GIREP newsletter

Groupe international de recherche sur l'enseignement de la physique
International Research Group on Physics Teaching
Internationaler Arbeitskreis zur Förderung des Physikunterrichts

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Method in the Physical Sciences

John von Neumann, born 90 year ago

Emphasis on methodology seems most often to arise when there are symptoms of trouble, when realization of difficulties makes necessary a re–examination of some position inherited from the past. Because traditional attitudes in the sciences seem to have been firmer and more self-assured than in other disciplines, there has perhaps been less searching of the scientist's conscience and, therefore, less concern with methodology on his part. Yet he has not been without concern, for there have been within the experience of people now living at least three serious crises – or reverberations of earlier crises – which have caused him to reorientate his thinking. We can use these crises as prototypes for reference, and we can calibrate our statements with their help.

There have been two such crises in physics – namely, the conceptual soul-searching connected with the discovery of relativity and the conceptual difficulties connected with the discoveries in quantum theory. In the case of relativity, the crisis was brief and violent. The second persisted over a longer period, during the almost thirty years in which the quantum theory took shape. (...)

To begin, we must emphasize a statement which I am sure you have heard before, but which must be repeated again and again. It is that the sciences do not try to explain, they hardly even try to interpret, they mainly make models. By a model is meant a mathematical construct which, with the addition of certain verbal interpretations, describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work – that is, correctly to discribed phenomena from a reasonably wide area. Futhermore, it must satisfy certain esthetic criteria – that is, in relation to how much it describes, it must be rather simple. I think it is worth while insisting on these vague terms – for instance, on the use of the world "rather." One cannot tell exactly how "simple" simple is. Some of the theories that we have adopted, some of the models with which we are happy and of which we are very proud would probably not impress someone exposed to them for the first time as being particularly simple.

Simplicity is largerly a matter of historical background, of previous conditioning, of antecendents, of costumary procedures, and it is very much a function of what is explained by it. If the amount of material which is unambiguously explained – that is, explained with no added interpretations or commentaries – is extremely extensive, if it is also very heterogeneous, if one has clearly explained a large number of things in very different areas, then one will accept a good deal of complication and a good deal of deviation from stylistic beauty. If, on the other hand, only relatively little has been explained, one will absolutely

insist that it should at least be done by very simple and direct means. It must be also said that the criterion, that a lot should be explained, has to be applied with a good deal of sophistication. Indeed, some of the nuances of all these requirements can probably only be appreciated intuitively.

The ability to describe – or to predict – correctly is important in such a model, but it need be decisive per se. Also, in scientific prediction it does not matter enormously wehther prediction occurs before or after the fact. Of course, it must be correct. However, as I mentioned above, it is considered very important that the material which has been correctly described or predicted should be heterogeneous. Let me analyze this requirement in somewhat more detail. If possible, the confirmation should not all stem from one area alone. In this sense, it is considered particularly significant to find confirmations in areas which were not in the mind of anyone who invented the theory. Thus, if you discover that the theory, which was necessitated by difficulties in one area, describes things correctly in entirely different areas, this is highly significant. It is even more important, if things have not been previously very harmonious in these latter areas and there was no sense of optimism about them. – In this regard, the enourmous authority of quantum mechanics is typical. It was probably strongly conditioned by the fact that quantum mecahnics came into being because of varios difficulties in spectroscopy and of various other problems of atoms and molecules which are variously connected with spectroscopy, but that it was then suddenly found capable of describing or predicting correctly various things in chemistry, in solid-state physics, and even to have some bearing in epistemology. These were hardly on anyone's mind at the beginning. (...)

In evaluating what these models do, one should also emphasize how little of directly interpretive element need be attached to them. In this respect, it is instructive to look at a classical example. In other areas, even in some within science – for instance, biology – it is, or was, considered very important to which one of two major types the view that one takes of the area belongs. Specifically, whether the view is causal or teleological. (...)

This contrast is very wellknown from biology. It is also familiar with a number of fileds increasingly removed from science. It is usually considered as a very fundamental contrast: the causal and the teleological procedures are viewed as mutually exclusive, as highly antithetical ways of explaining phenomena. It is therefore very important and very characteristic that in science there need not be any meaningful difference between these two descriptions. Indeed, in classical mechanics there are two absolutely equivalent ways to state the same theory, and one of them is causal and the other one is teleological. Both describe the same thing, Newtoniain mechanics. Newton's description is causal and d'Alembert's description is teleological. This has been known for well over two hundred years. All the difference between the two is a purely mathematical transformation. In principle such a mathematical transformation is no more profund than choosing to say four instead of saying two times two. In other words, by purely mathematical manipulation one can show that each of these two ways gives exactly the same results as the other.

Thus whether one chooses to say that classical mechanics is causal or teleological is purely a matter of literary inclination at the moment of talking. This is very important, since it proves, that if one has really technically penetrated a subject, things that previously seemed in complete contrast, might be purely mathematical transformations of each other.

Things which appear to represent deep differences in principle and of interpretation, in this way may turn out not to affect any significant statements and any predictions. They mean nothing to the content of the theory.

Thus we have an example where alternative interpretations of the same theory are possible, but where the question of whether one uses one or the other is decided in a manner quite different from what is generally believed to be the valid way. Indeed, the criterion is one of mathematical convenience or taste.

There is also another example where this is the case, but only up to a certain point: beyond that point seriuos, substantively relevant differences of interpretation arise. The example is quantum mechanics. I will limit myself to that part of the theory which refers to the electronic shells of the atoms. For these a theory is known which seems to be entirely satisfactory at present. This theory can be described in two different ways which differ quite importantly, somewhat in the manner of the causal and teleological interpretations of Newtonian mechanics discussed above, though the difference in this case is not quite as striking and profound as there. The two descriptions are, first, the original procedure of Erwin Schrödinger which describes this part of quantum mechanics by an analogue with optics, and second, the method of Werner Heisenberg which describes this area in completely probabilistic terms.

Since these descriptions were first formulated, a great deal of work has been done on both and they have been further elaborated. In the process it was demonstrated that they are matematically equivalent. The prevalent taste is today, and has been for more than twenty years, rather in favor of one of the two interpretations, namely, the statistical one. (It must be said, however, that there have been in the last few years some interesting attempts to revive the other interpretation.) It was, moreover, quite clear all along, that ultimately the motive for choosing one or the other attitude would be connected with the fact that quantum mechanics, in spite of all its successes, is contiguous with areas in which the theory is not satisfactory, specifically, with the quantum theory of electrodynamics and subsequently with the quantum theory of particles like mesons and their successors.

About all of these we know a great deal less than about the original area of quantum mechanics, and we are here in the midst of grave difficulties. The reason for preferring one version of quantum theory over the other has usually been the intuitive hope that one or the other would give better heuristic guidance in extending the theory into those areas which are not yet properly explained or not yet properly theoreticized and controlled. Throughout the last twenty years this has been prevalently believed to be a matter if finding correct formal extensions of existing theory. If this ultimately proves to be the case, it will determine the final choice. Questions of form, even when the mathematical contexts are equivalent, can therefore have great heuristic and guiding importance, and in the end determine the outcome.

There have been some individual exceptions to this rule. Some physicists certainly had definite subjective preferences for one description or the other. However, there can be hardly any doubt that scientific "public opinion" in the end will only accept that variant which succeeds in pointing the way to explaining wider areas with greater power. In other words, while there appears to be a serious philosophical controversy between the interpretaion of Schrödinger and Heisenberg, it is quite likely that the controversy will be

settled in quite an unphilosiphical way. The decision is likely to be opportunistic in the end. Theory that lends itself better to formalistic extension towards valid new theories will overcome the other, no matter what our preference up to that point might have been. It must be emphasized that this is not a question of accepting the correct theory and rejecting the false one. It is a matter of accepting that theory which shows greater formal adaptibility for a correct extension. This is a formalistic, esthetic criterion, with a highly opportunistic flavor.

The whole article was published in 1955 in "The Unity of Knowledge", L. Leary, Doubleday, New York.

A Brief History of GIREP

In the years 1960–64 OECE (that later became OECD) arranged a series of international meetings to encourage the renewal of Physics teaching. The meetings proved to be a valuable source of inspiration for the participants. However, from 1964 OECD concentrated on other fields and stopped supporting meetings on physics education. – A number of persons who had attended the previous meetings, led by prof. W. Knecht, Switzerland, believed that the series of international meetings on teaching physics in schools should continue. To this end they formed an international working group: GIREP was founded March 1966 with prof. Knecht as President. – At the beginning the number of members of GIREP was quite small (a few tens), but it soon grew to over 100 and now, since may years, it is quite stable at about 200. – Very soon GIREP began to organize international meetings, finding sponsorship from Universities, Ministries of Education, UNESCO, ESA and many other national and international organizations. One way the Ministries of Education sponsor the Meetings is paying for the attendance of local school teachers. Here is a list of GIREP meetings from the very beginning:

1. Jan 1967 (Lausanne, Switzerland): in collaboration with the International Commission of Mathematics Teaching, preliminary informal meeting on the co-ordination of mathematics and physics teaching at the secondary school.

2. 30 Oct – 5 Nov 1968 (Malvern, UK): Study and discussion of the Nuffield Physics.

3. 30 July – 5 Aug 1969 (Copenhagen, Denmark): Energy in the lower secondary school, Quantum mechanics and Relativity in the higher secondary school.

4. 16–18 Mar 1972 (Kiel, Germany): joint GIREP–UNESCO Meeting on the implementation of curricula in science education with special regard to physics teaching.

5. 14–20 Oct 1973 (Venezia, Italy): "Electricity, magnetism and quantum mechanics in the secondary school".

6. 6–10 Sept 1976 (Montpellier, France): Two main topics: "First steps in teaching physics at the beginning of secondary school", and "Probability and Statistics in physics teaching".

7. 14–21 July 1978 (Oxford, UK): joint ICPE–GIREP Meeting on "The role of the Laboratory in Physics Teaching".

8. 19–24 Aug 1979 (Rehovot, Israel): two topics: "Teaching Waves and Oscillations" and "Current Problems in Physics Teaching".

9. 6–12 Sept 1981 (Balatonfüred, Hungary): "Nuclear Physics, Nuclear Power".

10. 20–25 Aug 1984 (Zeist, Holand): "The many faces of teaching and learning mechanics".

11. 18–23 Aug 1986 (Elsinore, Denmark): "COSMOS – an Educational Challenge"

12. 7–13 Sept 1989 (Balatonfüred, Hungary): "Energy Alternatives – Risk Education".

13. 19–24 Aug 1991 (Torun, Poland): "Teaching about Reference Frames – from Copernicus to Einstein".

14. 16-21 July 1993 (Braga, Portugal): "Light and Information".

Coming GIREP Meetings are: RIO FOLLOWUP – SCIENCE EDUCATION AND ENVIRONMENT, 22–27 Aug 1994, Eger, Hungary and SPACE, TIME, ENERGY FRONTIERS IN PHYSICS EDUCATION, 1995, CERN, Genf, Switzerland. In 1996 ICTP, Trieste with University of Udine, Italy, and in 1997 Ljubljana, Slovenia is planned to host our Meeting.

Since 1969, all Meetings published Proceedings, that were distributed to all members. But, occasionally, other Proceedings were also distributed; for example: *Proceedings of the ICPE Conference on Education for Physics Teaching*, Trieste 1980, *Proceedings of the ICPE Teaching Modern Physics Conference on Condensed Matter*, Munich 1988 (some copies are still available at the cost of mailing expenses, the first one: c/o Silvia Pugliese Jona, the latter one: c/o George Marx, addresses on the last page of this NL); *Proceedings of the Conference MICROSCIENCE*, on computers in Science Teaching. *S.P.J.*

Science and Mathematics Education for the 21st Century: towards Innovatory Approaches

International Conference, 26 Sept – 1 Oct 1994, Concepción, Chile

The aim of this Conference is to analyze the field of Mathematics and Science Teaching in the broad perspective of the coming Century. The scientific and technnological progress implies new challenges for science and mathematics educators. Science and mathematics teaching must, therefore, be faced with innovatory approaches. The idea is to discuss general orientations for the whole educational systems and for all educational levels and modalities in order to satisfy the needs for the 21st Century.

The main questions to be asked will be: * How does science and mathematics curriculum differ from country to country and is it possible to arrive to some common topics and approaches? * How does technological and scientific progress affect science and mathematics teaching? * Do Multimedia improve science and mathematics teaching? * How should assessment be integrated in an innovative approach to science and mathematics teaching? The conference will include plenary sessions, workshops and four group sessions for presentation of papers in biology, chemistry, physics and mathematics education. – The Conference Proceedings will be published and made available free of charge to all participants. – The Conference language will be English. – The Conference registration fee is US$ 150. Special discounts will be given to school teachers and students, graduate students and postgraduate students. – A list of suggested hotels, including details of costs per night will be delivered to all those interested in attending the Conference. An estimate cost per day, including maels, is US$ 100. – Further details: *Prof. Marilú Rioseco G., Facultad de Educación, Hdes. y Arte, Univesidad de Concepción, Casilla 82-C, Concepción, Chile.*

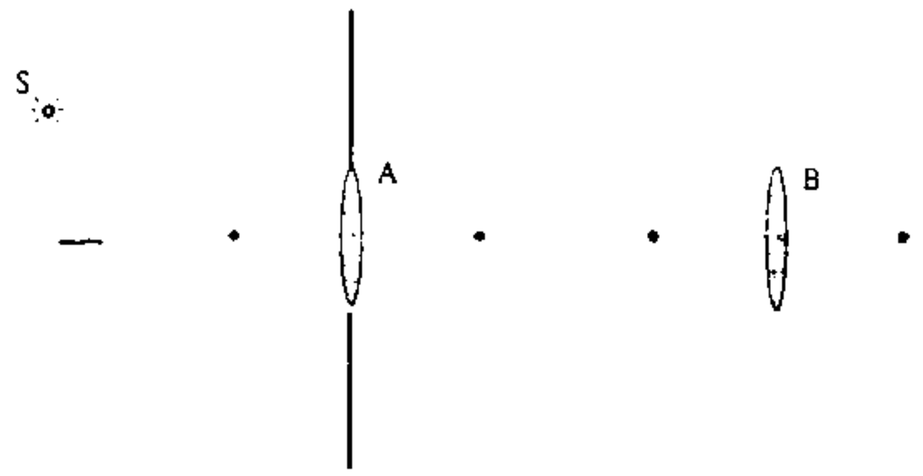
Thermal Isolation of a Dog's House

The project is a part of a bigger one, namely: "Energy Saving, Stop to waste energy for heating". The aim of the project is to examine the heat escape from houses and to look for a method of preventing that. The project should involve qualitative and also quantitative investigaton. One of the proposal is an investigation of quality of thermal isolation of dog's house. In the project can be examine the thermal conductivity of different materials, combinations of layers, importance of order of layers, shape of the house, protecting windows, doors, temperature gradient inside the house, the role of the position of the heater, and many other things. – The project can be done by a group of the students, in school or at home. It can be individual work, or also a family project (very welcome to involve parents). It can be done by small children and college students. – Students should learn how to design a project, consult with specialists (teacher or other person), perform, document and present the result of investigation. – There is nearly unlimited number of different project, starting from play with constructing igloo, to lab investigation of different materials. – The result will be published in a kind of general report. In case of interesting results it will be presented on GIREP conference in August 1994 in Hungary. In Poland they will be presented on junior workshop (May 1994). – The project is plan to be continued in the next school year (after gaining this year experience). We also hope to find sponsors. – The subject of investigation is universal, interesting for students of different countries. The result has not only academical value but measurable economical one. The project goes in the direction of the project: "50 simple things kids can do to save the Earth". *I invite children from all over the World to joint us.*

Zofia Golab-Meyer, Institute of Physics, Jagellonian University
Reymonta 4, 30059, Krakkow 16, Poland

Problems

There is a point like light source in S; A and B are lenses.



a) Does the lense B create any image of S?

b) Can you see the image without any screen? If you think: yes, mark the area where you can see the image of S.

After *Miky Ronen, Israel*

From the speed of the wave on the surface of water, and from the speed of the sound inside the water how can you estimate the order of the size of a water molecule?

Edward Teller, USA

International Meeting of Science Education Journals

Gaeta, Italy, August 1993

This three–day meeting, organized by "La Fisica nella Scuola", journal of AIF (Associazione per l'Insegnamento della Fisica, Italy) brought together about 50 people, Editors and members of Editorial Boards of Science Education and Physics Education Journals and others, to discuss the problems involved in the production and dissemination of such journals. – The Meeting was structured in plenary sessions and workshops. In the plenary sessions the general problems facing the participants were surveyed at the beginning of the Meeting and conclusion was drawn at the end, while the bulk of the work took place in the four workshops. The main topics of concern are well illustrated by the titles of the workshops:

1. SUPPORTING AUTHORS –How to encourage potential authors (in particular people who do not usually publish such as students, young researchers, teachers, etc)? Which mechanisms in order to encourage larger dissemination of research findings? How to help non-English-native authors to publish and make non-English published work better known in the Anglo Saxon world?

2. THE NATURE OF RESEARCH – Which are the appropriate formats for reporting different kind of research work? Which are the appropriate research design criteria and data analysis methods? What is the role of social research methods in Science Education?

3. JOURNAL AUDIENCES AND THEIR NEEDS – What balance between new scientific information and classroom materials? Which are the special knowledge needs of science teachers? Which are the adventages and disadventages of spontaneous versus comissioned articles? How to improve the image of science?

4. THE MAKE–UP OF A JOURNAL – What is the role of special sections and/or notes? Of special issues, suplements, thematic editions? What is the difference between the role of a journal and the role of a magazine?

The Meeting was attended by a wide spectrum of journals, mostly from the English speaking world and from Europe. It is a pity that the south of the world was practically not represented, except possibly through Dr. Holbrooke of ICASE. Among the attending journals, some are published by associations of scientists, teachers or researchers, some by independent publishers. Some rely on spontaneous material, others largerly on comissioned articles. Some are directed to a wide scientific minded public, some mostly to professionals, some especially to students. The participants knew each other's characters and concerns through the informative materials each of them had previously sent to the organizers, that had been collected with other working materials in a substantial Pre-Conference book. Getting to know and to discuss common problems with people working in different though related fields proved to be a stimulating experience and one to be repeated. – Proceedings are expected to appear in a few months. Those who are interested can please write to me.

Silvia Pugliese Jona
(address on next page)

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GENERAL INFORMATION

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FEES

The accounting year runs from January 1 to January 1, Fees paid after September in any year will be credited on the following year, unless the applicant specifies otherwise. – The current fee (1992) is 10 £st, **preferably paid into one of the two London accounts** or, if that is not possible, the equivalent of 10 £st in the currencies and into the accounts indicated application for (or renewal of) membership, with members paying their own bank charges and mailing costs. It is possible and advisable, in order to reduce bank expenses, to pay several years together in advance. – In cases of real difficulty of payment, please contact the Secretary who is ready to advise whether special arrangements can be made.

London accounts:

a) GIRO: Fees in £st should be made out to "Brian Davies re GIREP" GIRO Account n° 53 889 4806. This number must be quoted and the money sent to GIROBANK, c/o The Post Office, Eccleston Street BO LONDON SW11 9LS, UK. At the same time, please send a note to the Treasurer confirming how much money you sent and when and for what years. b) Non GIRO: made out to "GIREP ACCOUNT N° 90301248" and sent to the Treasurer.

Italian Account: Equivalent of 10 £st can be paid, in Italian Lire only, made out to "Marisa Michelini" and sent to: Dr Marisa Michelini, Dipartimento di Fisica dell'Universita', via delle Scienze 208, 33100 Udine, Italy, fax: 39–432-558-222.

APPLICATIONS AND NEW MEMBERS

Applicants for membership should, please require the Application Form from the Treasurer

INQUIRIES – CHANGES OF ADDRESS

Please, address inquiries concerning fees to the Treasurer. Other inquiries may be addressed to the Secretary or to any other member of the Committee. Please, send notice of changes of address to the Secretary.

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