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HELPING STUDENTS TO SOLVE RESEARCH PROBLEMS: AN INTERDISCIPLINARY PERSPECTIVE

Our informational time requires the development of specific models to deal with it. During the past 20 years, we witnessed the evolution of the amount of information along with the change of habits of the students, particularly when it comes to look for and select information. In our experience, the students need help to start to perform a research since the very beginning: understanding the current situation in a given topic of interest. Because of that, we develop a method, integrated by 4 other methodologies, and we tested already many times with great results. The methodologies we include are systems theory, mapping studies, information quality and competing hypothesis. These tools are from different areas of knowledge but when used sequentially, the students go from problem conceptualization to testing hypothesis.

***Keywords**: systems theory, mapping studies, data quality, competing hypothesis.*

Introduction

None has any doubt about the positive aspects of living in the information society, but most of us don't realize its dark side until we have to solve a difficult research problem where the information available is superabundant.

The constant flux of information makes it necessary to face this situation from both a comprehensive perspective and a methodologically consistent one. This is not just about the amount of information but also its quality and how to evaluate it in order to have the optimal sources of information to work with.

In addition to superabundant information there is increased time pressure that affects researchers in 3 ways. There is a lack of time to (1) develop a clear definition of our research problem, (2) develop a search strategy to find high quality information, and (3) determine appropriate decision processes to select the most relevant information. These all create weak points on our work that lower its academic value.

Finally, when the students are about to start to prepare their dissertation most of the times the methodology courses are too theoretic, little practical, and they give little tools to apply when it comes to write it.

Materials and methods

Here we will present four methodologies: systems theory, mapping studies, data quality and competing hypothesis. All of them together allow us go from the problem conceptualization to the hypothesis testing in a methodologically consistent and structured way.

The idea of a using a combination of methodological tools, in an articulated way has its origin in a request made by the Peruvian Air Force. They wanted a dedicated course on research methodologies. We did not want to present to them just a collection of isolated, non-related methodologies that have little value when used standalone. So after reviewing a series of tools and considering along with them the mental process we have when we are developing a research, we developed an approach of using an integrated series of tools for our course.

Here we will present the four methodologies and how we link them in order to give to the students an easy to apply tool.

I General Systems Theory

Out of the four methods that conform this proposal, the systemic method, developed after the general systems theory is the oldest and widely used in different disciplines. This theory has its detractors and fervent fans who «see» reality through it.

Ludwig von Bertalanffy (1969), father of the general systems theory, recognizes that Aristotle took the first step on this path with his famous phrase «the whole is greater than the sum of its parts». So, this theory, proposed by the Austrian scientist, with an organic perspective, articulated the theoretical developments that arise in the first half of last century, on systems in different areas of knowledge.

In his book (Bertalanffy, 1969), whose concepts are described in numerous articles, presents the three premises that sets the basis of his approach: systems exist within systems; the systems are open; the functions of a system depend on its structure.

Ludwig von Bertalanffy (1969) also makes other contributions that have to do with the operation of these systems. For example, he suggested that systems have an input either of materials, energy or information, which are used within the system for its components in different processes, and then give a result or product or output.

In the above concept, the timing of the sequence input – process – output clearly indicates that we are working with a dynamic vision of reality and its components.

In order to assimilate the ideas proposed by von Bertalanffy (1969), we present the following examples form very different knowledge areas: biology and strategic decision making.

The application of the systemic method to biology is so clear a familiar that surprises us: when we think in an ecosystem a concept that it is broadly used today, we can split the word in «eco» and «system», in other words, house systems, in this case, house is referred to our planet, or our big house. The concept of ecosystem from a systems theory perspective, includes its abiotic and biotic components, food chains, ultimately evolution.

Today all talk about ecology, including the above concepts, without even thinking that the organization of the ideas have the systemic method embedded.

If we dig a little and taking the information presented on the subject by FAO, who when defining the concept of ecosystem, it says that it «refers to the unit of animals, plants, humans, soil and climate, all related among them and forming an ensemble in equilibrium. Each of these elements influences the other and their relationships with each other depends on the overall balance».

If we analyze the idea presented here we see that it mentions the various components and their relationships and also speaks of a balance or homeostasis, one of the emergent properties of the systems.

Then states that the important thing is that the very definition of the ecosystem is based on the interdependence of its components (fauna, forest, soil, water, air, human beings) and how the balance between them can be maintained.

The example presented here shows how a theoretical development of a specific topic includes the concepts of systems theory, without even mention it. This is the magic of this theoretical approach developed by von Bertalanffy (1969).

There are two types of approaches that can come out: a study of the system and its components, considering the processes that occur inside it, and another the border, characterizing and studying the processes that take place there, in the limit. In both cases we have to consider what happens in the surroundings: from where the inputs come and to where the outputs go and changes it.

In the specific case of our course, the systems theory is the key to take the first step in the conceptualization and understanding of the research problem.

This tool allows us to identify not only the problem we want to study, and separated from its environment by building a (theoretical or actual) border but also individualize or identify their constitutive parts and the relationships between them and processes occurring within the system;

and finally it also allows us to define the research objectives, which at the end, frame our system.

II Mapping studies

This tool comes originally from the medical sciences where, for both pharmaceutical companies and physicians, it was very important to have a methodology to collect the information of the results of the implementation of treatments or uses of a product. The collection of data should be made in such way that the gathered information should be comparable and consistent. The need for standardization was the basis for the development of this tool.

This structured search method was then discovered and assimilated by the researchers of systems engineering, or informatics in general, and they mostly used it to develop the state of the art of the subjects in which they were working. Barbara Kitchencham (2010) has been the driving force behind this issue, while Dr. Marcela Genero Bocco (2014) of Alarcos Group (UCLM, Spain) is the leading Spanish-speaking experts.

But before going into details of this tool it is important to understand the reason for their inclusion here.

When most people perform searches, especially when rigor is required in the collection and analysis of results, many times, they just select a search engine, either Google or some virtual library, then they enter some keywords and finally they review the results and choose some of them. They follow this sequence of steps almost without thinking, and without registering the process or the results or the selection criteria.

This way of working smuggle a lot of errors, either by the keywords entered into the search engine, or the articles selection criteria. In the latter case, cognitive biases make people choose based on whether it is useful to our research, or comes from a source we consider valid. In other words, if its supports our thinking, we select it. We have this tendency and unless we use a tool with allow as to avoid such a deeply rooted bias, we are lost even before we start!

This is where the systematic review comes to our aid, giving us a guide of standardized procedures, with checkpoints, which allows us to perform a structured and replicable search.

Here is the sequence of work, divided into phases:

Phase 1: Planning the review.

The first step is to identify the need for a review: it has to do with the need to summarize existing relevant information on a topic or research problem. Having that ensemble of information allows us to know the state of art of an issue or problem.

The second step is to formulate research questions: this is the most important part, since they will lead the search process. Here we take what developed in the systems theory stage, when we study and conceptualize

our problem and then identify what aspects of it are going to study, and how we will do it. The formulation of the research objectives and research questions are the link between this first two methodologies.

A key point of this tool is that when the search is done, the selection of articles will be carried out based on whether they answer or not to the research questions, not how they do. This is how we start to elude our cognitive bias.

Once we have questions, we need to define the search protocol: a formal and detailed specific plan where each of the steps and features are identified. There is a list of the components of our search strategy:

- Search terms, alternative terms, synonyms; use OR, AND.
- Sources of information: virtual libraries, magazines, conferences, gray literature, Google.
- Inclusion and exclusion criteria.
- Quality criteria of each publication (of its content regarding the research problems and objectives).
- Strategy for data extraction (form design).
- Synthesis of extracted data (data analysis form in relation to the research questions.

Phase 2: Executing the review.

Now we do the search work itself: identifying relevant research using selected search terms and apply the criteria of inclusion and exclusion on the results obtained after used the chosen search engine.

It is important to point out that even when this tool was designed to be used both in medical search and later in academic libraries, its use using other search engines like Google had proved to be very useful and with interesting results. This aspect is quite important if we consider that not all the students have access to a digital library and also that not all problems are academic ones.

Once the first search is done we can analyze if our original protocol needs a revision, for example, refine or expand the keywords, change the research questions, use other sources of information, in order to have relevant and representative articles to be analyzed.

If we consider that the results obtained are fine, we can proceed with the selection of primary studies by first applying the criteria of inclusion and exclusion to all articles retrieved and second, those who remain are studied using the research questions. Those answers are incorporated on the data extraction file (usually an excel file), which already contains data specific to each publication (author, date, publisher, title, etc.). Then these results are analyzed, as in a traditional way and if feasible graphics are produced in order to better show the results of the mapping study.

Not always a study of the quality of selected studies is done, its importance will depend on the subject and the particular case. In any case

always must specify the criteria and method of evaluation, whether qualitative or quantitative.

Phase 3: Writing the Report.

In this last phase the results obtained are shown and it is essential to clearly state the procedure followed, including every possible detail of our work. The purpose of this way of presenting information is provide to the reader all the information he/she could need to repeat our study.

In the case of our methodological integration, the performance of the systematic review is essential for the other two tools that follow: first, is the raw material that will be evaluated in terms of their quality, with the methodology of quality information and the other, they will be the evidence to be used to validate the assumptions in the methodology of competing hypotheses.

III Information quality core concepts

In a world with an overload of information it is important to find a method to evaluate and categorize it in order to better profit both its content and metadata.

In this context is where information quality, developed by researchers at the MIT (Cambridge, MA, USA) provides help.

We consider their methodology as a 3 legs table: a. Categories and dimensions. b. Participants. c. TDQM cycle.

a. Categories and dimensions.

Wang and Strong (1996) developed a framework to evaluate and hierarchically organize information. In order to build it, they survey information consumers and MBA students about which attributes the information should have, resulting in 179 attributes. Then, they did a new survey with the objective of learning the importance of the attributes identified before to a bigger pool of data consumers. At the end of the process they identify 16 dimensions, grouped in 4 categories (Table 1).

Table 1

Information Quality Categories and Dimensions (Fisher et al, 2006)

Categories	Dimensions
Intrinsic IQ	Accuracy, believability, objectivity, reputation
Contextual IQ	Value-added, relevancy, timeliness, completeness, amount of data
Representational IQ	Interpretability, ease of understanding, representational consistency, conciseness of representation
Accessibility IQ	Access, security

b. Participants.

The participants are Collector, Custodian and Consumer (3C's), who are the stakeholders in the flow of information inside organizations. The

identification of the role played by the different actors in a given process (4), and an evaluation of their performance, will allow understanding organizational problems.

c. TDQM cycle.

The Total Data Quality Management is a continuous cycle that when is applied by an organizations will allow them to implement an IQ Program and check its results in the future (1). It includes 4 steps: Define, Measure, Analyze and Improve.

Finally, the information quality tool, including all its components, gives to the people who use it a new multidimensional perspective which allow them to have at the same time the broad picture of the quality of the information they gather, and at the same time a lot of detail of them.

IV Competing hypothesis

This tool was developed by Richards J. Heuer (1999), an intelligence analysis expert from the CIA (Central Intelligence Agency USA), between 1978 and 1986 and was released for the entire community in his book Psychology of Intelligence Analysis.

This methodology was designed to be used in cases of complex problems, where there are many possible futures scenarios and there is a lot of evidence to be consider to their verification.

The operating mechanism of this tool is basically the simultaneous study of all possible hypothesis and contrast them with existing evidence. The result will be a table with all the hypothesis organized according to amount and type of evidence each one has.

With the hypothesis matrix, where the estimated correlation between the two elements and then try to identify, by the sum of the different probabilities, the hypothesis with more support in the available evidence is placed probability is built.

It is important to point out what Heuer (1999) says: the result of the methodology is which hypothesis has more support according with the available evidence and not which is the hypothesis with higher probability of occurrence.

In the context of our methodological integration, we generate the hypotheses using our research questions from the mapping study.

The evidence used here is the one identified in the stage of systematic review, which was also evaluated with the tool of information quality. It is also possible to analyze how behave the evidence according to its quality hierarchy with the hypothesis we are testing.

Also, using as evidence the items obtained in the review we avoid a very important way cognitive biases that would have us choose only confirmatory evidence of different scenarios. Table 2 shows the format of the matrix is observed.

Table 2

Competing hypothesis matrix

Evidence	Hypothesis 1	Hypothesis 2
Evidence 1	+	+
Evidence 2	+	--
Evidence 3	+	Not apply
Evidence 4	Not apply	++
Evidence 5	-	+
Total	3+ 1-	4+ 2-

Note. The + means the evidence support the hypothesis and how strong it does; the – means that it doesn't support it and not apply means that has not relation to the hypothesis under study. (Author version of the original in Heuer, 1999)

Results

Under the umbrella of the Humboldt International University of Miami and the NGO ArgIQ, we presented this course four times.

Here we present the four tools that are part of this methodological proposal that aims to help the researcher to work in an environment of high volume of information, high uncertainty and cognitive biases. But it is important to mention that at the beginning of the course we took some time to try to understand how we think and how we make decisions, with the objective of making the students reflect on their cognitive biases and how to deal with them.

Integration works as follows:

- The systems theory helps us to frame the research problem while identifying the objectives we intend to work with.

- The previously developed objectives are transformed into research questions for the mapping study. This methodology is critical because it will be used to identify and select the items we use as raw material for our work.

- The articles selected in the mapping study will be evaluated and hierarchically organized according to the information quality categories and dimensions.

- At the final stage, the research questions are used to develop the hypothesis, the items selected in the mapping study will be the evidence (hierarchically organized according to the information quality tool) used to test each hypothesis.

The students should write at the end a document where all the tools are integrated and show their conclusions at the end.

During the course we work intensively with each student to help them to think through and analyze their own research problem using each methodology.

So far we presented this course in two formats: in the traditional class and using a website to exchange material and send tasks and interact

between classes. Depending on the students, each of the modalities had its own pros and cons.

Until today we presented the course four times, with different results, most of them positives. The students consider that the use of the enchained methodological tools help them to finally «solve» their research problem and give them a new perspective when it comes to read other kind of documents or thesis.

The sole negative results were obtained when the students didn´t have a research problem to work with. They learnt how to use the tools but they never arrived to a final document with conclusions.

Out of the 43 students that complete the course, just about 15 are willing to rewrite their final document into a book chapter to be published by the HIU and which will be used as course material.

Conclusions

With the experience we have so far, we can say that the tool we develop and presented here is quite useful for our students not just to deal with a typical academic research problem but also to evaluate others research and developments.

They were able to incorporate all the methodologies and learned how to apply them in different problems.

What we consider most important is that they were able at the end of the course to deal with their cognitive bias in

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Марія Дж. Еспона. Допомога студентам у вирішенні дослідницьких проблем: міждисциплінарна перспектива.
Інформаційна ера вимагає розробки конкретних моделей для вирішення дослідницької проблеми. За останні 20 років ми стали свідками еволюції обсягу інформації поряд зі зміною звичок студентів, особливо коли справа стосується пошуку і вибору інформації. Згідно проведеного експерименту встановлено, студентам потрібна допомога в організації дослідженні з першого етапу: розуміння поточної ситуації в заданій темі, що представляє інтерес. Для цього ми пропонуємо методологію, інтегровану чотирма методами, які ми тестували багаторазово, отримуючи високі результати. У число використовуваних нами методологій входять: теорія систем, картографічні дослідження, якість даних і конкуруюча гіпотеза. Ці інструменти взяті з різних областей знань, але, коли вони використовуються послідовно, студенти переходять від концептуалізації проблем до гіпотези дослідження.
Ключові слова: *теорія систем, картографічні дослідження, якість даних, конкуруюча гіпотеза.*

Мария Дж. Эспона. Помощь студентам в решении исследовательских проблем: междисциплинарная перспектива.
Информационная эра требует разработки конкретных моделей для решения исследовательской проблемы. За последние 20 лет мы стали свидетелями эволюции объема информации наряду с изменением привычек студентов, особенно когда дело касается поиска и выбора информации. Согласно проведенного эксперимента установлено, студентам нужна помощь в организации исследовании с первого этапа: понимание текущей ситуации в заданной теме, представляющей интерес. Для этого мы предлагаем методологию, интегрированную четырьмя методами, которые мы тестировали многократно получая высокие результаты. В число используемых нами методологий входят: теория систем, картографические исследования, качество данных и конкурирующая гипотеза. Эти инструменты взяты из разных областей знаний, но, когда они используются последовательно, студенты переходят от концептуализации проблем к гипотезе исследования.
Ключевые слова: *теория систем, картографические исследования, качество данных, конкурирующая гипотеза.*

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