve the research questions

Research Questions	Research Instrument Questions	Variables	Statistical tests
1. How do plagiarists obtain unacknowledged sources from the Internet?	1. Do you copy sources from the Internet via search engines without acknowledging their authors?	Yes/ no	Single group tests like the single group t test, or the z proportions test and the X^2 test.
	2. Do you copy sources from electronic resources like Science Direct or Ebsco Host without acknowledging their authors?	Yes/ no	Single group tests like the single group t test, or the z proportions test and the X^2 test.
	3. How often do you copy un- acknowledged sources from the Internet?	Never----Always	Any member of the X^2 family or correlation tests, e.g., Phi coefficient, the contingency coefficient and Cramer's V, or the lambda coefficient or the uncertainty coefficient (U).

Building a Concept Matrix

How a matrix is to be constructed is a process that relates more to the personal creativity, proficiency and originality of the researcher than to rules and principles. Miles and Huberman 1994: (240-241) state that there are no *correct* matrices, only *functional* matrices. Researchers should keep in mind that they will have to modify earlier versions of literature survey matrices as their understanding of their research topic grows.

A Word Processor Based (or Pen-and-Paper Based) Concept Matrix

Figure 4 below provides a sample word processor based concept matrix that focuses on the research theme of e-Readiness, how ready members of particular communities are to adopt electronic resources for every-day use:

Figure 5: A typical concept matrix showing which concepts are discussed in references for a literature review on e-Readiness

References	Concepts									
	E-Education Policy	E-Learning	Access To ICT Services	E-Schools	E-Strategies	Community Development	Digital Inclusiveness	Institutional Development	Innovation	Readiness Evaluation
Barabash et al. (2003)		1								
Bridges. Org (2005)										
Brown et al. (2004)										
Buckner and Stoner (1999)	1					1				
Cette et al. (2001)										1
Chasia (2002)		1	1	1	1			1	1	
De Villiers (2005)		1								
Finlay (2005)			1							1
Gilwald (2004)	1			1						
Govindsamy (2002)				1				1	1	
Hiralal (2005)	1				1					1
Hoffman and Novak (1998)			1							
Jacobs and Herselman (2002)					1					1
Jiamton and Sillis (2005)									1	
Kelly (2004)	1						1			
Markle Foundation (2001)						1		1		1
Matthew (2003)			1						1	1
Mbarika et al. (2005)										1
Melody et al. (2003)						1				1

As can be seen above, the layout of the concept matrix is straightforward. In the leftmost column the references to be reviewed are listed in abbreviated Harvard style. The head of each column displays a concept that was extracted from the problem statement of the research project. If a relevant concept is discussed in a particular reference a 1 (one) is placed in the appropriate cell.

In order to determine the relevance of a source the researcher does not have to waste time by reading the whole article. It is sufficient to scan the abstract (where the content of the reference is summarised prospectively) and the summary/ conclusions section (where the content of the reference is summarised retrospectively) to determine the relevance of the reference.

This approach enables the researcher to conduct a critical comparative literature review of all references listed under each concept. This approach emancipates the reviewer from the tyranny of being trapped within a particular reference, and from merely providing general paraphrases of references. It also enables supervisors to establish at a glance that only relevant literature is being reviewed and captured in the bibliography because *references that do not appear on the concept matrix may not form part of the literature review and should therefore not be included in the bibliography.*

Although the understanding of these concepts is central to the attention of researchers the literature may not contain some examples of the historical analysis of this type. It should be noted that epistemological classifications could be included in the matrix just after the reference to address this. This should be done to show how important this article is epistemologically in terms of the topic being researched.

A Spreadsheet Based Concept Matrix

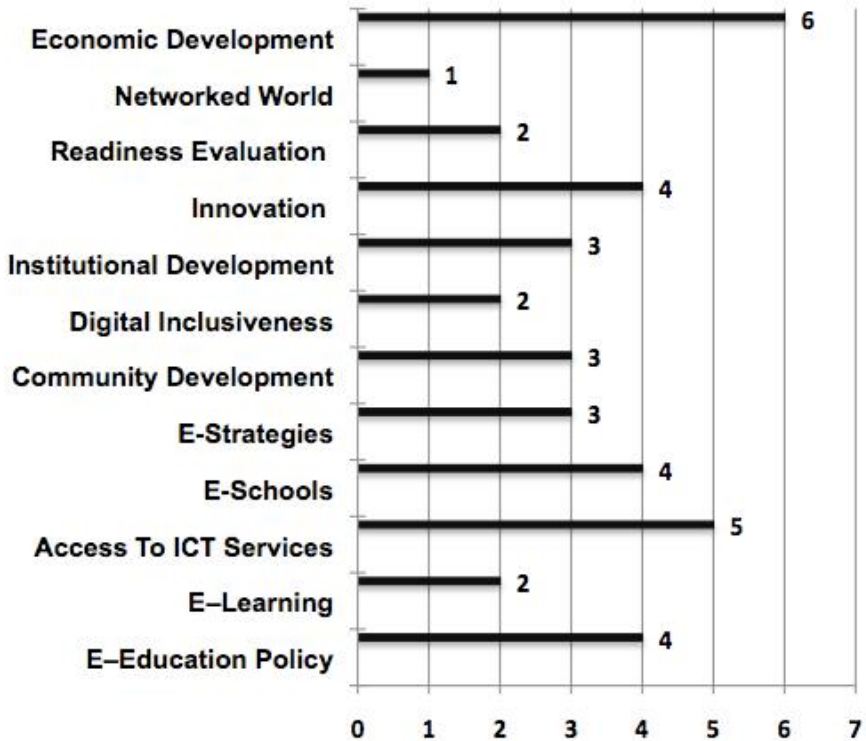
The concept matrix can also be created as an electronic spreadsheet, allowing the researcher to easily keep track of how many references deal with more than one concept in the overall theme under investigation as well as how many sources deal with a particular concept. This allows the researcher to differentiate between core references that deal with multiple aspects of the research theme, and references of a more peripheral nature, and with well researched and less well researched concepts as shown in Figure 6 below:

Figure 6: A typical concept matrix in electronic spreadsheet format, with an added row indicating the total number of sources per concept as well as the total number of relevant concepts per source for a literature review that focuses on e-Readiness

Concepts	Total relevant concepts per source	E-Education Policy	E-Learning	Access To ICT Services	E-Schools	E-Strategies	Community Development	Digital Inclusiveness	Institutional Development	Innovation	Readiness Evaluation	Networked World	Economic Development
References													
Total sources per concept		4	2	5	4	3	3	2	3	4	2	1	6
Barabash <i>et al.</i> (2003)	1		1										
Bridges. Org (2005)	3			1				1			1		
Brown <i>et al.</i> (2004)	1				1								
Buckner & Stoner (1999)	2	1					1						
Cette <i>et al.</i> (2001)	2				1								1
Chasia (2002)	5			1	1	1			1	1			
De Villiers (2005)	1		1										
Finlay (2005)	3			1							1		1
Gilwald (2004)	1	1											
Govindsamy (2002)	3				1				1	1			
Hiralal (2005)	3	1				1						1	
Hoffman & Novak (1998)	1			1									
Jacobs & Herselman (2002)	2					1							1
Jiamton and Sills (2005)	1									1			
Kelly (2004)	2	1						1					
Markle Foundation (2001)	3						1		1				1
Matthew (2003)	3			1						1			1
Mbarika <i>et al.</i> (2005)	1												1
Melody <i>et al.</i> (2003)	1						1						

One of the benefits of the electronic concept matrix is that it visually references in summary format the number of sources per concept, or how many different relevant concepts a particular reference covers, enabling the researcher to distinguish between primary and secondary references, or between major and minor concepts as is the case of Figure 7 below:

Figure 7: Bar graph showing the number of sources per concept on the concept matrix for a literature review that focuses on e-Readiness, generated from the electronic spread sheet that was used to create the concept matrix shown in Figure 6



From the above graph one can conclude that ‘economic development’ (6 references) and ‘access to ICT services’ (5 references) are the two most researched concepts on the *theme* of e-Readiness, followed by the concepts ‘innovation’, ‘e-Schools’ and ‘E-Education Policy’ (with 4 references each). By contrast, ‘Readiness Evaluation’, ‘Digital Inclusiveness’, ‘E-Learning’ (at 2 references each), and ‘Networked World’ (with only 1 reference) were not heavily researched aspects of the E-Readiness theme.

Discussion and Conclusion

In this paper we have proposed the use of two types of matrices to achieve traction, coherence, progression and closure in research, namely the *problem-research question alignment matrix* that is used to ensure that the sub-problems that are identified in problem statements are properly aligned with the research questions that the researcher poses to ensure viable empirical results, and the *concept matrix* used to present a concept-centric rather than an author-centric literature review.

The problem-research question alignment matrix ensures that the whole research process is problem-solution oriented by taking the problem statement as point of departure. This firstly is done by extracting subproblems from the general problem statement and aligning research questions with each of the subproblems. The alignment and cohesion of the research design is enhanced by basing the array of research instrument questions on the questions of the problem-research question alignment matrix. Closure is achieved at the end of the research process if the researcher demonstrates to what extent s/he is able to answer the research questions by means of her/ his own empirical results, on the principle that the extent to which one is able to answer one's research questions, is the extent to which one has succeeded in solving the problems that prompted the research in the first place.

The concept matrix ensures that the researcher conducts a concept-centric problem-solution oriented literature review provided that the search terms for the review are extracted from one's problem statement. Furthermore, the literature review essentially is a qualitative content analysis of available information already published on the problem under investigated. It can be a study of the research object alone, with the aim of collecting information about its structure, process and relationships, increasing the familiarity of the researcher with the research object and establishing the credibility of the project. In addition, it can consider previous research, attempting to link it with the study currently planned. It may also be geared towards a historical or comparative analysis of the issue in question so the current study can be placed in a historical context. Finally, it may review a theory of methods and techniques most suitable for the study, simply by looking at the ways other researchers have approached the topic, and by evaluating their suitability and effectiveness (Sarantakos 1998: 129).

Punch (1994: 93) writes that without adequate training and supervision, the neophyte researcher can unwittingly become an unguarded projectile bringing turbulence to the field, fostering personal trauma (for researcher and researched), and even causing damage to the discipline. There are many cases where students have attempted to conduct a literature review (see some previous section) but many failed and their studies therefore failed as well. O'Neill in Wellington *et al.* (2005: 89) states that conducting a literature review is a bit like climbing your way up a pyramid, where the total area at any particular point in the climb represents the search area for the review at that particular moment in time. You start in the largest area at the bottom and slowly move upwards, all the time refining and narrowing your searches, as you move from incompetence to competence.

Wellington *et al.* (2005: 87) state that reviewing the literature involves searching, collecting, prioritising, reading with a purpose and seeking out key issues and themes, and then presenting and discussing these critically. The aims of a literature review are:

- To establish which of the problems identified for solution by means of empirical research have been solved by other researchers so that they can be removed from the research equation
- To give readers a clear idea of the nature and context of one's research
- To convince the reader of one's knowledge of the field
- To build a case for the empirical part of one's study

If one looks at the way novice researchers attempt to survey literature, it seems that the supervisor has failed to acquaint the student with the different phases for conducting a proper literature review. The first phase is where many students get stuck and remain – they cast about collecting data with no defined problem statement from which they extract keywords to serve as filter for the identification of relevant literature. They read each reference in detail rather than using abstracts and summaries to establish relevance, and they start summarising the literature with no plan in mind, and end up with a document without a proper layout, showing no coherence and progression, and in many cases ending up perpetrating intentional or unintentional plagiarism because they have not kept track of the sources of

the ideas that they jotted down so that, even if they wanted to, they cannot properly acknowledge their sources. This is the first and probably the worst case scenario. In our view it reflects a mindstate of unconscious incompetence.

The next phase is when students begin to appreciate how little they do know of the topic, but they set out without a plan and write unsystematically without knowing where they must stop creating pages upon pages of copious notes. They rely on the supervisor to tell them what they must leave out. We call this phase conscious incompetence. The next phase is conscious competence. In this phase the student becomes aware of the fact that s/he is coming to grips with the major references that relate to the problems under investigation. Due to the student's newfound confidence is sometimes difficult for the supervisor to properly advise the student what to, leading to disagreements about what should be included in the literature review and what should be left out and often leading to unfounded mistrust on the side of the student.

The final phase is where the student has become a true researcher. This stage we refer to as *unconscious competence*. The student creates a proper problem statement and extracts key concepts from it that s/he then uses to search for refereed literature to be used in the literature review. By using key concepts derived from the problem statement, the *problem statement itself becomes the filter* that ensures that only literature relevant to the problems under investigation forms part of the review. This method also enables the researcher to determine to what extent problems that s/he has identified have been solved by other researchers, enabling the researcher to remove solved problems and *reformulate the original problem statement, the research objectives and the research questions*, the latter which forms the basis of particular more detailed questions posed to respondents in research instruments like questionnaires and interview schedules.

The researcher generates content for the concept matrix by surveying *only the abstracts and summaries of references*. Once the appropriate literature to review has been identified the researcher commences with the literature survey proper, which entails a critical analysis of each reference to identify potential solutions to the problems under investigation. The critical analysis of individual references should be followed by a *critical comparative analysis* of all references that are listed

under a particular concept, to establish differences of opinion, converging opinions and consensus among experts under review.

In this approach to literature review the researcher systematically reads each article, considers the validity of what is being read, and thereafter classifies the reference thematically. The importance of using this method is that the student must realise that s/he cannot use everything in an article but should instead concentrate on those aspects that relate to the problems under investigation.

The key concepts on the matrix therefore become the key concepts embedded in the headings in the literature review. The concept matrix enables the researcher to subject all literature to critical comparative analysis. The references that have been ticked in a particular column of the concept matrix are subjected to critical comparative analysis in the thesis. The concept matrix also enables the researcher to establish at a glance whether s/he has identified enough references under each concept. The researcher can order each column of the matrix in different ways to foreground different aspects of the knowledge contained in it. The matrix can be reorganised according to:

- Publication date, demonstrating longitudinal aspects of the topic (*time-ordered matrix*)
- Table rows containing verbal information about the view of role occupants on a specific issue of the project (*role-ordered matrix*)
- Integrated data on a summative index or scale, thus organising several components of a single, coherent variable (checklist matrix)
- A central theme (*conceptually clustered matrix*)
- Outcomes and dependent variables (*effects matrix*)
- Present forces that are at work in particular contexts showing processes and outcomes (*site dynamics matrix*)
- A series of events displayed in any possible order (*event listing*)
- A field of interrelationships between dependent and independent variables, describing causal connections between them (*causal network*) (Sarantakos 1998: 360).

Wellington *et al.* (2005: 83) state that in writing about the literature, one is adding to it, by creating links, drawing attention to particular issues

and contributing one's construction of the 'story' to told in existing research.

It is a long and 'rigorous' road for a researcher to progress from unconscious incompetence to unconscious competence. The supervisor will have to be patient and has to ensure that the student keeps a proper record (the matrix) of the process. The matrix should be added as an appendix into the dissertation. The student cannot move directly from unconscious incompetence to unconscious competence but has to follow each stage the sequence of understanding shown in Figure 1.

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