METHOD OF LEARNING IN SCIENCE

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All knowledge and understanding of the materials and appliances of practical life and of the phenomena of the world of matter and force must be ultimately based on our personal experience, either in perceiving events, or the actions of other people and their effects, or more directly by ourselves acting on things and noting what happens. Experience of one kind or another must be the source of all meaning and understanding of physical reality, although thought and imagination can transform experience into the higher and more universal plane of general law and theory.

The primary mode of learning, therefore, is to gain experience of the physical world around us by 'acting on it in various ways and noting what happens'. This is instinctively the young child's mode of learning. He acts on various things in a variety of ways, either on his own impulse, or in imitation of, or under the direction of others, and thus gains an ever increasing experience of the behaviour of things and substances under various conditions. It is true that in certain fields he has little, or no experience, e.g., in the properties and action of magnets, frictional electricity, chemical action, generation of electricity, surface action, etc. He, however, comes to school with a fairly extensive experience of materials, force, motion, heat, light, sound and uses of electric currents. Such experience is of necessity inexact, indefinite, and superficial. It has been subjected to little analysis and organisation by thought. It is merely a loose mass of experience relating to the things of everyday life, and to its practical purposes. It is the aim of science teaching to extend this experience, to make it more exact, clear and full, to organise it into general laws, and to rationalise it through explanation and theory. To quote Dewey, "Science is experience being rationalised".

It is clear, then, that one important method of learning science must be:

The gaining of exact and clear experience in fields in which the boy has little experience by the primary method of "acting on things and noting exactly what happens," e.g., acting on chemical substances with water, heat, or acids and noting what happens.

Observing more clearly and accurately what happens in situations in which they have experience, e.g., friction, pupils have a fairly extensive experience of friction by sliding, sledging and bicycle brakes. There is need, however, for accurate experimentation to make clear and standardise the conditions that determine friction. Similarly with levers, action of forces, etc. The starting point in all such enquiries must, of course, be in the recall and examination of the experience they already have.

Knowledge, however, can advance far beyond the plane of perceived facts. By thought the intelligence can probe behind facts to those factors and conditions that are hidden, obscure, and frequently unperceivable. For example, we can directly experience the upward force necessary to support a solid body by the hand and to move it upwards; but we cannot perceive the upward force that supports a ship, or that causes a cork to rise in water, or a balloon in air. Only thought can reveal these obscure and hidden causes of events that are familiar to all. If the teacher is to guide his pupils' thought in revealing these hidden causes, he must know how such thought proceeds.

It is a psychological truth that an unknown situation is interpreted by, and in terms of, the known on the grounds of some similarity or analogy of the unknown to the known. For example, suppose we are faced with the problem of finding the cause of a ship floating on water, or a cork rising on water, or a balloon in air. If we call to mind the experience that a solid body requires the upward force of the hand to support it and raise it, we can infer by analogy that water is exerting an upward pressure to support a ship, and cause the cork to rise, and also, that air is exerting an upward pressure in supporting and raising a balloon.

It is by such inferences from analogy that the intelligence is able to form conceptions of those conditions and forces operating in the world of reality that are hidden from perception, but the understanding of which is the key to our grasp and mastery of the world of matter and force.

Such inferences are, however, only of the nature of suppositions or hypotheses. They are not established truths. Inferences from analogy are not logically infallible, and must be subjected to test to see if they will work under other circumstances and conditions. Hence the test takes the form of arguing: "If it is true, what would happen under this, that, or other circumstances?" For example: If water exerts upward pressure, what should happen if an object that sinks is weighed in air and in water? Or if air presses upward, what should happen to a column of water, if we arrange to bring the upward pressure of the air to bear on its lower surface?

Such experiments test and verify or disprove our suppositions. They test our thought. They form the dramatic crisis to which our creative thought works, and they decide and resolve the issue of true or false.

The essence of this second stage of scientific method is:–

(a) Examination of some situation familiar to the pupils to reveal some specific problem.

(b) Search in the past experience of the pupils to find some apt analogy that will bear on the problem.

(c) Examination of the analogy to make clear the idea exemplifies, and the application of this idea to the problem to form a suggested explanation.

(d) Investing an experimental test that will verify or disprove the suggested explanation.

It is the art of teaching to stimulate, help and guide the pupils in this process of examination, suggestion, and verification, and of final expression in concise notes and diagrams.

The essential nature of the scientific method is thus clear. It is quite true to say that the natural

sciences are observational and experimental studies. They are just essentially studies demanding thought and imagination. Observation and experiment provide the basis of facts of experience from which thought starts; experience provides the analogies by which thought infers possible explanations; and testing experiment gives the facts that verify or disprove our imagined suppositions; but it is thought that leads our understanding to the grasp of what causes lie behind the world of sensible experience.