

SCIENTIFIC COMMUNICATION AND ITS RELEVANCE TO RESEARCH POLICY

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This paper addresses the relation between developments in scientific communication and research. The developments in scientific communication are related to developments brought about by opportunities provided by the development and wide-scale introduction of modern information and communication technology. However, this paper does not focus on technological developments, but rather discusses how these new developments in scientific communication enable developments in research and research policy, and vice versa. The role of scientometrics and bibliometrics in this context is briefly discussed.

Introduction

Scientific papers are the natural resources for scientometrics and bibliometrics and therefore developments in the nature of scientific papers will affect the way these studies can be conducted. Similarly, scientometrics and bibliometrics may well provide substantial contributions to these developments and will provide some of the measurement tools to observe the consequences for research and research policies.

This paper therefore touches on structural aspects of the change towards an electronic environment of scientific communication. To that end, we make use of conclusions based on in-depth interviews held with individual researchers, research institutions and companies.* Further conclusions are based on field experiences acquired in discussions with partners in electronic publishing.

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* Elsevier Science (1997), "Report of the third round of the Editorial strategy project".

Scientific communication issues

Scientific publishing: Value in the process

In previous papers¹⁻³ we have concluded that the crux of the scientific publishing process is:

"Authors want to publish more, readers want to read less".

This statement characterises in a concise way the key actors, the author and the reader, in the process. Indeed, the author wants to have his work spread to all of his colleagues in the world. Furthermore, we realise that the author not only writes, but also cites, is being cited, is being evaluated and appraised by the system. The author is therefore the most intensive and, probably, most important user of the scientific communication system. The reader, in turn, wants to read everything that is relevant for his research and nothing more; and the reader demands this at the right time and the guarantee from the system that relevant information cannot be missed.

In an electronic environment the above statement on scientific publishing will be even more valid, as the expectation is that an electronic communication environment will allow and stimulate higher selectivity in dissemination and use. Therefore, this statement can be seen as a succinct description of the efficacy and efficiency required in scientific communication and can be used as guidance in further considerations.

A change in the value chain of scientific publishing from the familiar linear information chain from author to publisher to library to reader – and there are many more finely defined steps in this chain – to an interactive communication "network", justifies the question if this is a structural change or just an efficiency increase of the existing chain. This means asking the question for the driving force in this change process. The main driving forces for this change are society-based and technology-based. The societal driving force has to do with the fact that research is already an important factor in the present knowledge-intensive economy⁴⁻⁶ demanding knowledge growth and intensive knowledge management.⁴

Technology is an important driving force as the developments in information technology "empower" the key actors in the system, i.e. the authors and readers. Similarly, research institutions and research enterprises are "empowered" to create new communication systems that increase the efficacy and efficiency of their present systems to an unprecedented level.

These two developments together push a structural change aimed at speeding up the advancement of research, i.e. at reducing the turnaround time of research to societal

implementation. Publications in research are claimed⁷ to be "seminal to the progress of research", and the issue is if this is and will remain valid.

Some organisational issues

There are many different ways of addressing the issue of the organisational framework of scientific communication. In this paper we are mainly interested in its organisation or relation with respect to the entire research process. We can then distinguish three different levels:

1. The first level, the core of the organisation, is the research process itself.
2. The scientific communication process at the second level surrounds this research process. In an electronic environment, the communication process will get more and more intertwined with the research process itself. This is from the research point of view a generally desired development: in fact, the research process needs the communication process for its own, internal efficacy. Therefore, every opportunity to bring these processes organisationally closer together will be supported. The two processes together form the "market" of scientific communication.
3. The third level that we can distinguish, is the product level of scientific publishing. This is the level on which the publishers have been traditionally active. As the entire system is moving into an electronic environment, we see the publishers gradually moving towards the more general communication level or attempting to become a more integrated part of the "market". As we have observed, this "market" is getting more intertwined with the research process.

Forces in the market

It may be helpful to summarise the main forces operating on the above second level of the market with help of the diagram of Fig. 1. This diagram shows four forces each consisting of two complementary pairs.¹

1. The first force is the "actor" force representing the demands of the key actors in the system: the authors and readers. We have observed that in the electronic environment these actors are "empowered" to more possibilities of "self-publishing" activities. Information can be prepared by the author at a much higher technical quality level than used to be the norm.

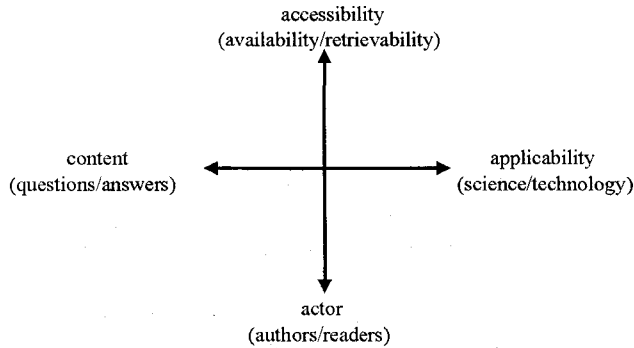


Fig. 1. The forces in the market

2. The other force more directly related to information exchange demands "accessibility". Here the changes in an electronic environment are rather obvious: in general, the "added" value provided traditionally by the publishers and libraries in terms of editorial value, dissemination and disclosure is eroded.
3. The third force is the "content" force. This force is internal to the research process. It is changing with the demands on research that we have seen to be changing because of societal developments. On a different level, there are new options in the representation of scientific content. E.g. scientific content is not restricted anymore to a two-dimensional representation, but can become multi-dimensional by the inclusion of original data sets, and is open for audio-, video- and other representations. Furthermore, there is the development towards dynamic documents.
4. The fourth force demands "applicability". This force represents the societal demands imposed on research and is therefore related to aspects such as the value a particular piece of research. This force carries therefore aspects of appraisal, credit and accountability of research. Strategic research conditions^{1,4} (see also below) make this force at present more prominent. The widespread trend towards strategic research is of relevance to the overall organisation of research in our society and will therefore impact on the "market".

The bottom three forces can be seen as analytically independent, but are interdependent, as the actors are accountable through their content for their research results. The accessibility force is indispensable for these three forces to become effective. It is therefore not possible to treat any of these forces in isolation and to

restrict discussions on the future developments of scientific communication to accessibility only. Such a "subsidiary" view is therefore under debate and must probably be given up.

Strategic research

An extensive discussion of strategic research is given in references.^{1,4,5} In this paper we restrict ourselves to merely discussing the consequences of communication. Whereas traditional research is primarily driven by "internal heuristics",^{1,4} strategic research adds "external heuristics" of the applicability of the research results for – societal – purposes. This leads to a new vision on research accountability, both for the research institution and for the individual researcher.

As communication is very much driven by accountability this development will affect communication in its very nature. The main demand is for research time under the present conditions of abundance of data, which means a trend towards "knowledge management", in particular of applicable knowledge.

Summary

We have seen that a number of developments are influencing scientific communication. Some developments are triggered by the change towards an electronic environment. Other developments originate from the research process, while at present being enabled by this change to an electronic environment. These developments are seen to be mutually supportive and lead to new and yet unknown requirements to the communication process. We should therefore raise the question what these developments mean to communication. Does it for example mean that publications as we know them now will be a degenerating species, while they are not anymore "seminal to the progress of research"? How will for example dynamic documents develop and impact on the communication process? Does the combination of internal and external heuristics mean an intrinsic conflict? These questions require an analysis of the main functions to be performed in the communication system in order to fulfil the demands of the market in response to the actions of the forces.

Communication functions

General introduction

To describe the requirements of the market it has been customary to define the following functions in scientific communication: the registration, archiving, certification and awareness function⁸ as the main functions. A systematic analysis of these functions and their classifications leads to the diagram of Fig. 2.

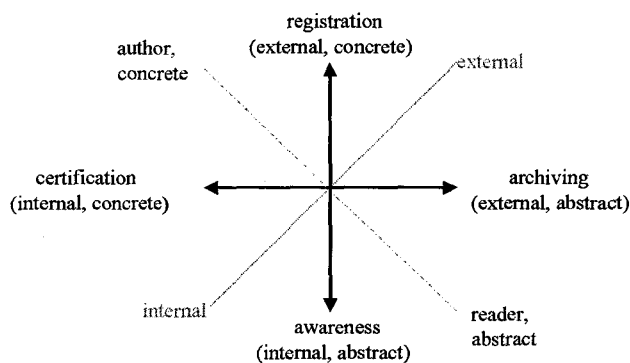


Fig. 2. Functions and transactions in scientific communication

These functions are developed from the point of view of the research process and this view provides a basis for the classification of these functions. Functions are defined such that they are invariant to any frame of reference, e.g. a paper or electronic environment. Because of this independence of a frame of reference, functions lend themselves to classification and thus allow speculation beyond a particular frame of reference.

Two functions are external to the research process and two functions are internal to the research process. Similarly, one can define two "author" functions and two "reader" functions. The two external functions are generally associated with stakeholders that are external to the research process, the registration function with the publisher and the archiving function with the library. These external functions have become external "institutions". In addition, the publisher lends some logistical assistance to the certification function and similarly the library to the awareness function.

By their very nature, the functions also represent different trust relations between the different stakeholders represented in these functions.⁹

Registration function

The registration function has to do with the act of registering the research results of an author. It is the first step in the formal communication process. In principle the author could act for himself with respect to this function, but in the paper environment the usual way of registering the paper is by submitting this paper to a journal published by a scientific publisher.

The electronic environment does not change this function in any fundamental way. The main difference is that the author is now able to submit a finished product himself. This makes the act of self-publishing for the author affordable and reduces the added-value on the part of the publisher if the paper is submitted to a journal of the author's choice, be it a print or an electronic journal.

At present, this registration function is already fully developed and matured for an electronic environment. Further development work is needed in issues such as authenticity, copyright, etc. and in the overall logistical process connected with the registration function. This logistical process is important as it may result in speeding up registration and in handling more complex information than e.g. simple text-based information. Developments in the logistical process are expected to change the balance between the author -and his institution- and the traditional institution connected to this function: the publisher.

The registration function is concrete and external. This function is an author function. In terms of trust, the registration function represents process-based trust, i.e. a trust relation characterised by direct experience between the stakeholders: the author and the journal, represented by the editor and the publisher.

Archiving function

The archiving function represents the "worldwide" archive that the research reader has at his disposal to satisfy his information needs for his research purposes at any point in time. In a paper environment this archive is physically localised.

In an electronic environment this needs not and will not be the case. In an electronic environment there are no limits to the archive, the storage capacity is "infinite" and is certainly not limited by shelf space or building space. Whereas the creation and maintenance of the archive used to be the task of the library – the archiving function

was the library function – and publishers contributed little "archives" such as journals, nowadays both publishers and libraries are developing and creating their own electronic archives. From the research point of view transparency between these disparate archives is mandatory. This leads to the emergence of a distributed, digital archive. This is indeed the main structural direction of the digital archive projects in countries such as the USA, UK and Germany.

Such a digital archive should then integrate *all* communication and information in the research process. This is not restricted to formal communication and information, but should also include informal communication and information. This raises the issue where formal ends and informal starts. "Community services" around journals or sets of journals are being created, and the issue of editorial control separating formal from informal communication has become an issue for discussion.

A distributed archive calls for standards, the present trend being to restrict standards to standards of "interoperability" between the various components of the distributed archive.

The development in terms of organisation is still in its infancy. It becomes increasingly clear that there will not be a single organisation responsible for a digital archive, despite attempts to realise this. A single organisation is apparently inconceivable with a distributed archive. The organisation of the digital archive is a very important issue of trust between the various stakeholders.

The archiving function is an external, but abstract function. It is also a reader function. In terms of trust, the archiving function represents institutional-based trust, i.e. a trust relation characterised by indirect experience between the stakeholders in the process: the reader, the library and the publisher.

Certification function

The certification function has some more technical aspects as well, but in the context of this paper the certification function is primarily related to "peer review". This gate keeping process in scientific communication and information is extensively discussed in the works of Daniel,¹⁰ Garvey,¹¹ Lock¹² and most recently Meadows.¹³ For brevity, we restrict ourselves in this paper to some relevant developments of peer review in connection to an electronic environment. Following Gross,¹⁴ the "peer review" process can be seen as a process of negotiation between the author and the editor of the journal. The negotiation is then on the "claims permissible in a scientific paper".¹¹

At present, we have a "binary" system; the verdict is either yea or nay. Next to the "author" scheme of the author negotiating with the editor of the journal, there is also the "reader" scheme. In this scheme the paper is added to the archive before being certified and is then being certified on the basis of reader reactions. This "reader" scheme requires an "infinite" archive and it is for this reason that within the context of an electronic archive it is now becoming technically feasible and is being proposed.

The electronic environment creates some interesting issues, such as how do we referee forward linking of a paper to future papers not even written or, how are we going to deal with retraction of already published papers that then in the end will fail in the scientific archive? External processes will bring economic arguments into the peer review process. The applicability of the reported research and thus the value added to the user would become part of the appraisal process. These developments may well trigger a departure from the "binary" system to a system in which comments are added to the paper, as proposed by *Zinn-Justin*.¹⁵ This will, in turn, lead to new issues such as: is it acceptable that these comments are anonymous and what does this mean for the accountability of or credit to the -anonymous or named- commentator? If we are going to create dynamic documents how can we separate credit and accountability of the author of one part, say the original dataset, and the second author who is using this dataset to present a new and possibly conflicting analysis and interpretation? This will lead to a concatenation of scientific results and papers, which calls for new ways for the sharing of credit and accountability.

It is therefore not inconceivable that these developments will require a new normative structure different from the normative structure of *Merton*¹⁶ that now largely sets the norm of the present paper-based scientific communication system. In summary, it is expected that the transition to an electronic environment will affect the certification function considerably. As certification is an internal function to the research process this change will have important consequences for research, and research policies.

The certification function is an internal and concrete function. As a concrete function it is an author-related function. In terms of trust, the certification function represents characteristic-based trust, i.e. a trust relation characterised by direct membership between the stakeholders: the author and the reader, the reader being often represented by the journal through its editor and referee.

Awareness function

The awareness function is the *core* function in the research and communication process. The function deals with the process of internalisation of information by the

individual researcher and relates to serendipity and association. The communication process should serve this function in the best possible way. The function is associated with search processes, linking, keywords, indexing, thesauri, metadata and other tools of retrieval.

An electronic environment promises yet untapped possibilities and extensive research is presently being undertaken.¹⁷ There is research based on the self-organising properties of science, not only text-based but also predominantly more symbol-based, such as searching on the basis of e.g. chemical structures or phase diagrams and the parameters contained in such diagrams. Other research is directed towards the so-called modularity of information. The research question then is can we distinguish and use self-contained modules in research papers? This would mean that in future a research article could be composed of a number of modules, either new or already existing in the archive. This would promote the re-use of our research base and reduce duplication in scientific communication. It would mean that the granularity in research information is reduced one level down from the scientific article level. This will have consequences for the research paper, and the use of these research papers for applications in scientometrics or bibliometrics. Indeed, it may well require new scientific indicators that serve serendipity and are instrumental for research policy.

The awareness function is an internal and abstract function. It is a reader function. In terms of trust, the awareness function represents values-based trust, i.e. characterised by indirect membership of the stakeholders in the communication "network".

Scientific communication: Organisational developments

Introduction

In the previous chapter we have seen that we can give a dynamic description of the scientific communication system in terms of its main functions and how these functions develop under the forces driving the system.

In this chapter we will speculate about future developments in the system, not so much technological but organisational developments. Here, the main question is: "is the development towards information exchange *during* the research process, i.e. *under real time conditions*?" Or, will the system essentially remain a scientific publishing system, i.e. information exchange *after* the research process?

The second option means that only the functions are relevant and that they can be developed independently. This means that more than one organisation is feasible and hence probable.

Under conditions of strategic research,⁴ the first option represents the most relevant and most desired development. For this option, both the defined functions and the transactions between these functions are important. This means that we are dealing with essentially one organisation. Next to the impact on the organisation of scientific communication, this will have a serious impact on the research process itself and its policy. The question arises what kind of organisation we can attribute to the scientific communication system. In order to answer this question we will review some characteristics of the virtual organisation.

Virtual organisation

We will analyse the question if some elements and aspects of the virtual organisation might be applicable. Needless to state that its product, the transfer of knowledge, is a virtual product. In this paper we use the definition of *Van Aken*¹⁸ for a virtual organisation: a virtual organisation is a special case of an organisational "network", it is an identifiable unity vis à vis external stakeholders and, as its most important characteristic, its ownership is distributed. A virtual organisation is an organisation of complementary partners, each bringing in his own, complementary expertise.

If we apply these considerations to the scientific communication system, such an organisation could well apply to the engine of this system: the distributed archive. This would mean that sharing of resources by complementary partners is mandatory in order to create such a distributed archive. The question is who these partners will be and distributed ownership needs to be discussed. When we speak about ownership, do we mean the research community, research institutions and organisations, publishers, libraries and other partners in the chain, and possibly entirely new partners?

Furthermore, we learn from the literature¹⁷ that in a virtual organisation strategic management must be strictly separated from operational management. This puts outsourcing in an entirely different perspective, in particular if we realise that we are dealing with four different functions, two internal, certification and awareness, and two external, registration and archiving, to the research process. Such a separation of strategic from operational management requires a rethinking of outsourcing as viewed from the research process and will thus require new schemes of outsourcing at different levels. It raises the question if the functions should not be re-integrated first before such new schemes can be considered and implemented.

Conclusions

In this paper we have dealt with a number of developments in scientific communication and information. We addressed the question of the kind of transformation we are witnessing in the change from a paper-based system to an electronic environment. The analysis on the basis of the forces and functions leads us to conclude that the transformation is not a product transformation, as such a transformation would only be driven by aspects represented in the accessibility force. We have seen that this force cannot be isolated from the other forces in the process: the subsidiarity of the forces has to be lifted. Therefore, transformation is not a technological transformation only.

We seem to be only at the beginning of the transformation process. It is just the tip of the iceberg that we are presently seeing. In this context, investigation of the functions of scientific communication allowing speculations on the developments of these functions provides a useful methodology. The model of forces and functions allows us to guess on how the iceberg extends below the water line.

These developments of the functions allow the conclusion that we are dealing with a structural transformation of the scientific communication system. We have put forward a view of the process as a continuous process of optimisation of these functions, under the action of dynamic forces. To study this process in more detail more research is needed, as is nowadays undertaken e.g. in the various digital library projects. This research should also be devoted to the structural aspects of the scientific communication system. We need to address the issue of the organisation and study further the possible aspects of virtuality of such a future organisation. This research will lean on research in scientometrics and bibliometrics, but cannot be restricted to these methods only.

In short, we are in need of a broad research programme on scientific communication. The methodology needs to be developed beyond the ideas of forces and functions presented in this paper. In terms of these forces and functions, the research should give priority to the functions of certification and awareness. These functions are *internal* and therefore more structural for the development than the external functions of registration and archiving. However, we have observed that it would be erroneous to analyse each function in isolation. Being external, the development of the registration and archiving functions is already somewhat further advanced. With respect to the organisation of the future scientific communication and information system a main issue for research is its structure and management.

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