

The Technology of Science*

Citations in the Light of a Critical Theory of Technology

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What is one of the most distinctive trait of academic writing? Is it the style of writing, the structure of the arguments, or maybe even the quality of the content assured by peer review? While the classic, modern scientific paper in the natural sciences often begins with an introduction followed by the methods, result, and a final discussion, I am convinced that most scholars of the humanities, and even scientists alike, will agree that academic writing comes in many forms. At this point, we will safely disregard the style, the structure, as well as the quality (c.f., [replication crisis](#)) as the one distinctive feature of scholarly writing. Instead, there is one other common element that will be found in most written outputs¹ in academia, which is the practice of citing. While the stylistic markup or frequency of those citations might vary across disciplines, the *scientific norm* of crediting the intellectual work that has influenced the current piece of writing. Both the norm of *scientific honesty* as well its negative pendant of *plagiarism* are two concepts introduced (if not drilled into) to first-year students at universities across the globe.

In this essay, I will attempt to briefly explore how critical theory of technology might be a useful method for the inquiry of technologies of science. I have deliberately used the rather broad term *technologies of science* in this case, as an analysis of different technologies and techniques of science and scholarship is the overarching goal, while this particular

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¹As always, exceptions confirm the rule as we can see in the case of Wittgenstein who is quite vocal about being an exception. In the preface of his *Tractatus Logico-Philosophicus* he notes “How far my efforts agree with those of other philosophers I will not decide. Indeed what I have here written makes no claim to novelty in points of detail; and therefore I give no sources, because it is indifferent to me whether what I have thought has already been thought before me by another.” and, once again, in the preface to his famous *Philosophical Investigations* “For more than one reason what I publish here will have points of contact with what another people are writing today. If my remarks do not bear a stamp which marks them as mine, I do not wish to lay any further claim to them as my property”.

paper constitutes a first attempt to apply concepts mainly taken from Feenberg (2005) to citation practices.

Introduction

The difference of references and citations has been developed by de Solla Price (1963). References are those items A differentiation that had an important impact on the development of academic publishing and especially evaluation. While references are “easily” retrieved by looking at each new publication. The references for an individual piece are usually complete (assuming that no mistakes were made during the writing) but retrieving a complete set of citations is not easily retrievable.

Meaning of citations

Wouters (1999) emphasised the difference between references and citations and described it as a difference in their genesis. While the reference is created by the scientist, a citation is the product of the citation index (Wouters (2016) revisits his position and concurs that the role of the reference in the creation of the citation has been underestimated).

Why do we cite?

Baird and Oppenheim (1994) provide a detailed list of possible reasons for citing:

- paying homage to pioneers in the field;
- giving credit to related work;
- the reference to a standard methodology or piece of equipment that has been used, citing rather than describing it in detail;
- providing broad background to the topic;
- correcting or criticising the previous paper;
- quoting earlier papers that offer corroboration for one’s ideas or claims;
- alerting researchers to your forthcoming work. This will be a forward citation, for example: ‘L.M. Baird and C. Oppenheim, paper submitted to Journal of Information Science’;
- drawing attention to previous work that is not well known, but ought to be;

- identifying an earlier publication from which the author obtained the original idea for his or her work;
- eponymic citation - the first reference to an idea, term or technique that has a person's name;
- citing a major figure because it makes your research look more respectable;
- citing a major figure because you think he or she may be a referee of the paper when you submit it to the journal;
- citing articles that fit the author's perceptions of the journal's readers and what they are expecting. In other words, to fit the characteristics and status of the journal that the author is submitting the paper to;
- citing according to the author's knowledge of the subject area (for example, the author's use of the relevant abstracting and indexing services to get a good idea of the prior literature will affect the articles he or she cites);
- citing according to the influence of his or her mentors. There is evidence [24] that 40% of citations to an author derive from that author's personal influence over the individuals who cite him or her;
- the author's carelessness. Many citations are miscited, and it is obvious the author has never read the original paper that he or she is citing. This is often because the author has copied citations he or she found in some other people's papers;
- the comprehensiveness (or lack of it) of the author's private reprint collection.

In today's time this list might have to be extended by various new types of citing. A few of the more interesting ones might be:

- citing a piece that was retracted in order to either point out the fact or eventually point out a XXX;
- data citations have become a crucial part of scholarly communication, especially in the hard sciences after moments of despair such as the replicability crises;
- citing open source software or openly licensed pieces of code that were used;
- URLs and hyperlinks as citations of alternative online resources that are not traditionally recognized as scholarly outputs (opening a whole new can of worms around the question of resolving URLs, broken URLs, deleted destinations, ...);

I am sure that many more could be found if this exercise is taken seriously, but the choice of my examples was deliberate as it becomes apparent that many of these new forms

of citations are enabled by corresponding technologies. Retractions can be communicated more efficiently as citations indices provide the extent of affected, those that referred to the retracted article, publications; the publication, sharing, and accessibility of datasets have become fundamental (if not a scientific norm) of modern science; similarly, transparency around the choice of computational methods is increasingly becoming the standard in any computational science; finally, the emergence of the WWW and its ubiquity in everyday life are unsurprisingly also seeping into citation practices.

What does it mean?

Some metaphors for citations as recalled by Cronin (2016):

- as scholarly bricks (Price, 1963)
- as signposts left behind (Smith, 1981)
- as applause (Nelson, 1997),
- as gifts (Hagstrom, 1982),
- as forms of reward or income (Ravetz, 1971),
- as tools of persuasion (Gilbert, 1977),
- as pellets of peer recognition (Merton, 2000),
- as paratextual baubles (Cronin, 2014),
- as frozen footprints on the landscape of scholarly achievement (Cronin, 1981)

A Brief History of Citations

I will re-visit the history of citations and briefly address similar practices before the emergence of the western scientific method. Around the 17th century the codification of the scientific writing process ensues and culminates in the introduction of citation styles and, soon after, citation indices. Scholars in informetrics and scholarly communication, and a plethora of **metrics* studies (biblio-, infor-, sciento-, webo-, alt-), still mostly agree that a thorough theory of citations is missing, while the quantitative work is happily continued.

Citations before the scientific method

- Even in the case of the Old Greek mathematicians the role of citations is significant (conflict Euclid vs Aristhotetels)

- In Hadith studies: *Sanadn* and *matn* are (https://en.wikipedia.org/wiki/Hadith_studies#Sanad_and_matn)
- In fiqh: understanding of law and god's rules <https://en.wikipedia.org/wiki/Fiqh>

Citation styles

Bazerman (1988) wrote a chapter on citation styles, *Codifying the Social Scientific Style: The APA Publication Manual as Behaviour Rethoric* is useful as an example for the exploration of the citation style within a socio-political setting.

“The official APA style emerged historically at the same time as the behaviorist program began to dominate experimental psychology. Not surprisingly, the style embodies behaviorist assumptions about authors, readers, the subjects investigated, and knowledge itself. The prescribed style grants all the participants exactly the role they should have in a behaviorist universe. To use the rhetoric is to mobilize behaviorist assumptions.” (Bazerman 1988, 259)

Bazerman (1988) and Small (2016) furthermore address the competitive and confrontational nature of science.

“Scientific discourse emerged as a way to win arguments rather than as a way to avoid them.” (Bazerman 1988, 258)

Different citation styles were established in:

- Chicago: 1906
- APA: 1929 (7 page document)
- MLA: 1977

Citation Indices & The Business of Scholarship

Citation Indices have a crucial role in the analysis of citations and technology. They are at the intersection of the new neoliberal form of education and scholarship consisting of private profit-oriented publishers, the universities as customers and content providers, and finally university libraries as their negotiators and managers of content.

A few examples of important historic and contemporary citation indices:

- *Mafteah ha-Derashot*, 12th century, biblical index
- The Talmudic citation index *En Mishpat* (1714)
- *Shepard's Citations* (citation index for legal research)
- Eugene Garfield's *Science Citation Index* (SCI, later SSCI)
- Elsevier's *Web of Science* (based on SSCI)
- Springer's *Scopus*
- Google Scholar
- OpenCitations run by the Initiative for Open Citations ([I4OC](#))

Citation Indices have been gaining in importance as the commodification of human resources and knowledge also led to an increased demand for evaluations and measurements. Questionable practices such as the h-index or the usage of the Journal Impact Factor (JIF) for the evaluation of researchers were made possible by the emergence of citation indices.

(No) Theory of Citations

Bibliometrics, scientometrics, altmetrics all have in common that they are infatuated with the citation.

How can the critical theory of technology help to formalize a theory of citations?

Interesting that Small (2016, 59) discusses the social and technical norms of scholarship. Brings examples for social norms that derived from practices and technical developments.

Small analyses the relationship between social and technical norms throughout a few historic examples. I argue that the role of technology is underestimated and can be further observed with recent developments.

Citation as technique instead of investigating them as metaphysical constructs.

Wouters points out that indicators derived from citation analyses have “settled themselves firmly in the fabric of science and scholarship” (Wouters 2016, 79). He goes on to call for a material-semiotic approach in citation theory.

Material Impact of Citation Objects

Wouters (2016, 88) suggests a material-semiotic approach to understand citations. He sees structural challenges in the global systems of knowledge production, reproduction, and distribution while increasingly complex dynamics are introduced into the management of science.

Concrete examples of technological dependencies in contemporary scholarship:

Referencing:

- Discoverability of previous literature
- Accessibility of that literature

Citing:

- automated extraction of references
 - still mainly limited to the extraction of the final reference section in articles
 - footnotes are challenging

Instrumentalization Theory & Citation Technique

I will now attempt to understand citations as technology/technique and continue to use Instrumentalization Theory (Feenberg 2005) as an alternative framework for a citation theory.

Feenberg distinguished between the *primary instrumentalization* and *secondary instrumentalization*.

primary instrumentalization stems from the functional relation of the object to reality.

de-worlds object to reveal the affordances and distances the technical subject from the object. This process is repeated in a cycle of decontextualization and recontextualization

secondary instrumentalization stems from its social investments and implementation.

The reduction happening in the primary instrumentalization is simultaneously only possible because of the social determination of the material and its new forms. This

determines the social meaning. Also involves “disclosure” or “revealing” of

Technology contains the social in two different ways: *systematization* and *valuative mediations*

Systematization the social meanings established throughout social interactions which are not governed by a unique logic. (indeterminism of technology)

valuative mediation ethical, aesthetic, and other social norms play into this as the social factors of technical objects

Citation styles seem to introduce the same separation of design and function. Seemingly all citation styles fulfil the same functions that we have previously discussed and their makeup is merely aesthetic and disciplinary.

Increasing importance on the systematization within citations can be observed as described in the differences between pre-modern and modern society. This development is not surprising as citations, are firstly a modern practice, but also they are increasingly being embedded into the neoliberal system.

This requires that the artifact be stripped of most valuative mediations. (Feenberg 2005, 79)

In junction with the assumption that the Mertonian norms might be some of the valuative mediations on citations (Zuckerman 1977, 88) we are now facing the question whether those norms might also be stripped away from citing technique (or other practices and technologies in scholarly communication).

While the traditional narrative suggests that these two realms constitute ontologically different entities, often reinforced by the image (and real world implementation) of separately operating engineering and design departments. UX & design and software engineers, architects and statisticians/engineers.

Harriet Zuckermann, Deviant behaviour and social control in science

The normative structure in science be thought of as comprised of two classes of norms, intertwined in practice but analytically separable: the cognitive (technical) norms and methodological canons which specify what should be studied and how, and the moral norms, expressed as prescriptions, proscriptions, pref-

erences, and permissions concerning the attitudes and behavior of scientists in relation to one another and their research. (Zuckerman 1977, 87)

Henry Small talks about the technical and social norms of science, but repeats the common narrative of two ontologically different entities. As Feenberg suggests within instrumentalization theory both the functional and social need to be treated as two sides of the same coin. Both the primary and secondary instrumentalizations are equally essential and influence each other in the formation of technology (scientific method).

Both technical and social norms are pervasive in science and are critical in regulating behaviour. But their origin and evolution are little understood. Technical norms govern what counts as a conscience and the general procedures we call the “scientific method”. Changes in technical norms are perhaps spurred on by major scientific successes or technical innovations that employ novel methods. If a new method becomes popular and incorporated into general practice, it will eventually be seen as a rule. Social norms may have evolved from general cultural values, but also from new social realities such as the rise of national styles of science and the need to insure the integrity of independent researchers. (Small 2016, 67)

Resisting and Democratization

Open Access as the initial political initiative to demand a democratization of research has now advanced into the democratization of the whole research process and that research process is a highly technical one:

- Open Source and Open Licensed Data at the heart of modern science
- Publication platforms, politics are increasingly intervening (PlanS).
- Citation Indices. New open alternatives such as the Open Citation Index.

Infrastructure & Open Science. E.g., the twitter hashtag and campaign [#DontLeaveItToGoogle](#) (Kraker 2018)

Conclusion

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