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In the opinion of scientists: are there rules in research? Pilot study on the most widespread rules of scientific research

En la opinión de los científicos: ¿Existen reglas en la investigación? Estudio piloto sobre las reglas más extendidas de la investigación científica

Na opinião dos cientistas: existem regras na pesquisa? Estudo piloto sobre as regras mais propagadas da pesquisa científica

Paula de la Lama-Zubirán [1, 2] • Alfredo de la Lama-García [3]
Marcelo del Castillo-Mussot [4]

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Abstract

Sociologists, ethnologists, philosophers among others have tried to identify the norms or rules that govern scientific research; however, so far, they have not been widely accepted by scientists. This team followed a different path to identify the rules that govern scientific work by asking researchers if, in their opinion, there are rules in scientific research, and, if so, what they are. An opinion poll was conducted among 270 scientists who received academic training at universities in Mexico, Europe, and the United States, and who work at three universities in Mexico. The instrument is based on a social psychology theory that divides memories into spontaneous and assisted, and a dichotomous probability distribution was used to identify variations. Between eight and nine out of ten researchers from physical, biological, and social sciences recognized that there are four rules for research: *to study reality as it is, have a critical attitude, have a methodological aptitude, and express willingness to openly publish results.* Despite the heterogeneity of the disciplines researchers practice and the variety of their academic training, there is a consensus among scientists about the validity of such rules to conduct scientific research, although most of the time they do not mention them spontaneously.

Keywords: science; epistemology of science; scientific investigation; methodology; sociology of science

Paula de la Lama-Zubirán. [1, 2], p.lamazub@gmail.com, Orcid: https://orcid.org/0000-0001-5735-9581
Alfredo de la Lama-García. [3], adela2422@yahoo.com.mx, Orcid: http://orcid.org/0000-0002-1254-7930
Marcelo del Castillo-Mussot. [4], marcelodlcstll@yahoo.com, Orcid: http://orcid.org/0000-0001-5061-2601
1 Dept. of Economy. Universidad Autónoma Metropolitana, Unidad Iztapalapa, CDMX, México.
2 School of Management. Institut Químic de Sarrià. Universitat Ramon Llull. Barcelona, Spain.
3 Dept. of Philosophy. Universidad Autónoma Metropolitana, Unidad Iztapalapa, CDMX, México.
4 Institute of Physics. Universidad Nacional Autónoma de México, CDMX, México.
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Resumen

Los sociólogos, etnólogos, filósofos entre otros han tratado de identificar las normas o reglas que rigen la investigación científica; sin embargo, hasta ahora, no han sido ampliamente aceptadas por los científicos. Este equipo siguió un camino diferente para identificar las reglas que rigen el trabajo del científico, preguntó a los investigadores: ¿Si en su opinión existen reglas en la investigación científica? Y si es así, ¿Cuáles son? Se realizó una *encuesta exploratoria* de opinión a 270 científicos que recibieron capacitación académica en universidades de México, Europa, EE. UU., y que trabajan de tiempo completo en tres universidades de México. El instrumento se sustentó en una teoría de psicología social que divide los recuerdos en espontáneos y asistidos, y se utilizó una distribución de probabilidad dicotómica para identificar sus variaciones. Entre ocho y nueve de cada diez investigadores de las ciencias físicas, biológicas y sociales reconocieron que las reglas para la investigación son cuatro: *estudiar la realidad tal como es, poseer actitud crítica, aptitud metodológica y disposición para publicar sus resultados abiertamente*. A pesar de la heterogeneidad de las disciplinas que practican y la variedad de la formación académica de los investigadores existe un consenso general sobre la validez de tales reglas para llevar a cabo la investigación científica, aunque la mayoría de las veces no las mencionan de forma espontánea.

Palabras clave: ciencias; epistemología de la ciencia; investigación científica; metodología; sociología de la ciencia

Resumo

Os sociólogos, etnólogos, filósofos, entre outros, tentaram identificar as normas ou regras que regem a pesquisa científica; porém, até agora, não foram amplamente aceitas pelos cientistas. Esta equipe seguiu um caminho diferente para identificar as regras que regem o trabalho científico, perguntando aos pesquisadores: "Na sua opinião existem regras na pesquisa científica? E, caso existam, quais são elas?" Foi realizada uma *enquete exploratória* de opinião com 270 cientistas que receberam capacitação acadêmica em universidades do México, da Europa, dos EE. UU., e que trabalham período completo em três universidades do México. O instrumento baseou-se em uma teoria de psicologia social que divide as lembranças em espontâneas e assistidas, e foi utilizada uma distribuição de probabilidade dicotômica para identificar suas variações. Entre oito e nove de cada dez pesquisadores das ciências físicas, biológicas e sociais reconheceram que as regras para a pesquisa são quatro: *estudar a realidade tal como ela é, possuir atitude crítica, aptidão metodológica e disposição para publicar seus resultados abertamente*. Apesar da heterogeneidade das disciplinas que praticam e a variedade da formação acadêmica dos pesquisadores, existe um consenso geral sobre a validez de tais regras para levar a cabo a pesquisa científica, ainda que a maioria das vezes não seja mencionada de maneira espontânea.

Palavras-chave: ciências; epistemologia da ciência; pesquisa científica; metodologia; sociologia da ciência

INTRODUCTION

Many studies have tried to explain the characteristics of scientific activity. Merton, in his well-known *Sociology of science* (1973), mentions that the scientific community has working standards somehow different from other communities. These include universalism, communism, disinterest, and organized skepticism, all of which protects science from the failings of other institutions. Academic fraud, if it exists, is very rare. This optimistic point

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of view has been criticized by scientists because it is a normative program and not an account of the way in which scientific communities work (Freeland, 2004; Pérez Tamayo, 2008).

From another theoretical platform (postmodernism), Bourdieu's opinion is contrary to that of Merton. For Bourdieu, what is dominant within scientific institutions (laboratories, institutes, disciplines, etc.) is a struggle for scientific monopoly between the great symbolic capitals —highly recognized academics and authorities—, that is, "those who define the rules of the game," and those who recently entered the field and want these rules to be modified to grow their symbolic capital (Bourdieu, 1997, 80-82). What Bourdieu stresses when he focuses on these conflicts is to accept that there will be as many rules as there are fields in science.

Other accounts on the performance of science come from *constructivist* anthropologists and ethnologists (Latour, Woollgar, Knorr-Cetina, Ben David) who focused on the study of scientific culture. The constructivists do not explicitly mention that there are *rules of convenience* in science, but they are very close to the idea of convenience when their most prominent anthropologist, Knorr-Cetina (2013) affirms that "Manufacturing processes (of scientific knowledge) involve *chains of decisions and negotiations* [Emphasis added] through which their results are generated." (p. 61). The relations of convenience that constructivism has privileged for science have been explicitly rejected by the scientists who have studied these authors. Because the constructivists despise the demanding tests to which the hypotheses are subjected to in scientific investigation, Pérez Tamayo (2008) points out that: "Constructivism was inaugurated with the determination to explain the formation of natural knowledge without taking into account its validity or relationship with truth" (p. 168). The most obvious case of this rejection to relativism was manifested by the publication of Gross and Levitt (1998), which initiated the so-called: War of Sciences.

Methodologists have also proposed some rules for research, asserting that if they are put into practice, original knowledge is obtained. The point is that among scientists there are both detractors and apologists of "the method". Perhaps the following statement made by Brezinski (1993) helps to understand the dilemma faced by researchers: "Rare and irrational have their place in any scientific discovery, but a certain dose of method is equally present" (p. 62). Some scientists (Einstein, Heisenberg, Planck, among others) indirectly posed some rules by adopting aesthetic considerations such as beauty, singularity, integrity and causality to accept theories. Others recover concepts such as certainty and truth (Poincaré, 1952). However, they have been criticized by the new generations of scientists, accusing them of rescuing categories that do not respond to the characteristics of current science (Bondi, 1977).

In short, many authors who are close to the field of science have written about the rules that govern it. One wonders whether active scientists have their own opinions regarding the general rules for conducting scientific research. Therefore, this research formulates the following objectives to respond to these concerns:

In the opinion of scientists, are there rules in scientific research? And, if so, what are they?

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THEORETICAL FRAMEWORK

This research seeks to test whether the opinions of scientists —trained in different disciplines and schools— coincide with some rules of scientific research. The importance of gathering opinions is based on an aspect of the theory of the science of human behavior, which asserts that opinions are probably related to attitudes. However, they only represent dispositions for the behavior and actions of the individual (Fiske, Gilbert & Lindzey, 2010). Thus, the opinions of researchers are not necessarily the valid expression of the rules of scientific research; although compared to other opinions, they have the advantage that the source of research emits direct information.

The first approximation to the existence of rules in science requires considering whether scientists believe in them. It should not be forgotten that a heterodox approach is provided by Feyerabend in his classic book *Against Method*, where he claims that in scientific research "that there is not a single rule, however plausible, and however firmly grounded in epistemology, that is not violated at some time or other" (Feyerabend, 1993, p. 14). In social sciences, this statement is especially relevant because what this philosopher says is that if there are rules, to be valid, they must be followed by researchers.

On the other hand, there is Huizinga, who in his also famous book, *Homo ludens*, claims that science, since it studies reality, has no game rules, but its method for obtaining knowledge is a game where rules exist. (Huizinga, 2014). This belief is confirmed by microbiologist Pérez Tamayo (2008), who mentions that "what could be established (through the examination of several or many of them [researchers]) is the existence of the elements that are common to them, what could be called 'the rules of the game'" (p. 49) Then, it seemed that the most appropriate way to find the rules was to look for them among researchers themselves, who are the ones who put them into play. For this reason, we analyzed several publications by renowned scientists in order to specify four possible rules.
According to Schrödinger (1996), the first rule was discovered by Ionian philosophers 2,500 years ago. He believes that it is the fundamental pillar of science. It is a question of believing that "the world as it is has regularities and laws that can be understood through observation" (p. 80). Thuillier (1988), shares this idea: "Science reveals reality as it is" (p. 8), and so does Pérez Tamayo (2008): "Of course everyone [he refers only to his work group] believed in the existence of a real world" (p. 48). Wigglesworth (1987), a biologist, gives it some psychological insight when he claims that: It is recognized that this is a religious approach: it is based on the unquestionable faith that natural phenomena conform to the <laws of nature>. The first question to be tested is: if scientists think that they are actually studying reality as such, is it then a general rule?

The second rule considered by researchers deals with a specific attitude, that is, a disposition to behave in a certain way against the facts. Biologist Ayala centers such quality around testing: "The critical element that differentiates the empirical sciences from other forms of knowledge is the requirement that scientific hypotheses can be empirically dismissed" (Dobzhansky *et al*, 1977, p. 477). Bachelard (1948) characterizes it as a general behavior of the scientific community: "Criticism [...] is necessarily an integral element of the scientific spirit" (p. 21). Thuillier (1988) is of the same idea: "The investigator must exercise his critical senses" (p. 16). Popper (Holton, 1978, p. 190) perceives it as a

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disposition for action: "I came to the conclusion that the scientific attitude was the critical attitude" (p. 190). This attitude, supposedly, controls the skills of the expert and submits them to the unrestricted respect of the results found (Freeland, 2006; Yankelevich, 2016), even if the deviations are unconscious (Gould, 2004). For this rule, we chose Popper's term, *critical attitude*, because it is a disposition to action, a characteristic of human behavior. This second rule was to be corroborated by the opinion of active scientists.

The third rule corresponds to the ability to test assumptions. Reference is made to the skills to carry out an experiment, a field work, or a documentary record, in short, a controlled observation. To acquire these aptitudes, it is necessary to learn and develop a series of skills, sometimes imitated, and others induced. It is known that there exist many limitations regarding technical and theoretical knowledge, as in the correct instruments of the discipline, and there is also a lack of understanding of the errors that could occur, whether random, systematic or natural (Plint, 1978; Wilson, 1952). Getting rid of errors help researchers to verify the assumptions of their research.

Among the researchers consulted, we did not find a term that synthesized all these mental and manual skills, so we proceeded to design it. It was estimated that all the skills described above are synthesized in a single agglutinating concept: *to have methodological aptitude*. That is, possessing the mental and manual ability to test assumptions. The challenge of this research is to test whether this concept is accepted by scientists when describing these skills.

The fourth and final rule to be verified is to determine whether it is necessary for scientists to be willing to openly communicate the results of their research. This rule has been especially emphasized by science disseminators like Bernstein (1978) and Freeland (2004), and scientific editors such as Vizcaíno Sahagún (2002). They highlight the fact that scientists do not often realize the importance of it: "It seems a lie, but there are scientists who do not know how to communicate their ideas, their results. And this is a frequent cause of rejection of articles." (Vizcaíno Sahagún, 2002, p. 23). The question that this research addresses is if this rule has a generalized acceptance in the opinion of the scientists.

To design the questionnaire, we carefully considered Medawar´s remark (1996): "Scientists observe their rules unconsciously, and in the sense that they are not able to express it clearly in words, they do not know it" (p. 32). Schrödinger (1996) has a similar opinion. For him, the fundamental attitude towards science is not evident because: "It has become a common attitude, to the point of forgetting that someone had to plan, make a program and embark on it" (p. 80). If both the aforementioned authors are right, researchers will not spontaneously mention the rules proposed by this study.

To solve the paradox that the rules of scientific inquiry would not be explicitly mentioned or recalled, nonetheless accepted by researchers, we used the theory of *aided recall*. It identifies two types of qualitatively different memories: a) The *spontaneous recalls*, which are mentions freely expressed by the respondent on the treated problem, and; b) The *aided recalls*, which occur when the pollster helps, through direct questions, the respondent to remember the problem investigated. (Glasner, 2011; Baack, 2008; Danaher & Mullarkey, 2003; Zinkhan, Locander & Leigh, 1986). In question two of the questionnaire, the researcher was to respond spontaneously to what he considered to be the rules of

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inquiry. From question three to six, the interviewer asked them about the four proposed rules, so that the scientists surveyed could remember them. Respondents who listened to each rule expressed their expert opinion, in order to accept or reject each of them as part of their professional practice.

THE METHOD

To answer the questions of this research it was necessary to survey the most representative people in the process of scientific research, namely (and more probably), those persons engaged full time in university, research centers, or other scientific communities. In general, scientists of this nature have been educated in an institution, whose tradition of work and values have left an imprint on them somehow (Bourdieu, 1997). For this reason, the variable used in this research corresponds to the place where the scientist, who works in a university, carried out the studies that allowed him to obtain their highest degree, at the moment of answering the survey.

Getting a representative sample of such a large community required visiting numerous higher education institutions around the world, and that was beyond the possibilities of the members of this team. However, we were fortunate to have access to researchers trained in most parts of the world at our own workplaces. “The obvious reply to any accusation of inbreeding is that it would be foolish to seek the nominees in distant lands when they may be in their offices on the other side of a corridor” (Curtis, 1970, p. 15), or in a nearby building or university. Thus, we decided to work with a *pilot, non-representative and intentional* sample conducting surveys only of full-time researchers and professors-researchers. For this reason, the results are tentative and exploratory.

The sample

By following the criteria above, we obtained the views of 270 academically trained scientists from a wide range of higher education institutions around the world, with the exception of Oceania, Asia and Africa. This means that the respondents attained their highest level of education in Mexico, the European Union, Great Britain, Russia, the United States, Canada, and the rest of Latin America (see table 1), usually postgraduate studies (87 %, see Table 2).

Table 1. Countries of origin of the last studies of the respondents.

Mexico	73
UE, Great Britain and Russia	24
USA y Canada	8
Southamerica, Central America and the Caribbean	5
Total	100
Surveyed	270

Source: opinion poll to Scientists at UNAM, UAEM Y UAM.

The respondents gained their scientific qualifications in a variety of educational institutions, from classical institutions such as Cambridge, Sorbonne, Complutense,

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Lomonosov, UNAM, or Berkeley, to modern institutions located in cities such as Glasgow, Edinburgh, Barcelona, Copenhagen, Mexico City, Los Angeles, or in other prestigious but less well-known educational centers such as U. de Eötvös Loránd, UAEM (Mexico), Heildelberg, among others.

Table 2. Level of Studies of the respondents

Doctorate	69
Master´s degree	17
Bachelor´s degree and specialization	14
Total	100
Surveyev	270

Source: opinion poll to Scientists at UNAM, UAEM Y UAM.

Field work.

University students, previously trained, carried out the field work within three universities: Universidad Nacional Autónoma de México (UNAM), campus Ciudad Universitaria; Universidad Autónoma Metropolitana, campus Iztapalapa, and Universidad Autónoma del Estado de México (UAEM) in ten faculties (see Table 3). The result of this first effort was encouraging since there were few rejections (3.6% out of 280 trials) and 30% of the respondents broadened their opinion. All these comments were recorded, which enriched the subsequent analysis.

Table 3. Surveys carried out by University.

University	Total
UNAM	36
UAM	34
UAEM	30
Total	100
Surveyed	270

Source: opinion poll to Scientists at UNAM, UAEM Y UAM.

The respondents´ areas of specialization were very varied, and we classified them into three major divisions: 1) Social Sciences, 2) Physical Sciences and Engineering, and 3) Biological, Health and Agricultural Sciences (see Table 4). Members of the disciplines of Literature, Linguistics, Law, Philosophy, Architecture and Communication were excluded from the survey.

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Table 4. Respondents' work area

Science	Total
Social	54
Physics, Chemistry and Engineerings	23
Biology, Health and Agriculture	23
Total	100
Surveyed	270

Source: opinion poll to Scientists at UNAM, UAEM Y UAM.

The questionnaires were answered by researchers or professor researchers located in the offices, classrooms or laboratories of the three aforementioned university faculties and institutes described in Table 5.

Table 5. Faculties and institutes in which scientists from natural and social sciences were surveyed

Area of physics, engineering and chemistry. It groups researchers surveyed in:	Area of biology, health and agriculture. It groups researchers surveyed in:	Area of social. Groups researchers surveyed in:
UNAM (University city) Institute of Nuclear Sciences, Institute of Physics, Institute of Applied Mathematics Research, Faculty of Physics (Sciences). **UAM** (Campus Iztapalapa) Academic Division of Basic Sciences and Engineering (CBI) **UAEM.** Faculties of Physics and Engineering.	**UNAM** (University City) Biological Sciences, Sciences of the Sea and Limnology, Earth sciences, Faculty of Biology and Faculty of Veterinary Medicine and Animal Science **UAM** (Campus Iztapalapa) Academic Division of Biological Sciences and Health (CBS) **UAEM.** Faculties of Biology and Medicine.	**UNAM** (university city) Institute of Economic Research. Faculties of Accounting and administration, Economy, Psychology and Political and Social Sciences. **UAM** (Iztapalapa campus) Division of Social Sciences and Humanities **UAEM**. Faculties of Administration, Economics, Political and Social Sciences, Psychology and History.

Source: Opinion poll to 270 scientists at UNAM, UAEM and UAM.

The questionnaire

The questionnaire was designed to record opinions on two types of memories: spontaneous, and aided or helped (Glasner, 2011; Danaher & Mullarkey, 2003; Zinkhan, Locander & Leigh, 1986). The first question results divided the surveyed scientists into two groups: those who do not believe there are rules in scientific research and those who do. In this way, we could identify the proportion of researchers who spontaneously expressed they did not believe in the rules of research.

Researchers who answered that there were rules indeed were asked: what the rules were. This open question allowed us to identify the rules that are freely expressed. If the answers to such question mentioned, hinted at, or suggested any of the four rules proposed by this study, then the assumption that they are not spontaneously remembered

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was rejected. If, on the other hand, respondents did not mention them, we assumed two things: they were not rules for scientific activity or they needed help to remember.

In order to test whether the rules proposed by this study are accepted by the investigators surveyed, even if they did not spontaneously remember them, were designed four other questions, what it were mentioned to all the respondents, including those who said there were no rules (we wanted to confirm their opinion). If the investigators surveyed reject any or all of rules they are reminded of, then these rules will be rejected as agreements governing scientific research. If, on the contrary, the scientists surveyed approve them, then the accepted rules will be considered as the rules of scientific research, in the opinion of researchers. The questionnaire is included in Appendix 1.

The statistical test

We carried out a statistical analysis per question and developed a dichotomous scale of the responses; in this way, we determined the variability of the averages. The binomial test was applied with parameter p (affirmative answers) with 95% confidence interval (Miller, Johnson & Freund, 1995), as the sample has 270 events (responses) the distribution is approximately normal (two-sided test) with 95% confidence level.

ANALYSIS AND RESULTS

The findings of this research were divided into two parts according to the level of memory demonstrated by the surveyed scientists: First, those that responded spontaneously and directly, and that related to the four rules proposed (answers 1 and 2); second, those who were reminded of them, based on direct questions asked by the interviewers (questions 3, 4, 5 and 6).

The analysis of spontaneous recall

The first question imitates a student asking a scientist: Do you think there are rules or agreements in scientific research followed by most active scientists? The answers divided researchers into two groups: a) those who actually believe there are rules in scientific research (80 %) and, b) the rest (20 %) who think otherwise (see graph 1).

Some respondents stated their reasons for believing that there are no general rules: “There is a distinction between hard sciences (natural sciences) and social sciences, and between different objects of study.” Another respondent said: “In the social sciences there are no agreements, in basic sciences there are,” and “There is an empirically proven methodology, whether they follow it or not, I do not know”.

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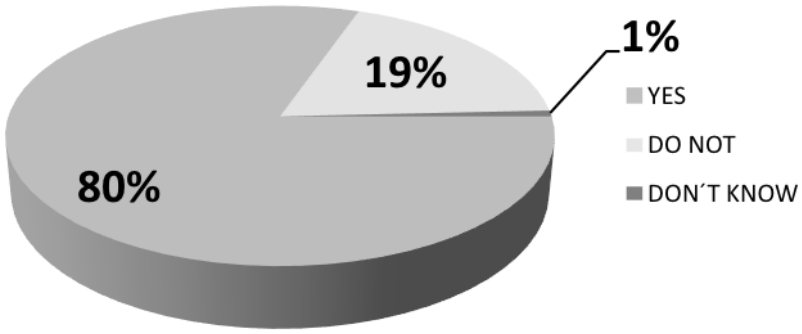
Graph 1. In your opinion do you think that there are rules or agreements in scientific research continue most active scientists?



Note: The 95 % confidence interval and its variation is ± 4.6 Are there rules? Source: Opinion poll to 270 scientists at UNAM, UAEM and UAM.

The surveyed scientists whose opinion was that there are rules in scientific research were asked the following question: "Could you mention some of these rules or agreements?" The spontaneous answers given to question 2 were grouped under two categories: 1) Those that directly or indirectly responded to the four rules proposed by this study -bold-, see Table 6.

From the four rules that were mentioned spontaneously, the most frequently remembered was *to have a critical attitude* (13 %). This rule occupies the third range mentioned spontaneously by the researchers surveyed (see Table 6).

The second rule mentioned spontaneously was *methodological aptitude* (8 %), which occupies the sixth rank of the rules remembered freely (see Table 6). Examples of the most significant comments are: "Development of instruments," "Precision," "Rigor in research," "Corroborate the experiments," and "Discipline, perseverance".

The other two proposed rules —*open publication* and *study of reality*— were not mentioned so frequently (2 % each). Some of the researchers' comments on these concepts were: regarding the first rule that "Everyone agrees on peer review for publication," and as for the other rule, "That's what science is usually about".

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Table 6. Answers to question 2. Could you mention any of these rules?

Agreements or rules	Mention of rule	They do not mention it
Follow the scientific method. (1 range)	34	66
Follow institutional regulations and guidelines (2)	17	83
Must be published (3)	13	87
Possess Critical Attitude (3)	13	87
To Have ethics or bioethics. (3)	13	87
To have methodological aptitude (6)	8	92
Training of Human Resources (7)	5	95
Produce original things (7)	5	95
To be linked to society (9)	3	97
I do not remember them (10)	3	97
Publish openly (11)	2	98
Study reality as it is (11)	2	98
Anothers	15	85

Notes: Each agreement or rule is compared to the total of respondents to be evaluated independently of the other rules. It includes respondents who did not believe there were rules in the research (question 1). The confidence interval is 95 % for each rule and its variation ranges from ± 7.43 to ± 5.1 Source: Opinion Poll to 270 scientists surveyed at the UNAM, UAEM and UAM.

The analysis of aided recall

Questions 3, 4, 5 and 6 of the questionnaire were designed in order that scientists accepted or rejected the four rules proposed by this study. All the scientists surveyed were asked these questions, including those who originally denied that there were rules in scientific research (20%). For this reason, the proportions of graph 2 include the total of the sample (270 researchers).

Question three was: *Do you think that one of the rules is to consider that in nature (or society in any case) there are laws or regularities that can be explained through observation and reasoning?* The affirmative answers amounted to 86% ± 4.19 of the surveyed scientists. The negative responses to this question amounted to 12%, and the answer "I don't know" to 2% (see graph 2, column 1, 2 and 3).

The fourth question was: *Do you consider that another rule would be that the researcher must have a critical attitude towards the object of study? That is, must scientists develop the ability to analyze the information contained in any research in an objective, impartial, verifiable and systematical way?* The affirmative answers given by the scientists surveyed totaled 88% ± 3.86 (see graph 2, column 4).

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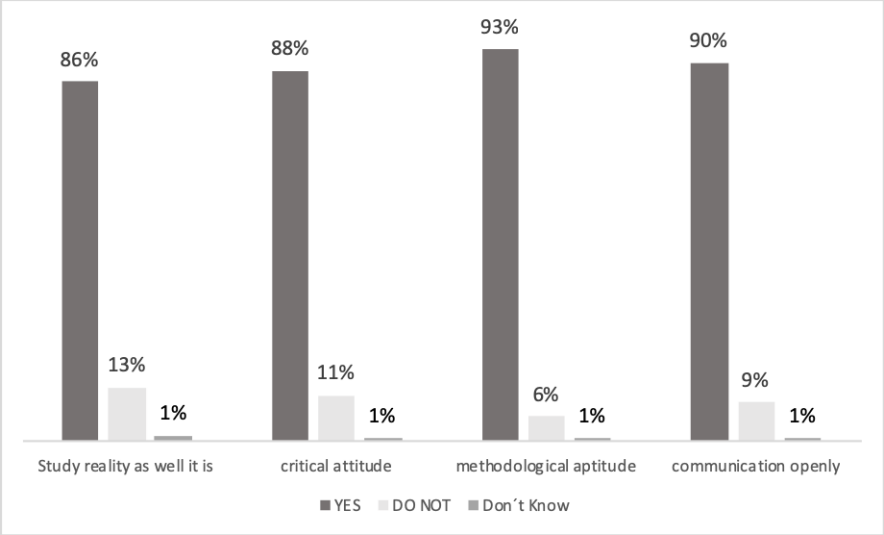
The rule related to instrumental and technical ability was assessed in question five and was put forward as follows: *Do you think another rule is to have methodological aptitude? That is, possessing the ability to use procedures, tools and techniques to test your assumptions?* The positive responses of the scientists surveyed were 93% ± 2.98, and, comparatively, it was the one that had the highest level of acceptance (see graph 3, column 7).

The last rule evaluated by the surveyed scientists relates to the report of scientific results, and was raised in question six: *Do you think that another rule would be that scientists must be willing to communicate their findings openly? (That is, that the results are verifiable or replicable).* The affirmative answers also registered a high percentage (90% ± 3.58, see graph 2, column 10).

Graph 2. Answers to questions 3, 4, 5 and 6 of the questionnaire



Note: The confidence interval is 95% for each rule and have a variation of ± 4.19 to ± 2.98
Source: opinion poll to 270 scientists from UNAM, UAEM and UAM.

DISCUSSION

It must be remembered that one of the main restrictions of this research is due to the fact that the sample is intentional and is not representative of the studied universe. This is a pilot study, so stricter tests must be performed to verify its generalizations.

It should be emphasized, that the opinions of scientists only represent their willingness to act, and are not necessarily the manifestation of the actions they follow when conducting their research. As expressed by Medawar (2013): “It is not easy, and it will not always be necessary, to draw a clear distinction between scientists who ‘actually investigate’ and those who perform scientific operations, apparently by heart” (p. 8). However, active scientists from any of the two classes mentioned by the author gave their

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opinion about the rules that guide their performance, and we had the advantage of counting with a direct source.

Another element, which is worth mentioning, is that this research resorted to a number of novel concepts. Perhaps the most innovative one, which is not found in specialized search engines and dictionaries, is *methodological aptitude*. We mentioned it in question 4 of the questionnaire, and it brings together all the skills involved in testing the hypothesis (knowledge, procedures, instruments and techniques). It was coined because several scientists had emphasized that it was not easy to list and perfectly know all the skills and experiences corresponding to this part of their professional work. For example, Budker (1982), experimental physicist, claims that "There is a set of elements of each day and hour of work that are not described in the manuals, nor in the monographs, nor can they be described in them" (p. 129). Another novel concept that we used here is associated with the willingness to do something (attitude) with the procedure that should be assumed by the scientist in face of the facts (meaning to be objective, rational, seek verifiability and systematization, etc.). From both categories —which the majority of surveyed researchers accepted— we developed the concept *critical attitude*.

The fact that scientists recognized both essentially new concepts refutes the idea that their responses follow a tradition or shared vision about what they consider to be their activity.

CONCLUSIONS

According to the results *pilot exploratory survey* carried out, we can claim the following: It was *provisionally* proved that when the scientists referred to the rules of scientific investigation spontaneously, their ideas are quite varied and most of them do not mention the rules that this study proposed.

The study also *provisionally* proved that there is great uniformity in the opinions of scientists when they are helped to remember the following rules: to understand reality through observation, to possess a critical attitude, to methodological ability to verify assumptions and the capacity to openly publish results. Finally, they accepted that these were the rules that govern the practice of scientific research.

The fact that the four rules are widely accepted when recalled by the scientists, but at the same time not mentioned explicitly and spontaneously by the researchers before that, could result in possible interference in their understanding, learned and practiced. If active researchers ensure these rules are perfectly evident to their apprentices and students, the number of young people willing to successfully follow in their footsteps will likely increase.

CONTRIBUTIONS.

The authors' participation in the design of the problem, instrument, and test, as well as the field work, tabulation, analysis, writing, and article reviews were as follows: P.L.Z. (40%); A.L.G (35%); and M.C.M. (25%).

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DATA AVAILABILITY STATEMENT.

The data supporting the results of this study is available as "supplementary files" on the Uniciencia website.

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Appendix 1

Cuestionario

Buenos días, tardes etc.
Somos un grupo interdisciplinario de estudiantes y especialistas de diversas universidades de Latinoamérica, estamos interesados en conocer las opiniones de los científicos en torno a su trabajo profesional. ¿Sería tan amable de contestar seis breves preguntas? Muchas gracias.

¿Es Ud. investigador o profesor investigador de Tiempo Completo? Sí ( ) No ( ) cancelar entrevista

En qué carrera o instituto labora _____

De qué Universidad (y país si no es México) _____

1. En su opinión ¿Cree que existan reglas o acuerdos dentro de la investigación científica que sigan la mayoría de los científicos en activo?

Sí ( ) No ( ) pasar a la p. 3 No sé ( ) pasar a la p. 3

2. ¿Podría mencionar algunas de estas reglas o acuerdos? No las recuerdo ( )

3. ¿Cree que una de las reglas sea pensar que en la naturaleza (o en la sociedad, en su caso) existen leyes o regularidades que pueden ser explicadas a través de la observación y el razonamiento?

Sí ( ) No ( ) No sé ( )

4. ¿Estima que otra de las reglas sería que el investigador tenga **actitud crítica** frente al objeto de estudio? Es decir, que desarrolle la capacidad de analizar de manera objetiva, racional, verificable y sistemática la información contenida en toda investigación.

Sí ( ) No ( ) No sé ( )

5. ¿Cree que otra de las reglas sea tener **aptitud metodológica**? Es decir, posea la capacidad para recurrir a procedimientos, instrumentos y técnicas pertinentes para probar sus supuestos.

Sí ( ) No ( ) No sé ( )

6. ¿Considera que otra de las reglas sería que el científico esté dispuesto a **comunicar los resultados encontrados de manera abierta?** Es decir, verificable o replicable.

Sí ( ) No ( ) No sé ( )

Por último ¿Cuál es el grado máximo de sus estudios Dr. ( ) Mtro. ( ) Lic. ( )

En qué especialidad _____ En qué país estudió _____
¿En qué institución estudió su posgrado? _____
Con el objeto de informarle del resultado de esta investigación y eventualmente para fines de supervisión de este cuestionario ¿Podría proporcionarnos su mail? _____
Esto es todo. Muchas gracias.

Nombre del entrevistador _____
En caso de cualquier aclaración favor de comunicarse con el Dr. Alfredo de la Lama al correo electrónico adela2422@yahoo.com.mx
Nota al entrevistador: escriba atrás cualquier comentario que haga el investigador. Por ejemplo, si condiciona alguna de las respuestas del cuestionario.

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