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SCIENTISTS AND DEVELOPMENT

MICHAEL J. MORAVCSIK

Institute of Theoretical Science, University of Oregon Eugene, Oregon 97403, USA.

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It is a great pleasure, privilege, and opportunity for me to be able to contribute to this new journal of the Thai scientific community. I am particularly pleased that at the very outset of this journal, discussion is devoted to the relationship between scientists and development, an area that I have been intensely interested and substantially involved in for the past dozen years.

The building of science in the developing countries, or science development for short, has assumed an identity of its own only in the last twenty years or so. Although it is still far from forming a well-researched, coherent discipline with ready answers to all problems, it has by now evolved a substantial body of experience and a correspondingly sizeable literature. In fact, I recently completed what I believe is the first book dealing specifically with science development[1]. Thus, it would not be possible to offer a comprehensive summary of science development within the framework of a short article in a journal. Since I hope that this new journal will continue to lend its pages to articles dealing with specific conceptual contributions to science development and with particular proposals for action programs in this area, I will devote this present article to a few fundamental remarks concerning the relationship of scientists and development. It is my hope that such general comments might serve as a framework for more detailed discussion in this journal at future times.

My train of thought will be a simple one. I will first attempt to analyze the characteristics of a scientist. This will be followed by a discussion of what we mean by development. Finally, the connection between scientists and development will be defined, and thus conclusions will be able to be drawn about how to achieve this connection.

Prof. Moravcsik received his training in mathematics and physics in Hungary and U.S.A. He is presently at the Institute of Theoretical Science, University of Oregon, Eugene, where he served a term as its Director. He is the author of two books and some 130 articles dealing with nuclear and elementary particle physics, the "science of science", and with science organization and policy, particularly in the context of less developed countries.

So let me first turn to a discussion of scientists. Rather than attempting to describe scientists in terms of some formal requirements they have to satisfy, I want to enumerate the motivations and attitudes of scientists, since this will be much more important in our later discussion.

First of all, a scientist is curious about nature, and finds an esthetic satisfaction in discovering the laws of nature. This has been the primary motivation of those who engaged in scientific studies over the centuries, and it remains the most important incentive and reward for present day scientists. It is not the only motivation: An urge to convert talent into accomplishment, a sense of competition, a search for external recognition, a desire to serve humanity, and other justifications might also play an important role in fueling scientists' interests in the investigation of nature. Yet, satisfying curiosity and acquiring new knowledge has been one of the most basic aspirations of civilizations over the ages. Such an interest has not necessarily been directed toward nature as defined by the modern natural sciences. We are also intrigued by social problems, by religious and philosophical considerations, and by psychological and spiritual matters. In all these areas, however, we seek to understand, and understanding brings us satisfaction and pride. Scientists, specifically, direct their attention to the laws of nature, and devote their full energies to the satisfaction of this aspiration for knowledge. As such, they differ from many other professions, the practitioners of which are not in the position to be able to be preoccupied most of their time with such aspirations.

A second characteristic of a successful scientist is his relentless drive and virtually limitless devotion to his task of discovering new aspects of nature. This is not unrelated to his first characteristic mentioned above, since he can combine his vocation with his avocation, and hence his internally propelled motivation dictates a pace not primarily determined by external working rules. In addition, the work before him is not of finite extent. Scientific knowledge is infinite, or at least it appears to be infinite to us at this time, and so only his personal skill, endurance, and energy limits the amount of work a scientist can do. Thus successful scientists often give the impression of being "possessed" by the zeal to do science. They frequently exhibit very high morale and a vitality directed toward their work which can hardly fail to produce results.

The third characteristic of a scientist is his acceptance of the criteria of truth and measures of success that govern scientific investigations. The most essential criterion by which a scientific theory is judged is whether it agrees with the results of experiments, that is, whether it conforms with scientific reality. I quickly hasten to add that in practice the application of this criterion is sometimes not as easy as it appears on paper. Experiments are often difficult to perform and occasionally incorrect results are obtained. Frequently several theories agree with particular experimental results, in which case other criteria must come into play also. But on the whole, and particularly in the long run, a scientific theory is judged by its power to predict reality as described by scientific measurements.

In other words, what the scientist produces must work. Another way to describe this characteristic is to say that the essence of a scientist is his ability as a problem

solver. He faces a problem, and then has to provide an answer whose effectiveness is judged by whether it works or not. This is an attitudinal characteristic which colors the scientist's outlook far beyond his particular investigation of the laws of nature, because in other areas also, he will seek a course of action with ascertainable results. Once a scientist is known to have this attitude, his effectiveness goes beyond purely scientific problems, and he will thus be able to apply his attitude toward the resolution of other difficulties also.

The fourth and last characteristic of a scientist that I want to emphasize in this analysis is his attitude toward novelty, new ideas, and change. As I mentioned, one of the basic tenets of the scientific community is that a scientific idea, no matter how beautiful, is of value only as long as it is in agreement with reality. Let me offer a very dramatic example. The idea that nature is governed by laws which are reflection-invariant, or, in other words, that one cannot tell "real" nature from the mirror reflection of nature, grew into a very fundamental belief of scientists during the two centruies preceding the 1950's. It was an esthetically very pleasing idea, and it was confirmed by the structure of Newtonian mechanics which was so immensely successful in predicting the motion of celestial objects and in serving as a scientific basis of much of engineering throughout the centuries. Yet, this idea turned out to be incorrect, as demonstrated by experiments carried out in the 1950's, and as soon as these experiments were established, scientists had no other course than to abandon this highly cherished, traditional, and beautiful idea. They did so within a year or two from the initial discovery, and by now there is no scientist in the world who would continue to cling to the belief in reflection invariance.

In fact, change is the most fundamental hallmark of scientific work. There is a constant striving in science to formulate new ideas, to uncover new phenomena, and to modify previous concepts so that they become more powerful, with a broader validity and a greater simplicity. A person who does not believe in change and novelty as a way of life could hardly be a scientist.

Although I have hardly scratched the surface in analyzing the traits that characterize scientists, enough has been accumulated for the purposes of this discussion, and so let me now turn to the discussion of development.

I want to offer the following sentence as a definition for the concept of development: Development is the course of action taken by an individual or a group of individuals in order to achieve a greater realization of his aspirations.

This appears to be a rather general and vague definition, and yet, there is much value in starting with such a broad conceptual statement. Let me first explain its basis. Virtually all generations throughout human history shared the common experience of finding a basic incompatibility between the extent and variety of human aspirations on the one hand, and the brevity of human life on the other. Exactly what these aspirations are depends on the time period, on the particular civilization, on the particular individuals, on their cultural, religious, and social context, and many other factors. Yet, whatever our aspirations may be, we have found that they always exceed the potential of our own lives. There is, therefore, a strong urge to expand this potential as much as possible, so that we can more fully attain our aspirations. This process of expansion is called development.

Development thus has two aspects: The improvement of the tools that further the realization of the aspirations, and the broadening and realization of the aspirations themselves. One of the important virtues of approaching the concept of development in the way I outlined is that it includes *both* of these aspects. More commonly, in the frequent discussions in national and international bodies, governmental organs, and even academic circles, development is thought of exclusively in terms of the material tools to improve the physical living conditions of people. While this is an important part of the first of the two aspects of development mentioned above, it is not even the totality of the first aspect, and has little direct connection with the second aspect.

Let me elaborate on this point in more detail. There is no question that a life expectancy of 70 as compared to 40 promotes the realization of the aspirations of most people, and that a person who has to devote an overwhelming fraction of his time to providing food and shelter for his bodily survival will have less of an opportunity to fulfill his more fundamental, non-material aspirations than a person who derives comfortable living from a 40 hour working week. Yet, efforts to bring about such conditions simply provide tools toward development in a more general sense. Very few of us truly believe that the purpose of our lives is to eat well and have a decent shelter over our heads. We need something beyond that, and development must make provisions for fulfilling those needs also.

It is sometimes claimed that the fulfillment of these other needs can be postponed until material conditions are sufficiently favorable. I do not believe that this is possible. All through history, people were simultaneously occupied with improving their material lot and fulfilling their non-material needs. No single individual wishes to forego the latter in favor of a greater preoccupation with the former. Thus development must address itself simultaneously to both aspects.

Let me now list four basic aspects of development as I defined it.

First, development is based on the compelling human drive toward self-realization. All of us, no matter when we were born and where we live, have some personal philosophy about the purpose and aim of our lives, and we feel an obligation to live up to this purpose and aim. The development thus defined need not be along scientific or technological lines. It might involve purely spiritual factors, or can be along the strengthening of interpersonal ties. Yet, in all cases the source of this development is a desire to realize our aspirations.

Second, development involves a willingness to devote effort and energy, and to make sacrifices toward this self-realization. One need not have a very sophisticated insight into the workings of life to comprehend that a lethargic, passive, and listless person will not achieve self-realization. Even in cultures where the direction of self-realization is believed to be determined by God or the gods whose service represents the aspiration of the people, there is a drive toward performing the acts and rituals to an ever increasing extent so as to bring about the action of the gods. Thus, development is basically an action-oriented undertaking, in which hard work, devotion, perseverence is believed to bring about the desired results of self-fulfillment.

Thirdly, development is directed toward the attainment of a situation that can then be compared with the original aspirations which sparked the effort. In this sense development has a built-in yardstick. Virtually every individual finds himself, from time to time, assessing his own life in terms of whether his achievements match his aspirations. In fact, groups of individuals, that is, communities, countries, civilizations, or even humanity as a whole, tend to do the same. Much of the moral teachings in all ages stress the disparity between our aspirations on the one hand, and our capabilities and achievements on the other, and hence urge us toward greater efforts. Admittedly the yardsticks used in such comparisons are bound to be subjective in that they use the particular aspirations of the individual or group in question which might or might not be shared by other individuals or groups. Yet, the element of an internal comparison and evaluation is strongly present in terms of the "subjective reality" applicable in the particular case.

Finally, the idea of development contains the intent to bring about changes in the direction of a greater self-fulfillment of aspirations. As mentioned earlier, our aspirations define the end of a road (perhaps at an infinite distance), a road which we must make progress on in order to come closer to our goals. Such a progress need not pertain to material changes in our environment. For example, the attainment of an enlightened state of mind and spirit in some Eastern religions and philosophies is thought of as the end of a long and very difficult road which however has little to do with material prosperity or a modification of our physical environment. In other examples, however, where aspirations pertain to different goals, the results can be very tangible. The pyramid of Khufu in ancient Egypt, the creation of the Taj Mahal, or the landing of man on the Moon are examples of aspirations which are reflected in something very physical indeed.

So much for the characteristics of development. We can now turn to the relationship between this development and the scientists whose traits we described earlier. In comparing the two discussions, we can conclude immediately that a connection exists in three respects.

First and most obviously, because of the technological consequences of science, scientists can play a significant role in the improvement of the material aspects of the tools of development. This particular connection is so frequently and extensively debated that it really needs little reemphasis here. This is not to say that the debates on this subject have resolved all differences in views. On the contrary, arguments continue about the extent scientists influence technology, about the amount of science needed for a given amount of technology, about the right "type" of science and the right "type" of technology for a less developed country, etc. I would, however, like to concentrate in this analysis on the other two connections between scientists and development, because those connections are not frequently discussed and hence are neglected in development planning.

One of these is the attitudinal kinship between scientists and development. A glance at the charactristics of scientists and of development as outlined earlier reveals a striking similarity. Internally directed motivation is essential for a scientist and is crucial in the development process also. A willingness to spend energy, effort, devotion, and skill toward the desired goal is also common between the two. Both scientists and develop-

ment have an agreed-on, internal yardstick against which success is measured, and which serves as a guide to define the direction of activities. Finally, a directive toward improvement and therefore change is inherent in development as well as in what scientists do.

Thus, the presence of successful indigenous science in a country should be a very powerful attitudinal influence on development along more general lines.

The final link between scientists and development is the fact that science itself serves as one of the aspirations toward which development is oriented. Achievement in scientific exploration has been the pride of many civilizations before us, and will likely continue to be so. It never ceases to impress me how people in every country and from all walks of life, when they learn in a conversation with me that I am a scientist, relate to me not as a person who can help in making material progress, but instead as a person involved in a fascinating though perhaps esoteric activity that they find attractive to participate in at least through the indirect way of conversing with me. Their questions are not directed toward technology, but instead toward the latest discoveries of astrophysics or elementary particles they may have read about in the newspaper.

In fact, science not only serves as an aspiration in itself, but science and the derivative technology create a new wealth of aspirations which previously were altogether outside the horizon of the people. In Thailand, a few centuries ago, the aspiration of intense human and interpersonal interaction with other cultures could hardly have existed, because communication with drastically different cultures by a significant segment of the population was out of the question, and hence was not even thought of. Today, with jet planes, communication satellites, radios, and mass-produced magazines, this is not a ludicrous aspiration any longer. Other examples for new aspirations created by science and technology are numerous. Printing created wide-spread literacy, and literacy opened up enormous horizons and with its novel aspirations. Space travel offers humanity a completely new view of the universe, which arouses countless new aspirations. Thus the body of aspirations itself develops, and science plays a very significant role in this evolution.

It terms of this triple link between scientists and development, can we say something about the "ideal" scientist in a less developed country? Surely so.

First, such a scientist must fully carry and maintain the characteristics of curiosity and high morale, perseverence and hard work, functional and critical problem solving, and experimentation and striving for change that I outlined earlier. A university degree does not make us a scientist, no matter where that degree came from, and a scientist can cease to remain a scientist if he loses these characteristics, even if he retains his degree title or professorship.

Second, a scientist must not only contain but radiate these characteristics, so they are evident to everybody and so that they become contagious in his environment. A scientist, beside carrying out his particular special research work, should function as a problem solver far beyond the particular areas he carries out detailed research in. This is not to say that scientists are omniscient. Not at all. But they can contribute to a broad area of development if they act in cooperation with others perhaps more knowledgeable about

the details of certain problems. Perhaps most importantly, a scientist must participate in the drive to make every inhabitant of his country a "scientist" of sorts, that is, to implant into people the characteristics of a scientist that are so close to the characteristics required by development in general.

This discussion of scientists and development, as indicated at the beginning, remained on a general plane. It was my intention to suggest that if one takes a broad view at both a scientist and the process of development, one perceives a striking similarity between them and so one can also define a very fundamental and comprehensive context in which scientists are not only useful but in fact indispensible to development.

Does all this leave you still unsatisfied and unoriented? It should, because the general framework I outlined needs to be filled with particular values, standards, goals, aims, and details before it can give you specific directives for action. I feel, however, that as an outsider to the Thai scientific community (however sympathetic I may be, and in spite of having had a first hand opportunity to get acquainted with Thai science), I cannot and should not dictate or influence too much the filling in of this general framework. How a Thai scientist can best transfer his attitudes to the Thai citizen, how the Thai scientist can participate most effectively in developmental problem solving, how a Thai scientist can most successfully fulfill his own aspirations toward scientific discoveries, are questions that must be resolved internally within your own community. The experience of other countries and suggestions from knowledgeable outsiders can be helpful in generating a fruitful discussion and in considering the various options, but in the final analysis the decision must be an indigenous one. In this sense the contribution of this article was hoped to be to provide a sufficiently extensive, versatile, broad, and pershaps somewhat unconventional framework so that it can include all of the aspects of Thai sceince development in the years to come. I hope that your new journal will play a crucial role in the filling in of this frame-work and hence in the creation of a science policy for Thailand in the broadest sense of the word.

Reference

1. Moravcsik, M.J. (1975) *Science Development,* Indiana University Press, A survey of about 100,000 words in length, with a bibliography of about 500 sources. Special efforts are being made to make this book available to potential readers throughout the world in exchange for a modest amount of local currency. The usual author's royalties have been plowed back into the distribution of the book. For further information about how to acquire the book, write to John Gallman, Indiana University Press, Bloomington, Indiana 47401, USA.