

Introduction to Science of Science Methodology

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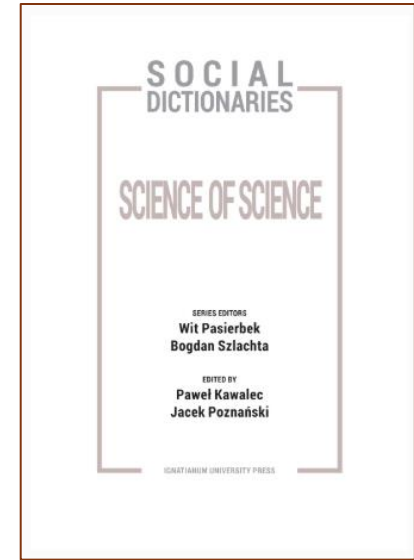


Agenda:

- 1) What is science of science
- 2) Mixed methods research design
- 3) Research routines – an illustration

1) What is science of science

science of science (broadly) – a group of research disciplines concerned with science viewed from three perspectives:



https://www.kul.pl/files/2027/media/plakaty/04/naukoznawstwo_pl.pdf

https://www.kul.pl/files/2027/media/plakaty/04/naukoznawstwo_en.pdf

- 1) theoretical – as a system of knowledge;
- 2) practical – as institutionalized research activity;
- 3) cultural – as an activity within specific historical, social, economic, political, legal, and cultural contexts.

HISTORICAL OVERVIEW

The theoretical foundations of science of science were established before World War II by a group of associates of the Scientific Department of the J. Mianowski Fund, under Stanisław Michalski's leadership.

The demand for knowledge about science stemmed from challenges associated with building a scientific infrastructure from the ground up in the newly reconstituted Polish state, formed from the territories of the three former partitions.

Michalski planned a **research institute** for the science of science, and founded the journal *Organon* in 1936.

In 1927, the term ‘science of science’ (*nauka o nauce*) was used by Tadeusz Kotarbiński, and the term *naukoznawstwo* appeared in the name of the Circle of the Science of Science (*Koło Naukoznawcze*), established in 1928 at the J. Mianowski Fund.

Within this group, Maria and Stanisław Ossowskis delivered a presentation titled *Problematyka naukoznawcza* [*The subject matter of the science of science*]. In 1935, the Ossowskis published an article *Nauka o nauce* [*The Science of Science*], outlining a draft concept for a new academic discipline.

An alternative conception of the field had earlier been proposed in 1925 by Florian Znaniecki in his article *Przedmiot i zadania nauki o wiedzy* [*The Subject Matter and Tasks of the Science of Knowledge*].

In 1963, on the initiative of Kotarbiński, the Commission for Science of Science was established under the Presidium of PAN, and in 1969 it was reorganised into the Committee for Science of Science of PAN.

In 1965, the quarterly *Zagadnienia Naukoznawstwa* (*Problems of the Science of Science*) was launched.

<https://apcz.umk.pl/ZN>

The Polish term *naukoznawstwo* (‘science of science’) gained widespread acceptance in the 1960s.

In English-speaking countries, the term ‘science of science’ was initially adopted as an equivalent, whereas ‘science studies’ came to be associated with the sociology of scientific knowledge.

More recently, *science of science* has been used narrowly to denote quantitative scientometric research.

Equivalent terms in other languages include *scientologie* in French, *Wissenschaftsforschung* and *Wissenschaftslehre* in German, and *naukoviedenie* in Russian.

For Florian Znaniecki science of science embraced broadly understood **knowledge**:

- scientific,
- pragmatic,
- moral,
- theological,
- philosophical.

Each field of knowledge was regarded as a coherent system of ideas governed by its own criteria of truth.

Maria and Stanisław Ossowskis confined the scope of science of science to modern.

Within science of science they distinguished two branches:

- the **epistemological**, which considers science as a distinct mode of cognising the world,
- the **anthropological**, which views science as a specific sphere within broadly defined culture.

Ossofski's five subdisciplines of science of science:

- **philosophy of science** (the clarification of scientific concepts, the classification of scientific disciplines, the general methodology of science);
- **psychology of science** (scientific creativity, the analysis of scientists' research activities);
- **sociology of science** (the relationship between science and economic, social, and cultural life, and other social activities);
- **practical-organisational** issues (scientific institutions, the application of science in practice, legal regulations, and the relationship between science and technology);
- **history of science** (the development of scientific ideas, the evolution of science and its institutions).

Elsewhere, the subject matter, scope, and structure of science of science were generally narrowed, often omitting theoretical foundations.

In J. D. Bernal's 1939 monograph *The Social Function of Science* the science of science was limited primarily to **practical matters** such as the organisation of science and research activity, the financing of science, the efficiency of scientific research, the assessment of science's social functions, and its interrelations with social processes.

In English the term '**science**' contributed to this narrowing, implying focus on the *natural and exact sciences* granting them a privileged status in science of science analyses, due in part to their stronger associations with innovation and the economy.

In Poland there is a long-running **debate** over how the field of *naukoznawstwo* (the science of science) should be organized as a discipline.

<https://slownikispoleczne.ignatianum.edu.pl/index.php/ss/catalog/book/569>

<https://slownikispoleczne.ignatianum.edu.pl/index.php/ss/catalog/book/556>

The disagreement is essentially about the relationship among the various sub-disciplines that study science:

- how autonomous they are,
- what methods they use,
- whether they add up to *one* science or *many*.

I. The federation approach – *naukoznawstwo* is an umbrella term over a set of relatively autonomous disciplines, each examining science from its own angle and with its own methods. It **dominates** standard encyclopedic definitions.

The science of science is essentially a federation of metasciences – history of science, sociology of science, psychology of science, logic and methodology of science, economics and policy of science, scientometrics, etc. – held together by a **shared object** (science itself) rather than by a single unified theory or method.

It is **pluralistic, less hierarchical, and more flexible**, extending to fairly free relations between the constituent fields rather than subordinating them to one master discipline.

Bohdan Walentynowicz, based on UNESCO materials, identified the following areas within the science of science:

- philosophy of science and theory of science;
- ethics of science;
- sociology of science;
- classification of scientific fields and disciplines;
- study of creativity and the psychology of scientific personnel;
- the history of the organisation of science and scientific societies;
- the organisation, administration, and management of research and development;
- economics, productivity, efficiency, and the financing of R&D;
- science and technology statistics;
- planning of R&D and government science and technology policy;
- technology forecasting and futurology;
- comparative science policy;
- science and technology legislation.

Types of subdisciplines within science of science:

1. philosophical (philosophy of science, which includes metaphysics, epistemology, and axiology of science);
2. formal (semiotics of scientific language, formal logic of scientific reasoning, and general methodology of science);
3. humanistic (history of science, psychology of scientific creativity, sociology of science, economics of science, and science policy);
4. applied (bibliometrics, scientometrics, scientific information and communication, science management and organisation, ethics of science, praxeology, and forecasting the development of science).

Branches of the science of science:

- 1) **theoretical** – descriptive and analytical and seeks to understand the nature, dynamics, and functions of science in culture and society (philosophy of science, epistemology, logic of science, methodology of science, history of science, psychology of science, and sociology of science).
- 2) **practical** – normative and synthetic and focuses on the organisation of science, the organisation of research and development, and science policy (praxeology, organisational and management sciences, scientific information and communication, and the economics and politics of science).

The federation approach was criticised for:

- reinforcing the classical disciplinary structure,
- lacking a conception of effective collaboration across disciplines,
- overlooking interdisciplinary issues.
- lacking a method of its own (science of science borrows methods from its constituent subdisciplines).
- redundancy against existing metasciences: how it differs from methodology of science, philosophy of science, or sociology of science – if it adds no distinct method or object.

II. Science of science as interdisciplinary research programs

With the emergence of international institutions (such as the OECD Ministers' Conference (1967), UNESCO's work on science classification and the founding of the International Council of Science Policy Studies in 1974, science of science came to be viewed as especially valuable for addressing **interdisciplinary problems** that fell outside the boundaries of traditional subdisciplines:

- scientometric research on the dissemination of scientific publications and public engagement with them;
- the development of journal rankings,
- indicators of scientific productivity,
- assessments of the economic impact of research and development,
- the creation of methods for forecasting scientific development and evaluating the consequences of scientific applications.

III. The integrative approach to science of science

It aimed at a genuinely **unified discipline** with its own subject matter and a synthetic perspective, in which the partial views are integrated into a coherent whole.

The dominant approach was **systems-theoretic** and **cybernetic**:

science was defined as a **self-organizing system whose development is steered by a stream of information**, providing a theoretical frame meant to unify the field.

This approach remained at a programmatic stage.

It was criticized for over-ambition and unrealizability: the integrative systems conception outran the realization capacity of the small, dispersed community of science-of-science scholars and lacked organizational support from decision-makers.

IV. The practical approach to the science of science

Practical science of science (Kotarbiński: *pragmatic epistemology*) is oriented toward **acting on science** rather than understanding it for its own sake (what science is, how it develops, and what its place in culture is). It is tied to the organization of science, the organization of research and development, and the shaping of science policy. It includes:

- praxeology,
- knowledge of organization and management,
- the information and documentation sciences,
- the economics and policy of science.

Its tasks include the optimal support of scholarly research work by social institutions, especially public administration, with applied subdisciplines such as bibliometrics, scientometrics, science management and organization sitting alongside it.

The practical approach treats science largely as **inputs** and **outputs** – an organized activity to be measured and steered, at the level of national policy but also of institutes and research teams – and it leans on quantitative instruments: scientometric and bibliometric indicators, statistical analysis, foresight, and the like.

The practical approach (esp. the economics of science and science policy) was consolidated after 1967 and, from 1970 onwards, was adopted by organisations such as UNESCO and the International Council of Scientific Unions.

They coordinated and funded research and have guided national governments to establish decision-making bodies, basing their science policy recommendations on empirical evidence and research.

The demand for research to support science policy led to the creation of national and international institutions.

Since the mid-1970s, research in practical science of science – pragmatic epistemology – has become a dynamically developing branch of science of science, complementing metascientific research in the philosophy (theory) of science, supported by the history of science and the sociology of science.

It was also the approach the communist state cared about most, because “science policy” was a lever of control.

The criticisms of the practical science of science:

- political instrumentalization, loss of autonomy and reduction to the ad-hoc tasks of “science policy” rather than independent inquiry.
- the resulting fragility – when it ceases to be useful to politicians it loses administrative and financial backing.
- drift from academic values – importing managerial and economic frames alien to scholarly inquiry.

Phases in the development of science of science:

<https://apcz.umk.pl/RF/article/view/RF.2019.019/17754>

1) a theoretical-philosophical phase (before and shortly after World War II);

2) a political-ideological phase (in the 1950s and 1960s);

3) a socio-economic phase (from the late 1960s);

4) a bibliometric-computational phase (2010 onward).

These phases mark periods of increased activity in particular approaches but do not exclude their coexistence in each period.

RUCH FILOZOFICZNY

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The Science of Science – Some Recent Advances

DOI: <http://dx.doi.org/10.12775/RF.2019.019>

2) Mixed methods research designs in science of science

<https://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-d9a9c81a-5284-43ca-9691-c97bf6d9084d>

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Metody mieszane w kontekście procesu badawczego w naukoznawstwie

Abstrakt. Głównym tematem niniejszego artykułu, w kontekście najnowszych dyskusji w metodologii badań naukowych, jest charakterystyka podejścia badawczego, które pozwalałoby w adekwatny sposób prowadzić badania w zakresie naukoznawstwa. Trudność tkwi przede wszystkim w tym, że badania naukoznawcze obejmują zróżnicowane aspekty, które w bardziej tradycyjnym ujęciu odpowiadają konglomeratowi różnych dyscyplin, ale jednocześnie, oczekuje się – m.in. ze względu na rekomendacje na podstawie badań – że wynik będzie miał charakter spójny i jednolity. Tego rodzaju problem obserwuje się nie tylko w badaniach naukoznawczych, lecz – z uwagi na rosnącą złożoność podejść do przedmiotu badania – również w przypadku wielu dyscyplin w obrębie szeroko rozumianych badań społecznych.

Artykuł zawiera przegląd zagadnień dotyczących jednej z nowszych propozycji metodologicznych rozwiązania powyżej zasygnalizowanego problemu – tzw. „metod mieszanych” – czyli podejścia stosującego w pojedynczym procesie badawczym różne metody badań w celu uzyskania spójnej i kompleksowej odpowiedzi na pytanie badawcze. Po ogólnej charakterystyce metod mieszanych oraz zarysowaniu dyskusji dotyczących ich podstaw, zaprezentowane są argumenty za oraz przeciw ich stosowaniu w badaniach, omówiona jest jedna z szerszej przyjętych typologii metod mieszanych, a także krótko przywołane są nieliczne przykłady badań naukoznawczych wykorzystujących to podejście.

Słowa kluczowe: metodologia, naukoznawstwo, metody mieszane, proces badawczy

Mixed methods in the context of research process in science of science

Research designs:

- 1) Single method approach:** entire research is conducted using either a qualitative or a quantitative method.
- 2) Multi-method approach:** different stages of the research process employ different methods. This is further divided into:
 - i) homogeneous:** All used methods are of the same type (e.g., exclusively qualitative, such as combining participant observation with case studies).
 - ii) heterogeneous:** Combines both quantitative and qualitative methods.

mixed methods research design – a specific case of a heterogeneous multi-method approach, defined as the **combined use of quantitative and qualitative methodologies within a single study** to provide a comprehensive answer to a single research question.

The rationale of using mixed methods:

- eliminating **biases** or **errors** inherent in any single method.
- ensuring that findings from different stages of the process **complement** and **complete** each other.
- gaining a more profound **insight** into the processes or **mechanisms** generating observed results (e.g., using qualitative interviews to explain the results of a quantitative experiment).

The main conceptual **barrier** to mixed methods was the **incommensurability thesis**, which argued that the underlying paradigms are fundamentally incompatible.

Modern methodology has largely moved toward a **pragmatic stance**, which posits that integration is desirable because it allows researchers to overcome the weaknesses of individual approaches and leads to more accurate inferences.

Mixed methods approaches in the science of science

Science of science aims to achieve comprehensive knowledge of science as both a system of social institutions and a research activity.

Methodologically, this approach is most closely associated with mixed-methods research, which integrates various techniques within a single research process to address one complex research question.

Typology of mixed methods approaches is based on:

- **the degree of integration** (partially vs. fully mixed),
- **time dependence** (concurrent vs. sequential),
- **the weight or dominance** assigned to each method (complementary vs. dominant).

3) Research routines – an illustration of MMR

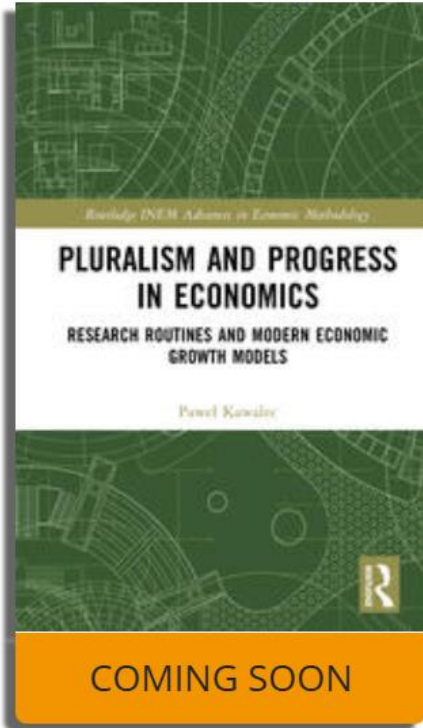
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Research Article
Paweł Kawalec*

**Transformations in breakthrough research:
The emergence of miRNAs as a research
routine in molecular biology¹**

<https://doi.org/10.1515/opis-2018-0010>

<https://www.degruyterbrill.com/document/doi/10.1515/opis-2018-0010/html?srsId=AfmBOop34uPn4J6pR1hWtx7bSmieII-Xo0DTjVZR4AjeitWVBvKAbkwa>



Research routines – characterized as a **meso-level unit of analysis** that integrates qualitative and quantitative arms to capture the continuous yet transformative nature of scientific progress.

<https://www.routledge.com/Pluralism-and-Progress-in-Economics-Research-Routines-and-Modern-Economic-Growth-Models/Kowalec/p/book/9781041138723>

As a mixed-methods design, it is specifically implemented as an **iterated concurrent research design**.

Research routines as a mixed-methods framework:

1. Integration of Qualitative and Quantitative Strands

The research routine design relies on the **mutual interactivity** between two distinct types of investigation:

- **qualitative arm** – involves the analysis of domain-specific **knowledge** to identify symbolic representation.
- **quantitative arm** – tracks bibliometric indicators and social network analysis.

2. Meso-level focus to identify transition phases

- traditional scientometrics – “micro-level” focus on individual publications
- philosophy of science – “macro-level” focus on broad categories (e.g. paradigms, research programs)

Research routines explain the **dynamics** behind observed statistical trends, providing a theoretical underpinning for big data quantitative analyses.

A) Empirical grounding of the emergent symbolic representation in empirical evidence

Solow 1957:

1909–1949 – productivity doubled due to:

1/8 – capital;

7/8 – “technical progress”

B) Nexus

Routines encompass both cognitive dynamics (the development and transformation of symbolic representation) and institutional dynamics (diffusion, training of personnel, funding, and the development of organizational structures).

nexus – a cognitive artifact that serves as a bearer of a **symbolic representation** (e.g., a model) recognized as standard within a given scientific community, which **functionally coordinates research practices** involving its use.

The emergence of nexus marks the beginning of the growth routine's **institutional dynamics (1970 onward)** – a network consisting of publications, research collaboration, and formalized structures, such as doctoral programs or institutes, is built around the nexus.

C) Network dynamics

The maturity of a routine can be measured using social network analysis tools, in particular through the growth of the so-called **giant component** (that is, the largest set of interconnected authors within a given field – a fragmented research community is merging into a unified, collaborative field around the routine).

D) Phases of development: routines pass through various stages: from exploration, through extensions and elaboration, to exploitation applications.