AMBIGUITIES AND DISCREPANCIES IN THE CRITERIA FOR EVALUATING TECHNOLOGICAL RESEARCH IN MEXICO[1]

Larissa LOMNITZ and Susana GARCIA SALORD
IIMAS - UNAM
Mexico

ABSTRACT

This paper examines the different definitions given by researchers to technological research. It is shown that the definitions are ambiguous, and that competing view points appear through the evaluation process. Their importance in the evaluation processes are considered, as well as the need for different criteria from those used to evaluate basic research. Definitions as well as specific criteria (utility, applicability, impact) are discussed. It is suggested that in the evaluation process a fight for legitimate institutional space and resources takes place opposing academic institutions to newly developing technological research activities.

RESUME

Cet article examine les différentes définitions attribuées à la recherche technologique. On montre l'ambiguïté des définitions proposées par les chercheurs et leur utilisation dans le processus d'évaluation de la recherche. Leur importance ainsi que la nécessité de développer de nouveaux critères d'évaluation (utilité, applicabilité, impact) sont exposées. Il est suggeré qu'une lutte se déroule au sein des instances d'évaluation pour l'acquisition d'un espace légitime et l'attribution des ressources opposant la recherche académique traditionnelle et les nouvelles activités de recherche technologique.

INTRODUCTION

The function of science in a developing country is the subject of permanent debate as the development of an internationally recognized scientific community requires time and considerable resources. Few developing countries have a surplus of the latter and there is frequent reluctance to make this sort of investment when the benefits for these societies are unclear.

There are two basic arguments: first, that a competitive scientific community has intrinsic values as it produces scientific knowledge and fosters the

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[1] A slightly different version of this text has been published in spanish by the same authors in M.A. Campos and J. Jimenéz (eds.), El sistema de Ciencia y Tecnología. Problemas y perspectivas, UNAM, Mexico, 1991.

development of higher education. According to this position the fundamental need is to create conditions favorable to the formation and development of a scientific community in the peripheral countries. Those supporting this point of view concentrate on fulfilling international requirements for the recognition and diffusion of scientific work (the publication of books and articles in reputable journals) without judging whether or not the knowledge produced has any immediate applicability or utility.

The second position emphasizes the importance of producing knowledge with practical uses, or of so-called technological research. The argument in this case is that the promotion of applied science is fundamental as this strategy can lead to the production of technologies which can be incorporated into the productive system. The fundamental criterion of evaluation for this type of work is wether the technological product (prototypes, patents, designs, etc.) aims at solving typical problems faced by the developing countries that is, evaluation focuses on utility.

The need to establish evaluation criteria that act as parameters for assessing the value of scientific and technological work and allow a fair evaluation to be made of the different activities, has become increasingly important. Research funding, the awarding of prizes and social recognition, as well as the assignement of grants and other types of research support have come to depend more and more on decisions made by agencies and organizations external to the institutions where the researchers actually work. The appearance of these decision-making agencies is closely inked to the policies promoting national scientific and technological development, although the demands of the scientific community have also played a role in their creation. We were asked to do this study by one of the grant-awarding agencies in order to facilitate their evaluation procedures.

Budgetary restrictions resulting from the economic crisis in Mexico since the mid-eighties have imposed an urgent need for the various committees to use explicit and clear evaluation criteria, as resources continue to diminish and the number of researchers and groups applying for economic support continues to grow. Generally speaking, the problems of evaluation do not arise when general, abstract criteria are discussed, but rather when the attempt is made to apply these criteria to concrete cases. Hence, the consensus that was achieved at the moment of definition, is lost at the moment of interpretation. The result is a multitude of meanings for the same criterion of evaluation.

This interference is a critical issue since the result of the evaluation determines vital questions such as the possibility of implementing programs of work, of continuing with a particular line of research, as well as having a substantial effect on the motivation of the researchers and their attitude towards their work.

This paper presents the results of a diagnostic study of the problems found in applying criteria to evaluate technological research. We interviewed more than twenty persons working in academic institutions, centers for technological and other organizations which offer consulting and other services. All the members of this group have worked actively for the development of the scientific and

technological community in Mexico. They have participated in various committees and have occupied administrative posts inside and outside the government as well as having been researchers themselves.

Our study detected four types of problems:

- epistemological problems, that is, problems relating to the definition and specificity of the activities evaluated;
- problems arising from the type of work evaluated, that is, whether it is individual or interdisciplinary;
- problems relating to the incidence of factors external to the research (economic, political, institutional) and which have nothing to do with the researcher's training or the quality of his work;
- problems deriving from the form of organization and the particular mechanisms that characterize each evaluation process;

We will describe the epistemological problems here since these are found in the majority of the situations where evaluation occurs.

The epistemological problems of evaluation criteria

The first evidence that we found of this type of problem was the diversity of terms used to designate the activities involved in the tasks that articulate scientific and technological development. The following are frequently encountered: *technological research, technological development, technological innovation, technological transfer.* Such heterogeneity does not cause any difficulties in the everyday development of these activities, since every group or institution adopts its own definitions which serve as guidelines for their work.

However, when evaluations are carried out and different codes are superimposed, a series of difficulties arise, preventing or interfering with the achievment of a consensus a to the value of a piece of work. This is a result of the heterogeneity and the ambiguity of the definitions used as a basis of conceptualization of the various activities involved.

1. The first **ambiguity** consists of the absence of a clear differentiation of boundaries and of a clear indication of the interaction existing between "technological research" and "technological development" (See the definitions in annex).

Some people start out with a concept of technological research as the act of combining elements of basic knowledge in order to achieve new applicable knowledge. This process comprehends the identification of the applicability of basic knowledge to the solution of concrete problems. Thus, technological development is the application of solutions suggested by technological research, adapting them to a particular circumstance and the needs of a particular user. From this point of view, the differences between technological research and

technological development is question of scale: technological research is the product of a laboratory, while technological development is produced in the factory.

Another conceptualization proposes that technological research is a complete process whose product is *applied or applicable knowledge*, whether or not this knowledge is ever used - for reasons that have nothing to do with its quality or intrinsic utility (economic or political reasons, the absence of a user). Thus technological research could be considered as an activity that is autonomous vis à vis technological development.

Yet another viewpoint is that technological research is a stage of technological development, the latter being a complex process which includes research and other tasks like organisation, administration, design, transfer and commercialization.

The problem for evaluation posed in the concepts we have outlined is found in the difficulty of establishing the difference between the concept of research and that of *adaptation* when they are both included as part of technological development. This situation arises because in Mexico, technological development tends to be defined as including a large component of adaptation, or, is actually synonymous of adaptation.

The "principle of technological reality" does not imply only the need to define the concept of adaptation, but also remits us to the concept of "copy", which is also ridden with other ambiguities.

2. Hence the **second ambiguity** is found in the definition and the relationship between *research, adaptation* and *copy*. There is a consensus that "copy" should be understood as *replica* and as using a technology designed in another context exactly as it is when purchased. The important point here is that consensus exists that copy is not technological development but, given the conditions under which copy occurs in Mexico, it should be accepted as part of technological development as it provides the opportunity for training technological researchers (The "Japanese" model).

From the same point of view, adaptation -unlike copy- implies *modifying* a technology in order to make it adequate for this particular conditions in which it will be used. In this sense, adaptation is often identified as a research process. The following arguments are used:

- adaptation assumes or requires a certain amount of research and experimentation that is not of a trial and error nature, but which aims at identifying the particular characteristics of a concrete problem, the design of a solution and the identification of the specifications that are adequate for the context in which the solution will be used.
- adaptation assumes innovation in that it produces something new: the adequate way to resolve the problem.

Thus, what justifies qualifying adaptation as research is that it produces *new knowledge* which is *useful* and *applied*. These arguments give rise to

discrepancies at the moment of evaluation because there is no agreement in the responses to the following questions: What is new knowledge ? An original idea, in the sense that it constitutes progress in the field (as is the case with basic research), or adaptation of something already known but that allows existing knowledge to be applied to a concrete situation ?

What is useful knowledge ? Something that finds a market and is sold, a process of adaptation that implies learning to do things that were not known before in Mexico, knowledge that solves a problem but that is not applied for reasons independent of the producer, or the solution of problems not involving research in the strict sense of the word but which is important to the country and can be applied ?

The argument that support each response generate discrepancies at the moment of evaluation because there is never an agreement regarding a basic question in all the debates: *which of all the activities involved in technological work are research activities and which are not, independently of their relevance to the country and the quality of the work ?*

3. The **third ambiguity** is found in the difficulty in establishing a clear and precise boundary between *technological development* and the *exercise of a profession.*

This difficulty derives from the fact that the process of technological development involves a series of routine activities that consist of taking a set of processes, techniques and available knowledge and applying them to a particular case. That is, technological development includes a series of activities that everyone identifies as the "exercise of a profession" as, for example, agronomy, computer science and, to a lesser extent, engineering.

In the case of agronomy the problem is that the specific work of the discipline presupposes a type of experimentation, seeking to adapt techniques to particular conditions. There is no consensus as to whether these activities constitute research or are simply the normal activities corresponding to the profession.

Another issue is that new technologies aimed at lowering costs which might be widely used, are not recognized as new technologies at the moment of evaluation since they have not been published according to the rules governing scientific publication.

For example, the fundamental problem in computer sciences is whether or not work on modelling or programming should be recognized as original contributions or technical back-up to research.

Evaluation criteria

If we start with the premise that technological development is the production of goods and services for the improvement of products and processes, the activities involved assume specific characteristics that are different from those in scientific research.

Technological development supposes interaction with the user: the latter can be identified at two levels: society and the individual. The impact, utility, and the recognition of the products of technological work are shaped by this interaction, just as the interaction between scientists constitutes the means for the diffusion and validation of the products of scientific work.

The results of technological development should have an application, and this application should have an impact: it should solve a problem or satisfy a need. It is in this sense that we can identify the aim of technological work as the production of goods and services, rather than the production of knowledge.

Therefore the specificity of technological activity means that specific criteria, not included in the evaluation of scientific knowledge, should be introduced. The traditional criteria for scientific knowledge, that is *quality* -making an original contribution to the field- and *productivity*--publication of reports or final results in media accepted by the national and international scientific communities- are joined by the criteria of **utility, applicability,** and **impact.**

According to our study, these are defined by reference to the attributes of the technological product. These are:

- **technical and economic feasibility**: the technological product should not only solve a problem but it should do so in a form that is adequate given the operating conditions of the productive sector in the country;
- **relevance**: the technological product should solve problems and satisfy priority needs related to the development of Mexico;
- the technological product should be **competitive** that is it should represent an advance over existing products in terms of cost improvement and other attributes;
- **commercialization**: the technological product should achieve commercial distribution and use;
- **impact**: the technological product should not only solve a problem and satisfy a need, it should also have users.

These attributes, however, are not conceptualized by means of precise indicators that might serve as guidelines for evaluation, which lead to heterogeneous interpretations. The problem of evaluation can thus be phrased as which products should be evaluated and what requirements should they fulfill.

Various types of products are found in the process of technological development and their characteristics affect the evaluation. These products can be grouped in two types: partial products and final products.

1. **Partial products**

-**protocol**: specifies the problem to be dealt with and the way it is to be dealt with. The problem posed for the evaluation of this product is that if the methodological proposal is not explicitly formulated, evaluation is impossible.

-**report**: this is a type of progress report of the project. It does not allow the quality of the work to be judged. It reflects on the progress made according to the program of activities.

- **technical report**: this is another type of progress report. The content of technical reports can be evaluated in that the quality of the work can be judged from the achievements reported.

- **publications**: this applies to the diffusion of some relevant aspects of the project. The problem, as far as evaluation is concerned, is found in the characteristics of the publications devoted to Technological work. In this field, the activity includes more than the publication of an article; thus, reports are usually more highly valued than articles and books.

- **prototypes**: this is a product, at a smaller scale, of what would be a final product. It can be evaluated according to criteria of utility, innovation, technical and economic feasibility.

-**design**: this is another type of presentation that implies in one sense a result and in another, something that still has to be done. At the moment of evaluation, the question that gives rise to discrepancy is whether the design is the application of something given or the creation of something new.

- **patents**: this is the certification of a process or product that does not guarantee utility, creativity or quality. For this reason, the majority of informants said that patents did not represent a significant product for the evaluation of a piece of work.

2. Final products

For the purpose of evaluation, some of the partial products can be considered as final products, for instance, prototypes, designs and publications. However, strictly speaking, the only final product is the so-called "technological package", the complete and applied solution to a problem with a commercial use.

The problem posed for evaluation by this perspective, is that if recognition were only granted to "technological packages" , very few pieces of work would be acceptable, since the possibility of achieving the package is not the individual responsibility of the researchers or technologists. Many of the circumstances that limit such a possibility are related to wider problems of technology application and commercialization.

CONCLUSION

The ambiguities and discrepancies that arise at the moment of evaluation of individuals and projects express the co-existence of two different orientations in the evaluation agencies: an epistemological criterion which judges the activities as processes and products of scientific research using parameters of quality and productivity, and a principle of technological reality which identifies as research other activities which are closer to adaptation than innovation and which relies basically on criteria of utility.

This is explained by the fact that the evaluation criteria are not "abstractions". Their content expresses different traditions. Each group and work environment

endows its work with certain peculiarities and thus tends toward a particular conception of science and technology.

In this sense we can identify three types of institutions involved in scientific and technological work:

- purely academic institutions, where technological research assumes the same characteristics as basic research and the researchers share the traditional "rules of the game" of the scientific community. Thus they are accustomed to being governed by the latter's evaluation criteria.
- decentralized institutions, where the technological activity is carried out linked with the provision of consulting and other services. This gives the research its peculiarities (the relationship with a client, the confidentiality of results, time and resources stipulated by formal agreements,etc.). It also means that the process includes tasks that are not specifically research tasks. On the other hand, the professional staff of these institutions are not usually trained in the "rules of the game" of academic activity and are evaluated following other criteria.
- centers of technological development, where the activities of research and consulting are carried out in direct relationship with a user. The process is oriented by the rules of the institution and of the agreement with the client. The characteristics of the work are similar to those of decentralized institutions, but there is greater autonomy regarding resources and the rules of the game. The work here is not governed by traditional academic criteria either.

The problem then is **how do you evaluate different traditions with the same rules?** not just with respect to the specificity of the activities corresponding to each, but also with regard to the time scale and the process of formation and development of each. It should be pointed out that the evaluation criteria current in most of the committees existing in Mexico for this purpose are those that are recognized and validated by scientific tradition. At the present time, when technological work is being encouraged, both scientist and technologists begin to share institutional space and to interact professionally. This situation is accompanied by a dispute for recognition and for new "spaces", which involves, without doubt, a struggle for power.

The moment of evaluation is thus one of the "scenarios" where, through the valuation of work and of individual or group performance, concepts are debated and institutional, disciplinary, group , and individual positions are fought over. As a result, the definition and application of evaluation criteria goes far beyond the valuation of a piece of work in terms of its inherent characteristics.

ANNEX

Basic definitions registered in the diagnostic study

TECHNOLOGICAL RESEARCH

- generating new knowledge for the solution of specific problems.
- generating a new way of doing things.
- generating new knowledge that permits the transition from the particular to the general.
- finding solutions to real problems, solutions that were not known previously or that had not been identified as such.
- developing something with existing knowledge that is altered and used for a given end.
- adapting existing knowledge to solve a local problem.
- generating knowledge that means a leap forward can be made in the solution of problems in a more efficient way than any known way up till now.
- improving the applications of what is known, more than getting to know more.
- activity with practical aims, to obtain goods and services.
- generating a new technique that is applied to a new problem that has not been solved by any one up to that moment.

TECHNOLOGICAL DEVELOPMENT

- making a product with a process and a material different from the traditional way, with better costs and attributes as a result.
- using basic applied information, translating it to industrial use by means of designs and products. The product should be competitive: better attributes, lower costs, and advantages from the point of view of service.
- finding technical solutions to different problems, that are economically feasible and of high quality.
- using existing knowledge to propose practical solutions that can be produced economically at an industrial level.
- bringing together known facts to solve a problem.
- adapting existing knowledge, applying it to generate new technology.
- process which consists of: identifying and making a diagnosis of the needs of a user and the particular form of interaction within the system and the culture of the user; developing an alternative that has a real and effective capacity to solve problems that have be detected; effecting a technology transfer, establishing a mechanism of interaction with the user and his system (documentation, advise, training, etc.).

• can be identified to the concept of reverse engineering: finding the changes necessary for a technology to adequate to local conditions and capacities - what is needed in Mexico is to modify the state of practice, more than to advance in the state of the art.
• integrating knowledge derived from technological research or someone's inventiveness into the production process.
• putting an idea into practice, which implies analysis, study, experimentation and modelling. Thus it is creating intellectual contribution, where what is important is not the idea in itself, nor who generates it, but its application.

EXERCISE OF THE PROFESSION

• the search of practical solutions to given problems.
• tacking the available technology and optimizing it for a particular case. This is more the elaboration of a design than the search for answers to basic questions.
• reiterative application of advanced techniques.
• using the knowledge produced by research to deal with given problems.