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HERBART'S VIEW OF THE PLACE OF MATHEMATICS IN EDUCATION.

THE claims of Herbart on the attention of the teacher are at last being recognised in this country. Not merely is he deserving of study as one of the founders of modern psychology, not merely does he attract our interest as the central object of veneration of a rapidly increasing school in his native country and in the United States, but he also takes up a position apart from most philosophers, in that he actually devoted a large part of his life to the work of teaching, and deliberately applied his psychology to education. To the readers of this Gazette, the opinions of Herbart, who offers us this rare combination of the theorist of the first rank with the successful teacher of boys and men, will be of additional interest when it is realised that he plays somewhat the same rôle as the staunch advocate of Mathematics in the curriculum that Herbert Spencer does for Natural Science. He urges that "for six hours weekly" Mathematics should be "the beginning, middle, and end" of every system of instruction. And the fact that *Mathematik* is of wider connotation than we should now award to it will not deprive his remarks of much of their value. It will be as well, however, to bear in mind that he includes in this term all that is not comprised in *Geschichte*.

Let us first consider his monograph on Pestalozzi's *Idee eines ABC der Anschauung*, published ninety-two years ago, in which the principle of observation is developed and applied to the whole realm of education.

After drawing attention to the radical danger that besets the untrained sight-perception, owing, he argues, to its concentration on "colour," he maintains that it must be met by *Anschauung*, which, by fixing the attention on "form," will give the necessary correction. The senses can only discover what the mind of the

child has been trained to see, so that the concept of "form" is one of the most important for the child to grasp. Now, Mathematics is the ideal subject for the cultivation of *Anschauung*, because it contains the substance of all that is necessary for the study of "form"; it is the best instrument for exhibiting to the child both the limit of his powers and his potential capacity. "In Mathematics, and nowhere else, is to be sought the thread for the child's early instruction, which can be so conditioned that it shall provide for its own use, as well as for all other studies, an authority at whose command distraction shall disappear and attention arise and persist." That is why "Mathematics is the beginning, middle, and end of every course of instruction."

But Mathematics is not to be taught for its own sake. The key-note to Herbart's position is to be found in the sentence:—"No one can be expected to think himself into the strict uniformity of Nature, who has had no training in the rigorous discipline of Mathematics and its deductions."

Let us note his standpoint. The studies included under the name of Humanities form a complete whole, with a central idea, viz. interest in Man; we must group the Natural Sciences into a complete whole with a central idea—interest in Nature. And with this, interest in Mathematics stands in close relation. Or, in other words, a many-sided interest, to use his own expression, is to be the source of apperception, and all the various divisions of the subject are to be taught for the sake of the light they throw on Nature. As the knowledge of the student grows, he is to study the natural sciences with reference to the light that Mathematics can throw on them. "The true place and rank of the natural sciences are not yet sufficiently determined; when these are defined, their inseparable companion, Mathematics, will also be given possession of its rights." And again, "From simple Arithmetic

to the Higher Mathematics, all must be connected with the study of Nature and with practical experiments in order to gain admission to the inner thought of the pupil." As soon as the most elementary Mathematical instruction forms for itself an isolated mass of concepts, it becomes "unpedagogic and at the same time it ceases to exert its full influence on the character." "To the real scholar a knowledge of Mathematics is indispensable, because without it a thorough knowledge of natural science is absolutely impossible."

In connection with Herbart's method, it is worth while examining his remarks on synthetic instruction. "The object of synthetic instruction is twofold; it must supply the elements and *prepare* their combination. The most general kind of synthesis is the *combinative*." This is to be exercised as soon and as often as possible. "It holds sway principally in the province of empiricism, where nothing hinders it from affording the recognition of the (logical) *possible*, of which the *incidental real* forms a part, and under which it may be classified in many ways. From this point it finds its way to the practical sciences, where it is the helper when successions of ideas have to be supplied to successive aspects of a given manifold. In the sphere of speculation the loss of this combinative synthesis may be sorely felt if it is wanting; this mathematicians have realised. Alike here, and in the sphere of taste, it becomes obscured through the peculiar kind of synthesis which rules therein, and which partly rejects inadmissible connections, and partly removes the mind from all irrelevant play of thought. Closely connected with the combinative concepts are those of *number*. Each combinative act is made up of a number of elements of complexion; number itself is the abstraction of these. . . . Speculative synthesis proper, entirely different from the logical-combinative, rests on relationships (*Beziehungen*). But the method of the relationships no one knows, and it is not the business of education to exhibit it. Neither is it the business of early years to take up a critical attitude towards nature. . . . The teacher must seek out, entirely regardless of *his* system, the least *dangerous* ways to prepare capacity for investigation as much as possible, and to awaken on many sides the impelling feeling aroused by single problems—the elements of speculation—for fear the young thinker should believe he will be soon at the end of his search. The safest without doubt is the study of Mathematics; unfortunately it has degener-

ated too much into a game assisted by lines and formulæ. Let it be led back as far as possible, to the thinking out of the *concepts* themselves." "Synthetic instruction supplies a number of new presentations, and has to work them out. It should observe constantly whether it *overfills* the mind or leaves it *too empty*. We shall find here, that not only the capacities, but also the disposition, varies at different times, and the treatment must be regulated accordingly. Further, government and discipline, but above all, the whole concentration of the teacher on the subject in hand, should operate in arousing an effort to comprehend everything completely, correctly, and immediately, and to grasp it clearly and luminously. Finally, beware of building *too quickly* on ground newly prepared. What is clear to-day is obscure again to-morrow; and he who is thinking laboriously on the particular cannot connect or apply. As to the elements, we must take care, whenever it is possible, that they lie ready long before they are wanted; further we ought always to build on a somewhat broad foundation, that there may be work to do, now here and now there, and change may thus be ensured. With respect to what is complex, it is very important, as far as possible, to occupy the mind with its forms, that it may anticipate the method and search for it itself. . . ."

Herbart holds that it is a mistake to allow the child to remain too long in a narrow circle; he must be always advancing, and at the same time learning to apply what he has learned. "If the object were simply to awaken self-activity, the rudiments would be quite enough to afford any number of problems, in which the pupils would enjoy the skill they had acquired, and would even feel delight in their own little discoveries, without ever learning the extent of the science." He then compares many problems to jests, legitimate and enjoyable at the proper time, but not to be allowed to interfere with the time for work. He thinks that the teacher should not stop to explain what will a little further on become evident. This reminds us of the remark made by Professor Chrystal in the preface to his *Algebra*:—"Every mathematical book that is worth anything must be read 'backwards and forwards,' if I may use the expression. I would modify Lagrange's advice a little and say, 'Go on, but often return to strengthen your faith.' When you come on a hard or dreary passage, pass it over; and come back to it after you have seen its importance or found the need for it further on."

But to resume. Problems dealing with the facts of Natural Science are infinitely more serviceable than mere practice problems, as the sciences are more readily explained by the use of mathematics when it stands in relation to technical knowledge. Again, the subject cannot be begun too early. That aptitude for this subject is more rare than for other studies is a fallacy, due, no doubt, to the late period at which the subject is begun. Further, mathematicians have neglected to place themselves on the same plane as their pupils. In arithmetic they have begun with simple combinations and geometrical forms, and have attempted to teach demonstrations to the child in whom the imaginative faculty is still lying dormant. Lines, angles, geometrical figures should be used in the teaching of number. "I have suggested marking out with bright nails on a board the typical triangles, and placing them continually within sight of the child in its cradle." Plane surfaces of varying forms, and angles, are to be carefully measured. The measurement of angles in degrees is the first preparation for geometry and trigonometry. Algebra should be introduced earlier than at present, in connection with number, under the form of literal Arithmetic, and soon assuming the form of general symbolical statement. "We ought to point out at a very early stage numerous examples of combinative operations, chiefly of the variations most commonly used. To this stage belong also the forms of space, at first squares and circles, as appearing oftenest in surrounding objects without analysis, and then angles. For illustration we use the hands of a clock, the opening of doors and windows, etc. Angles of 90° , 60° , 45° , 30° must first be pointed out. My *ABC der Anschauung*, which has its place here, presupposes a knowledge of this." And yet again: "The essential thing is the training of the eye in estimating distances and angles, and the connecting of this training with easy arithmetical problems. The object is not simply to improve the power of observing visible objects, but in particular to awaken the geometrical imagination, and to connect with it the arithmetical thought. Herein lies that necessary preparation for mathematics which is so often slighted. The means must be concrete objects. . . . The best to commence with are triangles cut from thin pieces of hard wood. Seventeen pairs of these are needed, all right-angled, and with one side of the same length in common. To find these triangles, draw a circle, radius 4 inches, and then draw tan-

gents, secants, etc. for 5° , 10° , 15° , etc. to 85° . The different uses of these triangles may be readily imagined. The pupils themselves must actually measure the tangents and secants, and record the lengths correctly—at first only in integers and tenths. On these are based simple problems, the immediate object of which is that the pupil may become accustomed to the observation of simple objects. . . . When he begins to measure plane surfaces, the wooden triangles are laid aside, and the geometrical construction takes the place of actual perception of a concrete object. At the same time, Arithmetic and Algebra begin to treat of simple proportion, and later of powers, roots, logarithms." So in every department, the subject is applied directly to some natural object or phenomenon. Thus the perception is trained.

[An excellent translation of *Die Aesthetische Darstellung der Welt als das Hauptgeschäft der Erziehung* (1804), and the *Allgemeine Pädagogik aus dem Zweck der Erziehung abgeleitet* (1806), has been published by Swan Sonnenschein and Co. (1892), with a preface by Mr. Oscar Browning. This volume contains the essence of Herbart's pedagogy, and I have freely drawn upon it for the purposes of this note.]

W. J. GREENSTREET.

MATHEMATICAL WORTHIES.

I. EDWARD WRIGHT.

Edward Wright was probably born about 1560, and he died in 1615. He was a fellow of Caius College, Cambridge. The chief source of information about him, besides his own published works, is an obituary notice in a Latin paper preserved in the college library. He furnishes a notable instance of the conditions under which mathematical science was pursued in his time. The main object kept in view was to supply material needs of life, principally at this period in all matters connected with navigation, and the promoters and supporters of research in this direction were not the universities, but the trading and mercantile communities. Wright was appointed by the East India Company their Lecturer on Mathematics, at a salary of £50 a year. He was mechanical tutor to the eldest son of James I., Prince Henry, who died in 1612 at the age of nineteen. For his pupil's instruction he designed and made a wonderful piece of mechanism, displaying all the movements of the heavenly bodies