



Science/Technology Education in Church-Related Colleges and Universities

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The Ideal and Reality of Science Education in Catholic Colleges and Universities

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The ideal of science education in Catholic schools depends on three factors. The reality depends on how these factors are implemented in a given institution, department, or course. The types of institutions, their goals, their faculties, and their finances will play important roles in determining this reality.

First, the sciences are among the Liberal Arts and Sciences. They are thus a part of a liberal education. Education, especially today, is incomplete without some knowledge and appreciation of the accomplishments of science and the methods used by its various branches. In addition, almost all colleges and universities will elect to educate professional scientists at the bachelor's level. Some will also offer programs at the master's and doctor's level.

Second, the sciences and technology are both the occasion of and the solutions for many of our current social and political problems. Thus some understanding of these subjects is important in the education of a responsible citizen.

Third, the sciences and technology inevitably interact with theology, philosophy, and religion. A confident and intelligent believer must understand these interactions.

The first two of these factors should be common to every type and system of education. The third is specific to the goals of religious schools and scholars. Further, all scientists must confront the interaction of science with philosophy, theology, and religion at least in their personal lives, as will most other people because of the popularization of scientific discoveries and concepts. Institutions will often take implicit or explicit stands about these interactions through their policies.

First some definitions and ground rules. By science and technology I mean the investigation and exploitation of nature guided by a set of insights which came out of the middle ages and began to have significant success in the 16th and 17th centuries. The writings of Nicholas of Cusa and Roger Bacon are among the early attempts to describe and organize some of these ideas. Important among these insights was the firm belief in a creator. A mind, infinite but much like our own, created intelligently and purposely. Our minds can, therefore, discover, describe, and understand the creator's plan, the rules by which nature operates. More technically, these insights deal with the use of experimentally verified data, and with the use of models to explain this data. Models are used to organize thought and also as expressions and forms of thought. New rules gradually developed about what constitutes a good model, and how models and their parts are to be tested, judged and evaluated.

My description will use physics primarily as the example of science. The other scientific disciplines experienced similar applications of these insights in ways appropriate to their subject matters. It should be noted that all disciplines including philosophy and theology have also incorporated many of these ideas in their recent development and thus have become "scientific". In all cases, that which is studied through disciplined observation, experiment, and model building tells the investigator the method by which it is to be successfully studied. Sometimes intuition and scientific taste are as important as logic. My ideas are based on relatively restricted understandings, some would probably say caricatures, of the sciences, other disciplines, and religion. Some would probably judge that the use of model in the religious arena is completely inappropriate.

In order to be a Catholic I must answer four questions which science does not address:

First. Did the physical universe just happen or did something exist for ever?

Second. Is this universe merely matter guided by a combination of its innate laws and chance, or is this something an eternal intelligent being designed?

Third. Did this intelligent eternal being intervene personally in my world through creation, revelation, and redemption?

Fourth. Is this revelation contained in the Judeo-Christian tradition and its scriptures, and is the redemptive intervention in the person of Jesus Christ and through His Church, the Roman Catholic Church?

Every human has to answer a similar set of questions either explicitly or implicitly. The atheist or agnostic will answer these questions quite differently. The answer to the fourth question will determine one's confessional commitment. The answers to these questions provides each of us with the model by which we understand the world and our place in it. This model provides the understanding by which we live and worship. Its purpose is to organize and make intelligible all of reality. This all inclusiveness is a property of the models used by philosophers and theologians of an earlier day and as well as of those called natural philosophers until after the middle ages. These are very different from the models used by modern science.

It should be noted that practitioners of the more speculative branches of science, such as cosmology, will answer or come close to answering the first two questions.

In the social and political areas as well certain questions must be answered. These answers set our social and political priorities. Thus they provide each one of us with the over-all framework or model on which our relationships with and actions towards others, towards social structures, and towards the state are based and are made intelligible. The answers to these questions gives us a model similar to the religious model but again very different from those used in science.

The scientific models of ancient civilizations, especially Greece, which carried over into the Middle Ages, tried to give organization to the material universe or a large portion of it. The astronomical model based on crystalline spheres, and the model based on earth, air, fire, and water, are similar to the religious models in their all-inclusiveness and in their lack of attention to precise details, of the religious model. In the same way they are dissimilar to the scientific models of modern science.

The religious model and other models similar to it are:

All inclusive - Its postulates or starting truths must organize all of reality.

Limited knowledge of major truths: Because the human mind is limited we must learn of the divine through analogy and revelation. The assents to some of the truths are based on faith rather than human reason and observation.

Major truths are not changeable. Therefore discovery is not anticipated except on the basis of the already known.

Details are relatively unimportant. Inaccuracy at the level of details can be tolerated. Details may be changed and are worked out as the model grows in perfection.

Urgent - The model must be put together in time for me to act. That is, in order for me to live and die by it.

Test of truth - The test of truth is revelation and human reason.

Personal commitment - A personal commitment to the model itself is necessary.

The models of modern science, however, have much different requirements:

Detail are all important: The models must be accurate quantitatively and explain minute details. The necessity to explain details supercedes the organization of a larger collection of data.

All inclusive - Although a universal model is the ultimate goal of the science this goal must await the inclusion of all details.

The model is changeable: Scientific knowledge is in principle tentative. As knowledge of detail advances through experiment and the relationships between the data are understood the models can be corrected to have broader application or improved accuracy. They can also be displaced by more accurate, more useful, more powerful, or simpler models. New data or insights may attack the model at the level of its fundamental postulates and thus may overturn the model completely.

Discovery is expected: The purpose of experimentation and scientific investigation is discovery. The body of scientific knowledge is constantly expanding.

The model is quantitative and mathematical: Since the model is mathematical those relationships which are described by mathematical operations in an equation become the most important. Even though the model is accurate certain data may be excluded or the model may be true only with in an imaginary limit. (The undergraduate is never completely comfortable with the elementary applications of the insights of Galileo and their later formulation in Newton's Laws of Motion because of the way friction is neglected.) Further these models are subject to the rules of mathematical logic. Thus no set of postulates can explain all reality. There are an infinite number of models which can explain any set of data. Some will argue that the contact of the model with reality is an isomorphism and not an identity.

Test of truth - The test of truth is the ability to explain and predict natural phenomena.

Commitment - The scientist's primary commitment is to an ever evolving process of discovery, not to the current models.

Scientific models differ in almost every important respect from the models used in religion, society, and many other disciplines. Scientific thought and method is governed by different rules and insights. The scientific models seek to describe and understand the world around us. Questions like: how is this best described? what are the relationships between the parts? how can this knowledge be used to build a technology or manipulate nature? are important. The religious and social models and those of the liberal disciplines, in so far as they try to address certain concerns, also produce models. These models seek to make one's place in the world intelligible and meaningful. The questions Where do I fit in? and How do I live in this world? are important.

These models are complementary. That is different views of the same reality for different purposes. Those of us who have some skill in the use of two or more of these models have the unique ability and thus an obligation to address certain problems. Our role is very much the same whether we are working in the school, with social and political concerns, or with the Church. A few comments about the three factors with which this paper began are in order.

First, science is one of the major accomplishments or creations of the human mind along with literature, art, architecture, philosophy, theology, etc. In recent centuries science has earned both great success and great prestige. The material dimension and much of the intellectual dimension of our civilization have been shaped by science. (Almost all other disciplines have to some extent incorporated scientific methodology and techniques where appropriate.) An education which passes over this method of thought and investigation is not humanistic or liberal. Scientific education is the teaching of scientific models, their use, and their meaning.

The science educator faces two very different groups of students: those seeking to meet a general education or core requirement and those preparing for a career in a scientific or technical field.

Many in the first group, and it should be stressed not all of them, come to the class room very poorly prepared for even the most elementary college level science. They are from elementary and secondary schools in which science courses were either unavailable or easily avoided. They lack rudimentary exposure to scientific thought and its vocabulary and have little or no mathematics. They are convinced that they cannot succeed at science and thus are prepared to dislike, fear, and distrust it. At times these students have unreasonably high expectations of what others can do for them through science and technology. They are apt to attribute to a corrupt suppression of knowledge the inability of science and technology to meet these unreasonable expectations through immediate solutions of currently pressing problems. Much of the work in these classes is remedial. Yet, at the same time, these students must be brought to a rather sophisticated level of understanding, comfort with, and trust of scientific models of thought.

Perhaps most distressing in these students is the inability to understand a quantitative argument. To them, things like radioactivity, carcinogens, pollution, and safety are either off or on. They see and feel no difference between a million and a millionth. Unfortunately, all current environmental problems and many social and moral problems have important quantitative components. The quantitative information keeps changing, making rethinking of the problems and their solutions necessary. An example: About twenty five years ago an expensive analysis done by an outside chemist was reported to one part in a thousand. One trusted it to one part in a hundred. Today it is relatively easy to measure the same thing to one part in a trillion.

These core curriculum students are in danger of never obtaining sufficient mastery of a scientific model to understand scientific accomplishments or the integration of science with the social or religious models.

Students preparing for degrees in science and engineering often have the opposite problem. They are fascinated by the scientific models appropriate to their disciplines. They graduate as highly trained scientists and engineers. Unfortunately, a combination of their own lack of interest or lack of integration in their core requirement courses leaves these young professionals with very unsophisticated social and religious models. Their ability to integrate their science with citizenship and religion for themselves and for others is, therefore, severely limited.

Second, some integration of science with social and political models is necessary for the citizen. The environmentalist, politician, or citizen concerned about and seeking action to correct the greenhouse effect, or acid rain, are often not happy with the accurate scientific answers to their questions. This answer is often that not enough is known to describe the extent of the problem or to predict the outcome of proposed solutions. Thus it is necessary to await further investigation before a course of action can be recommended. Further, some scientists when addressing these problems, will confuse or perhaps merge their scientific and social models. This example illustrates the importance of non-scientists having familiarity with the scientific approach and scientists realizing that they are speaking to people operating out of different models. Only in this way can tension be avoided among those seeking the truth from different perspectives. This example might enable us to understand some of the less fortunate interactions of science with theology and religion.

The federal, state, and local governments are forcing integration of the scientific and social models through regulation. For example, colleges and universities must have highly developed federally approved policies, and the organizational structure for enforcing these policies, to be eligible for federal research funding or to avoid substantial penalty. Some areas are: radiation safety, hazardous waste, biological hazards, animal care, human subjects, misconduct in scholarship, and soon conflict of interest in research.

Third the ideal interaction of science with some parts of philosophy and theology and with religion is one of complementarity. All of these methods of thought or belief look at the same truth from different points of view. The statements of the different disciplines on topics like: The origin of the universe, the origin and meaning of the human person, the human mind, human society and organization are quite different. This is because these statements must meet very different criteria, and serve different purposes. In short the statements will be made in the context of very different models. Complementarity is recognizable only when thinkers are clear about the models they are using. Complementarity is lost when one allows the different models to become mixed. That is when one tries to use the

scientific model to answer a religious question or vice versa. In addition some of the investigations and many of the applications raise moral questions. That is, we must decide how these investigations and their applications fit into the models which define our places in the universe and society.

History and the present teach a clear lesson. The ideas which form important parts of the scientific models also become important in social, philosophical, theological, and religious thought. Without a strong professional presence in and understanding of science the Church will abnegate the right to and the possibility of participating in the discussions about the integration of science, society and religion. The Church needs an arm of scientific education and scholarship. This arm can only be the Catholic colleges and universities.

Finally, for those of us who have some knowledge of both the scientific, social and religious models, the task in the three areas of education, citizenship, and service to the Church are much the same. In all three areas we face constituencies who either do not understand science or who are highly trained scientists often with little religious background or interest. We have a great potential for bringing about understanding by explaining the complementarity of the different modes of thought and their resulting models. Since most of those who service the church have a humanistic education it is incumbent on us to explain the scientific model and the complementarity of scientific knowledge with what they know and believe. At the same time we are the only ones who can help scientists understand the Church and its particular mode of thought.

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