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The Tacit Knowledge Dilemma in Open Science

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"The Tacit Knowledge Dilemma in Open Science" (SIG-KM)

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Background and Motivations

This research project is a work in progress. I began to outline it in a recent paper (Burns, 2021).

The project attempts to connect multiple literatures together including:

- Knowledge management
- Information science
- Scholarly communication
- Learning theory
- Philosophy of science

Burns, C.S. (2021). What documents cannot do: Revisiting Polanyi and the tacit knowledge dilemma. *Information & Culture, 56*(1). doi:https://doi.org/10.7560/IC56104

Tacit Knowledge / Knowing: Polanyi

The project is an attempt to come full circle back to Michael Polanyi (1962; 1966).

His statement, that "we can know more than we can tell," motivated Ikujiro Nonaka's research into organizational knowledge management.

However, Polanyi was a chemist and was thinking about science.

Polanyi, M. (1962). *Personal knowledge: Towards a post-critical philosophy*. University of Chicago Press.

Polanyi, M. (1966). *The tacit dimension*. University of Chicago Press.

Two Driving Questions

What parts of doing science require tacit knowledge?

Does that tacit knowledge raise a barrier to a fully open science?

Science and Rigor

Science is the production of **explicit** knowledge about the observable (social, physical, etc) world and what can be inferred from that.

The production of knowledge in science is not qualitatively different from the production of knowledge generally.

It it only different in rigor:

> "The sciences are not epistemologically privileged, but they are epistemologically distinguished" (Haack, p. 300, 2007).

Haack, S. (2007). *Defending science--within reason: Between scientism and cynicism*. Prometheus.

Science and Transparency

That rigor depends on a transparent science.

In recent years, enabled by newer technologies (web 2.0, etc), this need for rigor has led to a movement called *open science*.

> "Open Science is the movement to make scientific research and data accessible to all. It includes practices such as publishing open scientific research, campaigning for open access and generally making it easier to publish and communicate scientific knowledge. Additionally, it includes other ways to make science more transparent and accessible during the research process. This includes open notebook science, citizen science, and aspects of open source software and crowdfunded research projects" (UNESCO, 2017).

Open Science Movement | *United Nations Educational, Scientific and Cultural Organization*. (2017). Retrieved from http://www.unesco.org/new/en/communication-and-information/portals-and-platforms/goap/open-science-movement/

Transparency, Affordances, and Platforms

Transparency is possible by the technological affordances and the infrastructure and platforms needed to document the production of scientific knowledge.

Codifying Scientific Knowledge in Print

In print-only days, the main technological affordance was the printing press and the infrastructure included the system through which bound journals could be produced and disseminated.

We communicated reports via the paper, which itself over time became a more codified process, delineating the Methods and other sections of an article from its other parts.

Scholarly publishing developed alongside.

Raising the standard

The newer technologies and affordances that we have available to us today have raised transparency standards.

Codifying Scientific Knowledge Today

Those affordances include a multitude of technologies built on the infrastructure that is the internet and the platform that is the web.

These technologies include those that help us to:

- observe phenomena,
- collect our observations,
- store them,
- curate, clean, and process them,
- analyze them,
- disseminate them,
- debate and comment on them.

And all in a more visible fashion than in print-only times.

Scholarly Knowledge Management Systems

These affordances are not usually labeled as KM systems, but they could be because they work the same way.

They manage information and workflows:

Action	Affordance
observe phenomena	Social media, web sites, remote video, etc.
collect, store observations	Science notebooks, spreadsheet apps
curate, clean, process, analyze	Software for analysis, programming languages
disseminate	Data, print, and other research repositories
review, debate, comment	Social media, science blogs, online/open/post peer review

Scholarly Knowledge Management Practices

The production of knowledge is not qualitatively different (Haack, 2007).

Therefore, scientists work in ways that are comparable to other knowledge workers.

They:

- Work in groups and communities of practice
- Use social media/computing technologies to communicate and share information or tacit knowledge
- Follow workflows
- Use technology to manage workflows
- Use knowledge repositories (data repos, paper repos, code repos, bibliographic managers, etc) and integrate those repos into their work flows

All Scientific Knowledge?

But the question raised by Polanyi is:

Whether every part of doing science can be made transparent?

If not, is there some fundamentally important part of the scientific process that is tacit and that cannot be codified?

What resists visibility and codification?

In Polanyi's term, what is tacit in science?

Tacit Knowledge

For Polanyi, tacit knowing is permanently tacit.

It cannot be converted to codified knowledge.

For others, like Nonaka, tacit knowledge can be converted into explicit knowledge (articulation/externalization).

Nonaka was informed by cognitive psychology, which posits similar concepts and possibilities, such as declarative/procedural knowledge or conscious/unconscious knowledge (Anderson, 1983; Augusto, 2011).

Anderson, J. R. (1983). The architecture of cognition. Harvard University Press. http://www.worldcat.org/oclc/1056937264

Augusto, L. M. (2011). Unconscious knowledge: A survey. *Advances in Cognitive Psychology*, *6*, 116–141. https://doi.org/10.2478/v10053-008-0081-5

Subsidiary and Focal Knowledge

What knowledge is tacit for Polanyi?

For him, tacit knowledge is knowledge that integrates **subsidiarily** aware components into a **focal** component.

If we know how to hammer a nail (the foci), we also know how to hold a hammer, aim the hammer, and so forth (the subsidiary).

Knowing how to hammer a nail integrates these subsidiary components and the act of hammering emerges from these subsidiary things.

Science and Rigor

Scientific knowledge is no different than everyday knowledge but simply more rigorous.

Thus, just as knowledge about how to hammer a nail or recognize a face include tacit components, the things we do in the lab, in the field, etc. also entail the same kinds of tacit knowing.

That is, there are things we do in the work of doing science that integrate subsidiarily aware components into a focal component, and that these subsidiary components integrate into a whole that is more than the sum of their parts.

Codifying the Parts of Science

Since the production of scientific knowledge is more rigorous than the production of everyday knowledge, science is epistemologically distinguished (Haack, 2007).

It strongly focuses on the components of that process.

We focus on the subsidiary in order to be rigorous. This has led each scientific discipline to develop thorough methodologies: quantitative, qualitative, or other.

E.g., see the debates, tied to the open science movement, about the use of the p-value statistic:

Halsey, L. G. (2019). The reign of the p-value is over: What alternative analyses could we employ to fill the power vacuum? *Biology Letters*, *15*(5), 20190174. https://doi.org/10.1098/rsbl.2019.0174

Subsidiary and Focal Knowing in Science

What remains tacit in science for Polanyi is something more fundamental.

It's the process of discovery and the process of problem-finding.

Discovery and problem-finding are conjoined.

We cannot discover without first identifying a problem.

> Explicit problem-finding: through analytical means and thus codifiable.
>
> Tacit problem-finding: through creativity, eureka moments---moments when we seemingly integrate the subsidiary into our focal awareness (cf., Bryce, 2014).

Bryce, N. V. (2014). The AHA! Moment. *Scientific American*, *25*(4), 36–41. https://www.jstor.org/stable/24946187

The Open Science Dilemma

So the question remains:

If problem-finding is sometimes a tacit process, and therefore resists or is not codifiable, does this present an obstacle to a truly open science?

For a science to be fully transparent?

Potential Solution: Embedded

I think there are several ways out of this.

First, within information science and documentation theory, there is a growing body of evidence to support the theories of "embedded documentation" and "embodied information practice (Olsson & Hansson, 2019).

These ideas support the possibility that the tacit can be codified, or at least shown, in non-linguistic ways.

Compare this to Nonaka's (1994) concept of socialization: tacit to tacit knowledge conversion.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science, 5*(1), 14–37. https://doi.org/10.1287/orsc.5.1.14

Olsson, M., & Hansson, J. (2019). Embodiment, information practices and documentation: A study of mid-life martial artists. *Information Research, (24)*4. http://informationr.net/ir/24-4/colis/colis1928.html

Potential Solution: Learning Theory

Second, learning theory.

> "The learning strategies are called *holist*, preferring global predicates and relations of topics, and *serialist*, preferring not to use such relations and learning step-by-step" (Pask, p. 87, 1988).

Jahren (2016) describes a similar way of doing science in her book that details her work as a geo-{chemist/biologist}.

Compare this to Nonaka's (1994) concept of *internalization* (explicit to tacit), which he likens to the process of learning.

Jahren, H. (2016). *Lab Girl*. Alfred A. Knopf. http://www.worldcat.org/oclc/928679525

Pask, G. (1988). Learning Strategies, Teaching Strategies, and Conceptual or Learning Style. In R. R. Schmeck (Ed.), *Learning Strategies and Learning Styles* (pp. 83–100). Springer US. https://doi.org/10.1007/978-1-4899-2118-5_4

Knowledge Management: The Firm/Organization

Historically, KM has had a strong focus on organizational knowledge management.

For example, this has long been the focus of KM::

> "Knowledge management refers to identifying and leveraging the collective knowledge in an organization to help the organization compete" (Alavi & Leidner, p. 113, 2001).

But we can easily substitute the organizational with groups attached to conducting research:

> "KM refers to identifying and leveraging the collective knowledge in a research group to help the group produce new knowledge."

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues on JSTOR. *MIS Quarterly*, *25*(1), 107–136. http://www.jstor.org./stable/3250961

Knowledge Management: Applies to Doing Science

The aims of KM in the firm are congruent with the aims of KM in the doing of science:

> "most knowledge management **[and scientific]** projects have one of three aims:
>
> (1) to make knowledge visible ...;
>
> (2) to develop a knowledge-intensive culture by encouraging and aggregating behaviors such as knowledge sharing and proactively seeking and offering knowledge;
>
> (3) to build a knowledge infrastructure---not only a technical system, but a web of connections among people given space, time, tools, and encouragement to interact and collaborate" (Alavi & Leidner, pp. 113-4, 2001).

Other KM Ties

Beyond the production of scientific knowledge, team scientists must manage labs, which function in the way that knowledge workers in an office or firm function.

The management of scientific knowledge and the management of the lab doing science are two areas that could use KM.

When a lab manager or a postdoc leave, e.g., it represents a loss of tacit knowledge that was held by those people and that must be acquired by their successors.

This can impact the efficient functioning of the lab but also the production of scientific knowledge.

Similar Aims Exists in Open Science

Openness (Visibility!) in Open Science

Nosek, Spies, & Motyl (p. 623, 2012) outline three areas that can be opened:

Areas	Benefits
Data	"Inform, critique, and extend prior research ..."
Methods and Tools	"Reanalyze prior data with new techniques ..."
Workflow	"Aggregate data across multiple investigations"

Nosek, B. A., Spies, J. R., & Motyl, M. (2012). Scientific Utopia: II. Restructuring Incentives and Practices to Promote Truth Over Publishability. *Perspectives on Psychological Science*, *7*(6), 615–631. https://doi.org/10.1177/1745691612459058

Benefits of Open Methods and Tools

Specifically:

> "Open methods have the same effect [as open data] and also facilitate progress in reuse, adaptation, and extension for new research" (Nosek et al., p. 624, 2012).

> "Authors cannot identify and report [in publications] every detail that may be important in a method, but many more parts of the methodology can be shared outside of the report itself" (Nosek et al., p. 625, 2012).

- Using video
- Open Science Framework for "documenting and archiving research materials" etc.

Benefits of Open Workflow

To capture what is left out of a report/paper, the registry becomes integral to the scientific workflow.

Example registries and what they do or afford:

- Clinicaltrials.gov for NIH sponsored clinical trials
- OSF.io/registries designed to document workflows
  - Store work
  - Share work
  - Register work
  - Cite work
  - Measure impact via usage analytics
  - Connect services (e.g., Zotero, GitHub, Google Drive, Dropbox etc)
  - Collaborate with others

Technologies in place to support open science work flows

- Electronic Lab Notebooks
  - LabArchives: https://www.labarchives.com/
  - OSF: https://osf.io/
  - Project Jupyter: https://jupyter.org/
- Data Repositories: Recommended Data Repositories from Nature.com
- Manuscript Repositories: arXiv.org and others listed on Wikipedia
- Code Repositories: GitHub, GitLab, and more
- Social Media (general and specific): Twitter, Facebook, WeChat, ResearchGate, Academia.edu

Lots of Research Possibilities

There is a lot of opportunity for future research since current research on these two topics is limited:

- Current Literature: Search string: ["knowledge management" AND "open science"]
    a. Web of Science: 14 records
    b. Scopus: 41 records
    c. Google Scholar: 3K+ records, but low retrieval precision, so probably much less relevant set

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