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Intellectual Virtues and Scientific Endeavor: A Reflection on the Commitments Inherent in Generating and Possessing Knowledge.

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Abstract

In this essay, I reflect on the implications of intellectual virtues in scientific endeavor. To this end, I first offer a depiction of scientific endeavor by resorting to the notion of academic attitude, which involves aspects concerning the generation and possession of knowledge. Although there are differences between these activities, they have in common the engagement of diverse intellectual agents (scientists). In this sense, I analyze how intellectual virtues are linked to 1) scientific research tasks, such as theory appraisal, and 2) those tasks of vigilance and intervention in the uses of scientific knowledge. I conclude that intellectual virtues play a leading role in achieving higher quality scientific research and adequate foresight on the uses and impacts of scientific findings. In this order of ideas, I propose an agenda for further inquiries on these matters, highlighting the relevance of reflecting and empirically researching the relationship between intellectual virtues and science, as well as cultivating intellectual virtues in various stages of scientific training.

Keywords: Intellectual virtues, scientific endeavor, scientific research, knowledge generation, possession of knowledge, scientific responsibility.

Introduction

Since the mid-20th century, two issues with science as their main protagonist have gained increasing interest. On the one hand, a persistent reflection has germinated around understanding the procedure of science and the scope of algorithmic rationality conceived in the heart of the logical positivist tradition. On the other hand, various discussions driven by philosophical and social studies on science have addressed the implications that scientific knowledge can have on society. Justifiably, specialists in these issues have paid particular attention to the human dimension of scientific work and all that this entails: the fallibility in the judgments of researchers, their axiological burden, the network of social factors and personal interests that influence scientific practice, and a long etcetera.

Using the characterization of Collins and Evans (2002), it is possible to distinguish three major waves in the approach to this type of question. The first is concerned about the success of science and the social factors that explain it; meanwhile, the vision of the relationship between researchers and questions related to the social implementation of scientific knowledge was rather authoritative and characterized by an optimistic attitude towards the impact of science in the world (see, for example, the famous report by Bush, 1945).

The Second Wave of science and technology studies was particularly nurtured by socio-historical approaches, which led to methodological pluralism and the conviction that scientific objectivity is a problem involving different dimensions (i.e., epistemic, social, psychological, etcetera). Scientists were thus no longer conceived as authority figures capable of pronouncing unequivocally on technical issues of a social and environmental nature.[1] In this sense, the characterization of the relationship between science and society becomes one of blurred boundaries. If scientists were unable to resolve expeditiously and accurately the internal controversies within their respective disciplines by appealing only to scientific aspects (theories and methods), it was even more complicated to expect their resolution in decision-making involving the bulk of the social system and its problems.

Thus, in the Third Wave (Collins & Evans, 2002), the main issue is that, while the fallibility of science and the difficulties in achieving scientific consensus expeditiously have been recognized, how is it possible to defend the legitimacy of science in various social, political and environmental spheres? In this vein, are crucial the conceptions of expert and expertise, for although it continues to share with the second wave the conviction in the fallibility of science and the difficulty of achieving scientific consensus, it is nevertheless recognized that scientists play a fundamental role as experts in questions related to its field of work (Collins, 2018; Collins & Evans, 2007). Along with these concerns, there has also been a growing interest in ethical issues that point to the socially responsible development of scientific research, as well as the sustainability and social desirability of technological innovations, especially in the face of a scenario characterized by environmental, demographic, health and economic crises (Owen, Macnaghten, & Stilgoe, 2012).

At this point, it is relevant to observe that the activity of scientists, both in terms of basic research and forecasts about the socio-environmental impacts of science, is far from being an algorithmic and impersonal process. Instead, it is convenient to think of such activity as a human and cognitive practice that requires the judgment of subjects committed to their inquiries, deciding between various theoretical alternatives according to specific values and norms. In this order of ideas, we can take into consideration what Knorr-Cetina precisely asserts:

> ... The practical success of science depends more upon the scientist's ability to analyze a situation as a whole, to think on several different levels at once, to recognize clues, and to

> piece together disparate bits of information, than upon the [scientific] laws themselves (Knorr-Cetina, 1981, p. 3).

In other words, from this view, scientists are far from being considered perfect objective reasoners that apply predefined rules for every situation that challenges them. Instead, they are considered human beings embedded in a social context. Succinctly stated, scientific research and monitoring the impacts of scientific and technological knowledge are featured by uncertainty and difficulty in establishing definitive judgments on various issues. However, one should not understand this as an impediment to reaching sensible and well-founded conclusions on such matters since it is also true that the active role of scientists is a critical element in both forms of activity.

By renouncing the assumptions of algorithmic and uncontroversial rationality but considering the fundamental role of scientists, the conception of scientific endeavor that I intend to develop in this essay puts great attention on the responsibilities of scientists. One should note at once that these are twofold (but not dissociated) (Rhodes & Sulston, 2010): on the one hand, there are those issues concerning the generation of knowledge, such as the design of rigorous experiments, data collection, and the choice between rival theories; moreover, those matters related to surveillance and intervention about uses and impacts of scientific knowledge in various social spheres.

Although each of these issues is notoriously different, they share the agency of expert subjects in specific fields of knowledge who are committed to activities of a markedly epistemic nature, as well as an environment of uncertainty. To address these types of issues, it is essential, in the first instance, to recognize the strong relationship that both forms of responsibility have with scientific endeavor and, secondly, an approach is required that can account for the tasks that take place in the epistemic and intellectual sphere, both about knowledge generation and epistemic vigilance. In addition, the responsibility issues that interest me here are not limited to a question of skill or ability but also require considering an attitudinal or dispositional aspect to act following certain norms.

In this context, the worth of the so-called intellectual virtues emerges with particular interest given that, as will be shown throughout this essay, behaving in an intellectually virtuous way implies a strong commitment to the search for truth and avoiding biases that threaten epistemic procedure. Furthermore, in a broader sense, intellectual virtues are the ground for cultivating and exercising various intellectual skills and interpreting the diverse intellectual norms that rule out an epistemic practice (Streeter, 2006).

This subject, as I will state, is at the core of a good part of the responsibilities that flourish in the heart of contemporary scientific endeavor —as an intellectual practice— such as the critical selection and use of techniques and procedures (for example, data analysis), the assessment of multiples pieces of evidence, the improvement and implementation of rigorous methodological designs, as well as insidious problems of research practice misconduct such as fabrication and falsification of data. In addition, I argue that these virtues have an essential connection with features that, although they are not strictly constitutive of scientific research, are derived from it, namely: the responsibility of scientists, in their role as agents possessing knowledge, to weigh and warn about the use of scientific findings.

Matters of this nature are ineluctably linked to a strong sense of uncertainty and hesitation, which requires thoughtful decisions from scientists, a topic frequently covered within the broad framework of Responsible Research and Innovation that has aroused so much interest since the beginning of the 21st century, and from which a notion of prospective responsibility is highlighted, emphasizing above all the care for the future through the conscientious effort to conduct, apply and supervise scientific research in an inclusive, reflexive and responsible manner (Stilgoe & Guston, 2017).

Thus, I will argue that one can find a vehicle for a socially engaged scientific endeavor in the intellectual virtues since these are cultivable traits that contribute to facing complex scenarios and reaching plausible (although not definitive) solutions related to scientific research and the impacts of science and technology. Therefore, an anticipatory attitude toward scientific outcomes requires responsible scientists who are actively committed to these issues rather than individuals who are indifferent to or resigned to the growth of science (Guston, 2012).

In this sense, my aim in this essay is to reflect on the implications of intellectual virtues in the scientific endeavor, understood broadly as a process involving generating and possessing knowledge in a responsible way. For this purpose, in the second section of this paper, I will outline the main elements of a depiction of the scientific endeavor that focuses on the awareness of academic actors regarding their responsibilities as producers and possessors of scientific knowledge. In the third and fourth sections, I will argue for an approach centered on intellectual virtues to address issues concerning both spheres. To achieve this, I will resort, on the one hand, to the notion of academic attitude proposed by Thomas Reydon, who discusses the responsibilities derived from the activities of production and possession of knowledge, as well as the relationship between both spheres, taking as a premise the need for researchers to develop an attitude of awareness in the face of a scenario in which there are no specific rules for decision making in these areas. On the other hand, I will appeal to Howard Sankey's proposal regarding the role of intellectual virtues in scientific research. This author stresses that these virtues are essential in situations with a multiplicity of methodological norms, and it is necessary to weigh them carefully. Thereby, I will analyze the role these virtues play in the generation of scientific knowledge, contemplating their implications in implementing the methodological principles distinctive of scientific research. However, since my interest involves not only the responsibilities related to generating knowledge but also those related to having knowledge, I will account for how intellectual virtues can guide scientists in the tasks related to reflecting on the consequences of the findings obtained through scientific research. Finally, in the fifth section, I will offer some general considerations on the prescriptive nature of this proposal and its relationship with education in intellectual virtues and the training of researchers.

I will present some situations concerning scientific activity and scientifically informed decision-making in which this proposal can provide elements for analysis and discussion.

A Broad Notion of Scientific Endeavor

In a broad sense, science is both a body of knowledge about diverse aspects of reality, and a human activity. These facets are not separated; to speak of science is to speak of a vast enterprise conducted by people in pursuit of obtaining more or less precise descriptions of the world, which, whether we are aware of it or not, often affect various spheres of social life beyond the strictly academic. We can witness this by paying attention to the products of science with which we have daily contact.

However, it is expected that the implications of the scientist *qua* scientist reach only to the peripheries of research and the dissemination of the findings obtained through this research in the relevant media (e.g., journals, books, conferences, and etcetera), as well as the intellectual criticism of their peers' work. Of course, these tasks make up the process of producing scientific knowledge, which requires, among other things, evidence gathering, configuring theories and empirically contrasting them, the presentation of discoveries, and their evaluation by the scientific community.

Nevertheless, there is an increasing interest in the role of scientists outside the research area, especially in the responsibilities they acquire in their role as expert agents in certain epistemic domains (Carrier & Krohn, 2018; Kitcher 2011), which is linked to the necessary reflection and warnings about the impacts of science and technology on societies.

Both these impacts and the scientist's dispositions and actions concerning them are not strange since scientific research is conducted by communities belonging to social contexts that not only exert effects on the course of scientific-technological projects but are also influenced —directly or indirectly— by these last.

Seemingly, the first type of activity (i.e., scientific research) demands more responsibility for scientists. This supposition, known as the separability view, suggests that the role of scientists in making informed decisions about the impacts of science differs normatively from their role as researchers (Gundersen, 2018). This idea can be held with more or less radicality. However, in any case, it is substantially associated with the ideal of autonomy of science, which assumes that the ability of science to progress is substantially affected by the interference of moral, political, and social aspects proper to systems external to the scientific system (Polanyi, 1962). Nevertheless, despite the normative differences between the two types of activities, their closeness is substantially more significant than separability advocates could argue.

First, it is necessary to recognize that reflections and judgments on the impact of science on society are at least equally demanding since they require researchers to heft and reconcile different points of view and evidence from several sources, as well as assess the future consequences of the knowledge generated, which requires reflecting jointly with various stakeholders in a context of uncertainty (Arentshorst, de Cock Buning, & Broerse, 2016). Thus, the scientist's intellectual commitment is broader than the conventional picture of scientific endeavor (which only contemplates research activity) suggests.

Moreover, both cases —scientific research and science-society linkage— are characterized by a high amount of uncertainty. Regarding scientific research, it should be noted that although researchers seek to obtain true theories, there is always a risk that this aim will not be achieved (Luhmann, 1993). It is notably relevant because, given that there are no universal prescriptions for undertaking research but rather a multiplicity of methodological norms and values, scientists constantly face the possibility of failing in their decisions to evaluate theories. Thus, generating new knowledge requires scientists either to commit to using theories, methods, and tools that are already available and well-tested (playing it safe) or to engage in new areas that challenge what is already established, which brings them even closer to the possibility of failing in their search for truth (Sarathchandra, 2017).

Regarding the prediction of the social impacts of science, the panorama shares some similarities with the previous one in the sense that uncertainty is a fundamental ingredient in these matters since the impacts of science and technology often are disclosed in the future (either near or distant) which, however, does not diminish its importance for society (Adam & Groves, 2011). While it is true that accurate predictions about these concerns are largely unattainable, the anticipation of the impacts of science on society is by no means negligible. This anticipation is the essence of the anticipatory governance of science, which requires, among other things, a favorable attitude toward foreseeing plausible scenarios regarding scientific and technological impacts (Guston, 2012). It is explicit in such diverse and highly relevant areas as the use of nanotechnology (Maynard, 2014) or the environmental impacts of nuclear energy, especially concerning its link with climate change (Moriarty, 2021), to mention some examples.

For all these reasons, I argue that both spheres of activity involve the active role of researchers in the decision-making processes and development of various activities such as data collection and modeling —as far as research activities are concerned— as well as, for example, weighing and publicly discuss arguments against the impacts of anthropogenic global warming on humankind— regarding science-society linkage.

Nevertheless, there is another reason, and perhaps the most important, why the role of scientists can hardly be separated from their role in the surveillance of the impacts of science on society, and it has to do precisely with their status as experts possessors of knowledge. In this regard, Thomas Reydon (2020) has proposed the concept of academic attitude to encompass the concerns that arise from the relationship between epistemological aspects of scientific knowledge generation and those related to other features of academic life, such as teaching and public engagement. This proposal is noteworthy, as it offers elements to reflect on the strong relationship between being a generator and possessor of knowledge, as well as on the responsibilities arising from scientific research and the possession of the knowledge produced through it. Indeed, as will be seen, Reydon assumes that both spheres, the generation, and possession of knowledge, are in no way dissociated and that they have significant normative implications.

The academic attitude encompasses the specific conceptions of academic integrity, academic responsibilities, and the problems linked to scientific misconduct. (Although Reydon argues that these issues do not only concern researchers but also other academic actors such as professors, in this presentation, I will only focus on what mainly involves scientists, as they are the central object of the present work).

The notion of scientific endeavor expands considerably within the framework of these ideas, given the diversity of situations that the scientist faces, not only as a producer of knowledge but also as someone who has knowledge. Regarding the first role, Reydon stresses that researchers are responsible for ensuring the quality of the knowledge they produce. He is particularly concerned about academic misconduct that directly affects the content and quality of the knowledge produced. Fabrication and falsification of data are clear examples of this type of action. In addition, Reydon draws attention to the particular problem that plagiarism represents in this context by indicating that this action transgresses the link between the agency of researchers and the knowledge they produce:

> An author of an academic publication guarantees with their good name in the relevant academic community that the knowledge (in the broadest sense, including understanding, insight, etc.) contained in the publication has been produced with, to their abilities, the best possible methods, the best possible data analysis, the best possible argumentation, the best possible background literature study, the best possible theoretical preparation, and so on (Reydon, 2020, p. 26).

However, it is easy to realize that the relationship between the researcher's agency and the knowledge produced is at the core not only of plagiarism and other academic misconduct but also research in general. I agree with Reydon that researchers must ensure that they use the best possible methods, data, and arguments. However, this is not merely a responsibility in reply to the challenges that academic dishonesty represents; it is a responsibility inherent to the very fact of conducting quality scientific research.

As far as having knowledge is concerned, Reydon does not assume this as a sphere of action and responsibility dissociated from the first (i.e., producing knowledge) but instead characterizes it as an immediate consequence of the latter. It means that to the extent that scientists possess knowledge derived from their research activities and academic training, they become fundamental agents supervising the uses and impacts of scientific knowledge.

> […] having privileged access to a particular area of knowledge that the general public does not have access to entails the obligation to examine its possible consequences for society and humanity, and communicate these to the general people (Reydon, 2020, p. 23).

According to Reydon, the obligations to foresee and act on the possible consequences of scientific findings are not due to scientists' specific ethical knowledge but arise from their status as expert agents. Thus, he believes that scientists are responsible for facilitating or enabling public discussion and informed decision-making, highlighting the possible beneficial or detrimental uses of knowledge (Reydon, 2020).

Reydon points out that what is most fruitful for fulfilling the demands imposed by the roles of production and possession of knowledge is not the search for universally valid rules, principles, or guidelines for problem-solving. Instead, researchers need to nurture an attitude of awareness, which allows them to develop their points of view regarding how to deal with problems related to producing and having knowledge. Since there are no universal algorithms to guide scientific research and knowledge surveillance decisions, scientists must remain vigilant and critical of these issues. Tasks like these, I must emphasize, demand from scientists intellectual qualities that allow them not only the technical execution of specific research tasks (e.g., literature search, data collection) but also the responsible exercise of research techniques, the critique of the findings obtained by them and their peers, and the meditation on the uses and social implications of the knowledge produced.

In the two cases, I reiterate that it is essential to note that no recipe book can ensure to take successful decisions. Choosing scientific theories requires appealing to various epistemological principles to compare rival theories in circumstances where the evidence does not allow a clear choice between them. Furthermore, the scientific research process requires using multiple techniques and procedures whose suitability to the study problem is not always evident to the researcher and whose application is far from being an automatic process (see section 3 of this paper). Foreseeing with absolute certainty the future scenarios derived from the implementing knowledge is also a practically impossible task. However, scientists can reach reasonably well-founded beliefs resulting from their status as experts in a field, using rules of thumb, where possible, but most importantly, making situated judgments, which should be sensitive to diverse social and environmental contexts (Adam & Groves, 2011).

Following what I have explained so far, I will understand by scientific endeavor all those activities that are proper to the scientist as a producer and possessor of knowledge in specific fields. In this endeavor is interwoven a complex web of epistemic and ethical issues, not only in the research processes but also in those which are circumscribed by the concerns about the use and impact of scientific knowledge. These matters require a theoretical approach that can grasp their nuances by considering that such activities and responsibilities strongly engage the scientist as an intellectual agent.

Therefore, since both the production and the possession of knowledge are epistemic processes conducted by responsible agents, one of the main strategies that I will develop from here on consists of tracing the relationship between scientific endeavor as understood here and the concept of intellectual virtue. In order to do this, it will first be necessary to explain what intellectual virtues are.

Intellectual Virtues and the Production of Scientific Knowledge

An Overview of Intellectual Virtues

Virtues have been a recurrent object of study in philosophy; their presence is common in the work of classical authors such as Plato and Aristotle. In contemporary times, the study of intellectual virtues has acquired a leading role in the so-called virtue epistemology. Virtue theorists tend to be interested in certain intellectual characteristics (cognitive faculties, character traits, and competencies, among others) that play an explanatory role in the constitution of true or justified beliefs, emphasizing the epistemic achievement of gaining knowledge over mere lucky guesses of our beliefs. In other words, intellectual virtues are necessary for attaining knowledge.

It is worth clarifying, at least briefly, that virtue epistemology is usually divided into two major strands, each offering relatively different conceptions of intellectual virtue (Turri, Alfano, & Greco, 2019). On the one hand, the family known as reliabilist virtue epistemology portrays intellectual virtues as competencies or, in some cases, faculties (good sight or the ability to reason) that reliably lead to truth, or put in another way, that maximize true belief acquisition. On the other hand, responsibilist virtue epistemology conceives virtues as traits of the personality or character of an individual. This definition also contemplates the importance of epistemic reliability as a characteristic of intellectual virtue but encompasses other qualities.

In this essay, I will use a responsibilist conception of intellectual virtue since it is the one that has aroused the most significant interest in the philosophy of science, and which is particularly relevant to the efforts that I am interested in undertaking about the scientific endeavor since such an approach put special attention to individual's sensitivity to diverse norms (e.g., scientific methodological norms) that shape diverse forms of inquiry (Streeter, 2006), including, of course, the scientific research and the surveillance of its socio-environmental impacts.

Thus, I understand intellectual virtue as a trait of an individual's character. More precisely, it is a disposition that involves three components: 1) cognitive (thinking), 2) motivational, and 3) behavioral (King, 2021). Thus the intellectually virtuous agents regard knowledge as valuable, as well as worthy of obtaining and sharing; moreover, they desire knowledge and, in general, value epistemic goods such as true beliefs and the avoidance of ignorance for their own sake, and acts according to the dispositions of thoughts and motivations in very diverse contexts. This conception distinguishes intellectual virtue from intellectual skills since the latter are usually highly context-specific, and their use may or may not be motivated by the search for truth (think, for example, of a highly skilled data analyst who would use her knowledge and skills to falsify data). Examples of intellectual virtue are open-mindedness, impartiality, intellectual humility, and meticulousness, among many others. A particular case of intellectual virtue, phronesis, will be relevant when speaking about the scientist's responsibilities as an agent possessing specialized knowledge.

Intellectual virtues are not innate dispositions but are acquired and cultivated through habit. As already mentioned, they have a motivational component in addition to the purely cognitive one (Zagzebski, 1996). That is, subjects exercising an intellectual virtue are motivated to act in a certain way (e.g., listening to the opinions of their peers), even when they are unaware of their virtue. These character traits reliably lead a person to avoid error and propitiate the achievement of true beliefs, proving to be particularly relevant in inquiries of various kinds, such as scientific research, where the agency of attentive, persevering, and motivated subjects by the search for truth is usually an indispensable aspect for the attainment of various epistemic objectives (Baehr, 2011).

Intellectual Virtues and Scientific Research

Although the virtue approach has gained significant prominence on the epistemological scene since the 1980s, its explicit appearance in the field of philosophy of science has been relatively recent, although some hints are identifiable in works from the first half of the twentieth century, as in the work of Duhem, who declared:

> Since logic does not determine with strict precision the time when an inadequate hypothesis should give way to a more fruitful assumption, and since recognizing this moment belongs

> to *good sense*, physicists may hasten this *judgment* and increase the rapidity of scientific progress by trying *consciously* to make good sense within themselves more *lucid* and more *vigilant* (Duhem, 1914/1991, p. 218, italics added).

As can be seen, this is a position that is seriously committed to a notion of science that emphasizes not only the technical expertise of scientists but also their willingness to be impartial judges of the evidence obtained. In this vein, it can be argued that intellectual virtues (e.g., intellectual sobriety) may contribute to reducing choices of theories for reasons that may distort or restrict evidence, as is often the case in cherry-picking fallacies (Paternotte & Ivanova, 2017). Of course, this does not mean scientists should dispense with skills in their respective technical and methodological fields. Indeed, one expects that an intellectually virtuous scientist will strive to make skillful and appropriate use of the range of tools at her disposal since intellectually virtuous motivations not only lead to following reliable procedures but also direct the individual towards developing the appropriate skills to acquire knowledge in specific areas (Zagzebski, 1996).

To illustrate this, I will refer to two examples common to almost all areas of contemporary empirical sciences. First, the use of statistical methodology, and second, the role of Big Data in scientific research.

Making statistical inferences requires that the data in question meet particular conditions; for example, in the case of linear regression models, normality and homogeneity of variance in the distribution of errors (i.e., the difference between the observed values of a dependent variable and its expected values) must be required to ensure the feasibility of the linear model. Verifying these assumptions requires meticulousness and interest on the researcher's part to carry out the pertinent diagnoses. Thus, the researcher needs an intellectual responsibility to recognize whether the data in question have the necessary quality to determine the relevance and type of subsequent analysis.

Nonetheless, there have been many warnings of unjustified and erroneous uses of statistical techniques in scientific practice that violate the integrity of inferences (see, for example, Cohen, 1938; Ross, 1985; Thiese, Arnold, & Walker, 2015) as occurs when the researchers do not perform the necessary diagnostics. The causes of these problems include poor study designs, quick publication expectations, conflicting priorities, and the researchers' ignorance (A. W. Brown, Kaiser, & Allison, 2018).

On the other hand, in recent times, there has been a resurgence of the radical empiricist ideals of a science free of theories and theoretical interpretations, along with Machine Learning and Big Data analytics. The basic idea of the data-driven approach is that, given the massiveness of data on various phenomena and the analytical capacity currently available, the development and interpretation of models to explain the behavior of such data becomes an unnecessary (as well as slow and inefficient) task, since the patterns that emerge from the great ocean of data become evident, allowing researchers to dispense with any form of interpretative speculation (Succi & Coveney, 2019).

Although the benefits of the data-driven approach are undeniable, taken to its extreme, it raises more problems than it solves since more data does not necessarily translate into a better understanding of the world. It is so because data depend on what certain instruments and processes allow us to observe. In other words, data is a product rather than an autonomous entity that speaks for itself. In this sense, it is certainly not the absence of data that is the problem, but rather the use of trivial indicators and the excess of meaningless data (Innerarity, 2013). A virtuous approach to data analytics requires certain qualities of researchers, such as meticulousness and critical thinking, capable of providing meaningful interpretations.

I will come back to these examples shortly. For now, it is necessary to say that these problems demand, of course, institutional actions at different levels, such as the increase of economic resources and incentives for those who carry out research, as well as the development of a culture that promotes and emphasizes the responsible, aware and justified use of statistical tools, as well as a process for sound interpretation of data obtained. Achieving this goal, I would like to underline, implies a fundamental role of intellectual virtues such as intellectual humility (to recognize the lack of knowledge and facilitate genuine interdisciplinary work), honesty, and, in general, the interest in truth, precision, and understanding, which characterizes a competent and virtuously motivated inquirer.

At this point, it is essential to note that intellectual virtues can contribute to the generation of knowledge in two ways: on the one hand, by contributing to the weighing of situations to be avoided in the course of scientific research (e.g., avoiding making conclusions without adequately assessing the evidence on some question) and, on the other hand, by allowing scientists to correctly implement the principles of the scientific method according to the various problems they face (e.g., the most appropriate choice of the statistical technique according to the characteristics of the data).

Understanding in detail how this is possible requires an account of the relationship between the intellectual virtues and the methodological norms of science since the former cannot provide a complete justification of scientific findings.

I will resort to Howard Sankey’s proposal, an author who has reflected on these issues within the context of discussions on scientific objectivity. As an advocate of scientific realism, Sankey is committed to the ontological thesis of the mind-independent world (ontological realism), as well as to the conviction that scientific research can provide us with knowledge of that world, which, although it has great value, is always subject to correction, in other words, it is perfectible (for a more detailed discussion of this perspective, the reader can consult Sankey, 2008).

In general, for this author, intellectual virtues allow the researcher to choose between theories by weighing the epistemic values (parsimony, predictive power, etcetera) that they possess, around which general principles of theory-appraisal are configured (e.g., the search for parsimonious theories, the predilection for theories of great predictive power, among others). Thus, Sankey's proposal is fundamental because, although it recognizes the plurality of values and methodological norms that guide scientific research, it offers a possibility to deal with the uncertainty derived from this condition by highlighting the relevance of intellectual virtues in the choice of these norms.

I will first delve into this question and then discuss an aspect that Sankey overlooks in his current proposals (Sankey, 2020, 2021) but which is related to what he has called the specific rules of the experimentation (Sankey, 1995), that is, the methodological norms of a particular nature that are followed in the various steps of the research process, such as in the collection and analysis of data, to mention a few, with which intellectual virtues are also closely related.

According to Sankey, there are at least three broad senses of scientific objectivity: 1) ontological, 2) semantic, and 3) epistemic (Sankey, 2020). The first of these refers, in particular, to the independence between reality and the mind of the subjects who know and think. On the other hand, semantic objectivity refers mainly to the correspondence between theory and facts; this correspondence is also independent of what the subjects believe about these theories and propositions. The last of the senses of objectivity, epistemic objectivity, refers to the use of methods that guarantee left aside sources of bias, personal interests, etcetera, ensuring that only epistemically relevant factors play a fundamental role in scientific research.

For Sankey, intellectual virtues play a fundamental role in the context of theory- choice, allowing the scientist to ponder and apply the methodological norms for the evaluation of scientific theories, in the words of the same author:

> The judgment involved in weighing up and applying the methodological norms in the context of theory-choice may itself be a virtuous process in the sense that virtues are appropriately employed in the course of forming judgment (Sankey, 2021, p. 17).

This process, which involves the virtuous judgment of the scientist, has in itself an objective character since intellectual virtues manifest a form of cognitive or intellectual objectivity. Although Sankey draws on classic examples from the philosophy of science, considering impartiality as an example of intellectual virtue, it is still possible to think of the implications that other intellectual virtues could have in the context of theory choice, something that Sankey himself accepts. However, he leaves unaddressed (Sankey, 2021).

In any case, Sankey's proposal can be synthesized in the following fundamental thesis: intellectual virtues contribute to adequately weighing and applying methodological norms related to theoretical values to decide between competing scientific theories.

Nevertheless, evaluative principles, such as those previously outlined, are only some elements that constitute the methodological baggage of scientific research. There is a broad set of specific rules that guide the procedures of science, as occurs, for example, in conducting experiments, where different instructions and procedures come into play to ensure control of extraneous variables and sources of bias (e.g., through randomization) and instrument calibration, as well as data analysis (Sankey, 1995).

Although these principles are often associated with much more restricted contexts than those of evaluative principles of theory appraisal, they are not detached from the intervention of scientists' judgment as long as its implementation is far from being algorithmically determined. The features of the study problem often require meditation on the part of the researchers concerning the choice of technical alternatives. Impartiality, which enables neutral judgment regarding the characteristics of scientific theories, also plays an essential role in the implementation of specific scientific procedures, such as the assignment of subjects to various experimental conditions, in the analysis and interpretation of data (performing the pertinent diagnostic analyses) and even in the report of results.

Of course, in addition to impartiality, there is good reason to consider the implications of other intellectual virtues in the implementation of the principles of the method and theory appraisal, such as intellectual humility, which I have previously mentioned. This virtue understood as a disposition of individuals to recognize their intellectual limitations and their fallibility as a cognitive subject (King, 2021), may contribute to increasing the ratio of true over false beliefs to the extent that intellectually humble people are more likely to correct their beliefs since they are less likely to ignore other sources of information, such as the judgment of their peers or the findings of other research, even those that contradict their own beliefs; likewise, this virtue increases the power of belief generation by motivating the subject to seriously consider other opinions and sources of information beyond their own ideas (Lepock, 2011).

I want to clarify the implications of intellectual virtues in a broad sense by returning to the previously mentioned examples. As I have already mentioned, although it is common to make use of particular procedures to carry out various statistical data analyses, multiple aspects require attention and meticulousness on the part of the researcher, as well as fair-mindedness when judging which procedure is the most appropriate for the defined analysis tasks, as well as interpreting the findings obtained. These procedures involve judicious use of statistical modeling techniques, comparing multiple sources of evidence, judging the collected data, and even the ideological biases to which the research process is subject (Babones, 2016).

Similarly, the data-driven approach in data analytics faces the unavoidable need to provide sound interpretations to data that are products of various technical and methodological processes, which in turn presupposes a particular theoretical context. It requires the kind of virtues already mentioned, as well as awareness of one's interpretive frameworks and deliberately pursuing their creation and appraisal (Cukier, Schönberger, & de Véricourt, 2021). In this order of ideas, enthusiasts about the Big Data approach challenge the same problems that scientists have encountered throughout the evolution of scientific endeavor (and that were so rightly noted in the socio-historical studies of science): the multiplicity of methodological norms and epistemic values, which demand a conscientious appraisal by researchers.

In both instances of research (as in many others), the importance of intellectual virtues lies in their potential to contribute to the sensitive and objective assessment of the vast theoretical and methodological possibilities that scientists are confronted with when generating scientific knowledge.

Even though what I have already said is a general sketch, it should allow us to observe the plausibility of considering intellectual virtues as essential elements in scientific knowledge production if what is sought are epistemically responsible scientists —that is committed to the search for truth and the avoidance of the various biases that compromise scientific research.

However, as I pointed out at the beginning of this article, the scientific endeavor is not exhausted in the generation and testing of theories, so it is necessary to give rise to considerations related to that other set of activities and responsibilities in which those who perform science are (or should be) enrolled, namely: those of having scientific knowledge.

Intellectual Virtues in the Context of Having Knowledge

I have been explaining the relationship between intellectual virtues and the production of scientific knowledge. However, their role in possessing scientific knowledge is a scarcely explored issue in literature, even though this is of particular relevance, given the depiction of scientific endeavor described here. Of course, one should not interpret this as a disinterest in understanding the responsibilities and implications (particularly social) of scientists in their role as knowledge possessors. Indeed, there are good examples of efforts to address these issues, from which have been accounted the implications of scientific expertise in democratic societies (Kitcher, 2011) as well as the need (and inevitability) for scientists to be involved in moral issues related to the application of knowledge in society (Olivé, 2000). In this vein, particular attention has been put to the anticipatory governance of science and technology, understood as the social capacity to manage technologies in a responsible, reflexive, and inclusive way (Guston, 2014). However, for these approaches to be meaningful, engagement with scientific practices at different levels, such as institutional, cultural, and individual, is necessary (Stilgoe & Guston, 2017).

Although there is no doubt that these problems interweave moral issues with strictly epistemological ones, my purpose in this section is to deepen in the latter and to explain how intellectual virtue (as an individual trait) can contribute positively to address them, especially in the exploration of the agential and intellectual character of researchers' interventions in the discussions on the effects of knowledge in society.

As Olivé (2000) has pointed out, accurately foreseeing the consequences of scientific theories and technological developments is often not feasible. Scientists do not straightforwardly achieve these predictions because the effects of science and technology are not always evident or easily deduced from the current state of knowledge. Even so, researchers can still form reasonably well-founded beliefs that justify their actions concerning these consequences, for example, by warning about the effects of implementing a certain technology. Such situations require, to a large extent, the conscientious intervention of the scientist to evaluate the possibilities according to the available information, even if sometimes this means overlooking the most rigorous standards of science, such as, for example, the submission to experimental testing. These circumstances do not imply, of course, that the hypotheses put forward are irrational or lack objectivity in any way.

At this point, the scientists' intellectual virtues also become relevant since it is necessary to recognize that a particular disposition and capacity to link scientific knowledge and the experience acquired in years of research with a practical problem that may have an impact on the future of a community much larger than the scientific one. Advocates of approaches such as Evidence-Based Practice (widely accepted today in informed decision-making) have considerably undermined the practitioner's experience (Gascoigne & Thornton, 2013). Promoters of this movement claim that decision-making in practical matters (e.g., social intervention and medical treatment) finds its best foundation in scientific evidence, preferably from randomized trials and systematic reviews/meta-analyses (i.e., syntheses of statistical findings).

In this context, the characteristic expertise of professionals gained in their own practice, be it politicians, physicians, or, in general, researchers, is positioned at the lowest point of the evidence hierarchy (see, for example, Masic, Miokovic, & Muhamedagic, 2008; Burns, Rohrich, & Chung, 2011). Presumably, this removes all subjectivity from the processes of knowledge configuration, contributing to the achievement of very specific values for doing science and making informed decisions, such as impartiality and replicability.

However, dismissing a priori the role that expert judgment plays in informed decision-making may do more harm than good. Against this background, recovering the Aristotelian notion of phronesis is pertinent to shed light on the issue. This intellectual virtue is conceived as a form of practical wisdom that enables human beings to do what is right in order to achieve a good end. As a virtue, it develops through the experiences of individuals, providing them with the ability to appreciate the possible consequences of a given action in a particular context and to weigh the relative importance of certain features in specific situations (Hursthouse & Pettigrove, 2018), allowing to act in the most appropriate way according to the requirements of the context. By its nature, phronesis is one of the most important intellectual virtues regarding human affairs in the political and social sphere (Flyvbjerg, Landman, & Schram, 2012). Following the distinction between episteme (scientific, universal, and abstract knowledge), techne (technical knowledge regarding how to transform the world), and phronesis, we could say that the last one allows the prudent administration and application of the other two, as required in specific contexts (Flyvbjerg, 2001).

Throughout their training and professional life, scientists acquire knowledge and skills that allow them to rigorously test various theories about their disciplinary object of study and assess the consequences these theories could have for society (Bird, 2014). And even though there will be cases in which it will be challenging to foresee the consequences of a particular line of research, the intervention of scientists in monitoring the developments and impacts of that line of research remains fundamental because, without their experience and knowledge, it is difficult to have a precise idea of the scope and impact of scientific knowledge.

Certainly, from the paradigm of Evidence-Based Practice, some people could argue that as long as there is no rigorous experimental evidence regarding the impacts of science and technology, there would be no compelling reasons to act preventively. To this issue, in effect, are challenged scientists who must weigh between fulfilling the norms proposed by their own field of study and the surrounding areas (e.g., industry) or taking preventive measures (say, alerting society) in response to potential adverse effects arising from scientific discoveries and technological developments (Olivé, 2011).

Nevertheless, if we accept that even non-experimental evidence has epistemic value, as with correlational and quasi-experimental evidence, there would be no reason to refrain from using such evidence for informed decision-making. Consider, for example, the relationship between smoking and lung cancer. Some of the most convincing early findings in this area came from population-based studies, in which scientists observed a parallel increase in cigarette smoking and lung cancer. The correlational nature of the evidence obtained did not prevent scientists from beginning to express concern about it. Furthermore, such evidence eventually converged with that provided by experimental studies, particularly in animals (Proctor, 2012).

Therefore, an active role is required of scientists in this type of situation, and intellectual virtues are fundamental in making fair decisions regarding the means to avoid harm stemming from the implementation of certain scientific knowledge. More recent cases —whose controversies are far from settled— can be found in many different fields. To mention two significant examples, I will allude to the implementation of computational algorithms, which are at the heart of decision-making in crucial areas such as economics, and the discussions related to environmental and health crises.

While it is true that Artificial Intelligence has enabled significant achievements in various fields, numerous concerns have also arisen regarding algorithmically directed actions and decisions, both in the epistemic and moral dimensions: the lack of transparency in algorithmic processes, the problem of inconclusive evidence, the unfair and unexpected consequences of their implementation on social issues, such as discrimination of various social groups (Tsamados et al., 2022).

Determining these possible consequences and the ways to act upon them is a task that has required the joint work of multiple experts from areas such as philosophy and law, and of course, as one would expect, from science, since scientists are not only capable of determining the shortcomings or biases related to decisions based on algorithms, but also of developing and implementing appropriate solutions to such problems. Examples of these efforts are those of Pessach and Shmueli (2021) and Amin, Soleimany, Schwarting, Bhatia and Rus (2019). The practical wisdom nurtured in their fields of activity provides researchers with adequate intellectual tools to assess and propose solutions to the impacts (actual or potential) derived from such scientific-technological developments. I want to reiterate that this cannot be achieved immediately. Instead, it is the product of a formative process and the experience acquired during their academic life.

Meanwhile, environmental and health crises represent a fertile ground for uncertainty, confusion, disinformation, and misinformation (Nelson, Kagan, Critchlow, Hillard, & Hsu, 2020; Wang et al., 2022). It is not surprising, given the diversity of social structures that characterize the post-truth culture, such as epistemic bubbles that arise from an inadequate (though usually unintentional) coverage resulting from the omission of important epistemic resources (e.g., hypotheses, evidence, arguments), as well as echo chambers, in which diverse viewpoints relevant to the discussions at hand are actively excluded and discredited (Nguyen, 2020), the latter being particularly relevant when explaining the resistance to evidence that characterizes climate change deniers (Nguyen,

2020) and the anti-vaccine attitudes in COVID-19 pandemic (Müller, Tellier, & Kurschilgen, 2022).

While intellectual virtues do not ensure an escape from these structures, they do have the potential to protect the mental environment of individuals from such epistemic threats. Some examples are open-mindedness, intellectual humility, and skepticism (É. Brown, 2019). The phronesis can also be a relevant virtue in these areas, especially when the debate involves various stakeholders (political, economic, and social) linked to the scientific sphere and the need to reflect on the best scientific and technological resources to deal with such crises in a socially just and inclusive way.

Notwithstanding in the present section I have been focusing on the virtue represented by practical wisdom (phronesis), I recognize that other intellectual virtues are relevant in surveillance and intervention on the uses and impacts of science. Impartiality, honesty, and intellectual humility are undoubtedly valuable dispositions when assessing evidence regarding the uses and impacts of scientific and technological knowledge, for example, to avoid superimposing economic and business interests over those such as truth, as occurs in cases where evidence of adverse effects of some technical implementation is modified or concealed.

Highlighting the role of phronesis, however, contributes to understanding the fundamental role that the scientist, as the bearer of such wisdom, has in making informed decisions in different practical fields. In this sense, the exercise of phronesis enables researchers to serve as a bridge between the scientific sphere, and the civil, political, and economic spheres (Mejlgaard et al., 2019), contributing to the epistemic empowerment of diverse social actors in contexts of governance of science, technology, and innovation, in which certain forms of knowledge frequently acquire dominance over others (Valkenburg, Mamidipudi, Pandey, & Bijker, 2020).

Some considerations on the normative nature of this proposal

As I pointed out in the introduction to this text, this proposal is prescriptive in nature. It is not a description of scientific practice, but rather —and most importantly— a proposal on how scientific work should be carried out, based on the argument that intellectual virtues are relevant individual traits to improve both scientific research and the foresight of the impact that scientific knowledge can have on social issues.

Thus, at this point, a problem is how to cultivate intellectual virtues in those dedicated to scientific endeavor. Tackling this is not easy, as it seems to me that a thorough analysis would have to include a wide variety of stakeholders. However, I want to pay particular attention to two issues related to my interests in this proposal: the role that educational institutions can play in this discussion, especially because of their role in the training of scientists, and the development of a responsible scientific culture.

It is vital to begin by noting that the role of universities in the education of scientists is not static; it changes from society to society and from age to age. For much of the 20th century, it was common to associate the image of the university with the possibility of conducting scientific research free from extra-scientific distractions that potentially corrupt the search for truth (Peters, 2003; Polanyi, 1962). In this sense, intellectual virtues such as interest in truth and impartiality were flagships of such an academic culture.

Over time, however, this situation has changed. Since the end of the 20th century and the beginning of the 21st century, the value of universities has been identified with their success in generating high-quality research whose findings can be translated into commercial profits. The search for scientific knowledge has ceased to have a purely intrinsic value in favor of a more instrumental one. In this sense, the contemporary scientific production system has been characterized by a kind of academic capitalism that has enhanced the marketization of knowledge and increased pressures to achieve adjustment to the demands of various sectors, such as the industrial sector (Schulze-Cleven, Reitz, Maesse, & Angermuller, 2017).

This scenario has required institutions and scientists to adapt to normative contexts different from the traditional academic sector. In the case of scientists, the development of personal features, such as specific skills and knowledge, as well as flexibility for the adequate satisfaction of such demands, have been crucial issues (Lambert, 2009).

Intellectual virtues are no stranger to these reconfigurations. The role of these virtues is fundamental to overcoming the barriers that scientists (especially those coming from academia) have to face in their interaction with the business and industrial sectors, among which the challenges related to the orientation of research, and the costs involved in working in sectors such as industry, stand out (Tartari, Salter, & D'Este, 2012).

In contexts where entrepreneurship and interaction with industry are prevalent, other virtues could be added to those already mentioned, especially those associated with creativity, courage, and perseverance, due to their special relationship with entrepreneurial activities. Likewise, virtues such as epistemic collaborativeness (Kotsonis, 2021) and open-mindedness are essential to overcome this challenge since they can facilitate working within multidisciplinary groups and adapting to new normative frameworks.

Thus, it is evident that the virtues cultivated in a given academic context may vary according to the interests that govern the activities in those contexts. Nevertheless, this should not lead us to think that it is convenient to renounce particular virtues in pursuit of others according to interests that stand out in the particular situation in which scientists find themselves.

Some evidence (van Oudenhoven et al., 2014) suggests that, although the specific characteristics of a cultural environment may indeed lead to weighting certain virtues more highly than others, good candidates for universally shared virtues such as honesty, respect, kindness, openness, and tolerance can also be found. In any case, what should be clear is that intellectual virtues, though relatively stable character traits, are cognitive-affective processes by which an individual pursues certain epistemic objectives (e.g., reaching the truth), but always taking into account the specific features of each situation (Russell, 2009).

Hence, according to what I have discussed so far, my vision of an adequate education in intellectual virtues points out to training scientists who are sensitive to the specific conditions they face both in their scientific research practice (in regards to the production of knowledge), but also (and intimately related to the above) with the potential impacts, either positive or negative, that this knowledge may have for the society in which they live. In the latter case, it may be fair to see intellectual virtues as civic virtues (É. Brown, 2019) insofar as they can contribute to making researchers better citizens, responsibly participating in the democratic processes linked to monitoring the impact of science on society.

Achieving the development of intellectual virtues is both a crucial and demanding task. However, various strategies can be employed. From an educational point of view, Lapsley and Chaloner (2020) point out three prominent families of educational strategies: 1) an Aristotelian pedagogical approach that prioritizes the analysis of cases and examples, as well as the implementation of behaviors characteristic of virtues, 2) meta-cognitive strategies that promote reflection and the critical skills of inquiry activities, fundamental aspects for the development of virtues such as phronesis; and 3) promoting scientific identity, that is, the identification of the individual with the values and norms of science.

Along with these educational strategies, it is essential to consider reforms in diverse institutional instances. For example, bureaucratic innovations such as pre-registration and registration of research studies are crucial to fostering and preserving scientific impartiality and objectivity because such innovations promote transparency and critical discussion of both the methods implemented in a research project and the findings obtained (Penders, 2022). Although it might be thought that such measures may restrict the autonomy of scientists, from the point of view of designing a virtuous scientific culture, they are essential strategies for forming more responsible scientists. After all, intellectual virtues are cultivated through habit and flourish in propitious contexts.

Conclusions

My aim in this essay was to reflect on the implications of intellectual virtues in scientific endeavor. I want to summarize in general terms the argument followed in this effort. I have characterized scientific endeavor in a broad sense that subsumes both the tasks of generating scientific knowledge and monitoring its implementation and impact on society, which are linked to the responsibilities of production and possession of knowledge, respectively.

In both cases, the scientists lack universal rules that determine how to act, having to judge the best options for each specific situation. In the case of knowledge generation, they must determine the most appropriate means to test and choose their hypotheses; in the case of knowledge possession, they must judge, even in the face of incomplete evidence, the possible effects of the implementation of scientific knowledge and propose ways of action in the face of these effects.

Intellectual virtues, being dispositions of character that lead to truth and, in general, to epistemic achievement (e.g., precision, accurate explanations), constitute a fundamental element for reaching solid conclusions about the vicissitudes of scientific endeavor.

The specific challenges inherent to producing and having knowledge require a thorough analysis in each of these spheres. However, this is a considerable effort, given the distinction between them. Despite this, I argue that the generalities outlined here allow offering an argument for considering the link between both spheres, taking as axes 1) the agency of researchers and their responsibilities in the generation and possession of knowledge and 2) the value that a virtues approach can bring to this discussion.

I must emphasize that intellectual virtues, while epistemically reliable mechanisms, do not turn scientists into perfect reasoning and decision-making machines. My purpose in this paper was not to support a thesis like this. I have highlighted two issues: researchers must have not only rigorous and precise technical and conceptual tools but also the appropriate intellectual and motivational resources to assess the nuances of the complex variety of situations that arise in scientific endeavor. Moreover, researchers must commit themselves to search for the best solutions to these problems.

The virtues explored here, such as impartiality, intellectual humility, and phronesis, are by no means the only intellectual virtues that have a place in the scientific endeavor, and, of course, the proposal outlined here does not exhaust the conceptual and methodological possibilities that a virtue approach could offer for the study of scientific endeavor. For this reason, I propose the general elements of an agenda for future inquiries incumbent upon all of us interested in achieving a better science in both an epistemic and moral sense.

First, it is necessary to promote reflection and awareness of scientific endeavor in its broadest sense. The scientist's work is not limited to research and publication of findings but extends to socially responsible activity. Indeed, the broad image of scientific work is increasingly defended by various quarters. However, certain myths, typical of the narrow notion of scientific endeavor, are still common in certain academic circles (e.g., the axiological neutrality of science), so discussing these issues is not an idle matter.

Second, it is fundamental to inquire empirically about the presence and effects of intellectual virtues in the behavior of researchers, as well as the interactions between these virtues and other aspects inherent to the subjects and their social context (e.g., intellectual vices, beliefs, attitudes, values, etcetera). As will be noted, this requires a solid commitment to joint work among various disciplines, such as psychology, sociology, and philosophy, among others. This effort will have to be nourished considerably by naturalized epistemological approaches, as well as analytical proposals. Moreover, I have taken an individual-centered approach to virtues in this essay, so it would be valuable to consider the analysis of group virtues (Lahroodi, 2007). Although the controversies between virtue individualism and virtue collectivism are far from settled (Cordell, 2017), the insights provided by the latter may be important, since scientific endeavor is carried out by working groups and involves concerns related to the impact of scientific findings on society.

Finally, it is a crucial task intervening to cultivate the virtues of character in the various stages of scientific training. This challenge is significant, given that if we accept that intellectual virtues are built through habit, we must consider the weight of contextual factors such as social institutions, culture, and social learning in an individual's personality development. This point is closely related to the previous one since a better understanding of intellectual virtues can contribute to their development. If we are to optimize strategies to foster virtues, conscientious and empirically grounded interventions are unavoidable.

A virtue-theoretical approach will not solve all the issues related to the scientific endeavor, but if we assume that researchers are, in fact, their own working instrument, developing intellectual virtues is necessary for the achievement of a more critical and committed science, both with the search for truth and understanding of the world, as well as with the fair and beneficial use of scientific knowledge.

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Footnotes

[1] By scientist, I mean a person who generates knowledge through scientific research, whether basic or applied. Scientists may or may not be persons engaged in teaching, but fundamentally, they must have research experience. In this sense, I will use the terms scientist and researcher as synonyms throughout this text.