

# SCHOOL SCIENCE AND MATHEMATICS

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## EDUCATIONAL MOVEMENTS AND GENERAL MATHEMATICS.<sup>1</sup>

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It is nothing new to say that many a good movement has gone awry for the sole reason that it was inopportune. To one who is interested in the success of a desirable educational movement, the question whether the movement is timely is important. How may the timeliness of such a movement as that for general mathematics in the high school be gauged?

Without entering upon an adequate discussion of this theme, it may be said with safety that a large factor in determining the timeliness of a reorganization of mathematics along fusion lines is the extent to which it harmonizes with the dominant educational tendencies of the time. This is the phase of the question to be briefly discussed with respect to the movement for general mathematics.

Our first question then is: What are some of the dominant educational movements of the day, that are pertinent to our theme? Doubtless different persons would answer this question differently, and many of you might answer it considerably more correctly than I shall. But I feel it incumbent on me to try some sort of an answer.

As I study current educational literature and listen to educational discussions, I am led to think that one of the leading movements among practical educators is the effort to eliminate the general choppiness of high school programs. One such educator tells me that his main task is now and has been for several years past to do something to reduce the lack of contiguity of the high school subjects. That this lack of contiguity is a strikingly notable feature of our high school programs can be

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<sup>1</sup>From an address before the Mathematics Section of the Central Association of Science and Mathematics Teachers at Chicago, November 26, 1915.

readily seen by placing together a typical American program and a typical program of a German gymnasium. I choose a so-called English course such as prevails with minor variations very extensively throughout the North Central States. It is as follows:

| FIRST YEAR.            |  | Second Semester.   |  |
|------------------------|--|--------------------|--|
| <i>First Semester.</i> |  |                    |  |
| Algebra                |  | Algebra            |  |
| English                |  | English            |  |
| Physical Geography     |  | Physical Geography |  |
| Civics                 |  | Physiology         |  |
| SECOND YEAR.           |  |                    |  |
| Ancient history        |  | Ancient history    |  |
| English                |  | English            |  |
| Botany                 |  | Botany             |  |
| Arithmetic             |  | Arithmetic         |  |
| THIRD YEAR.            |  |                    |  |
| Geometry               |  | Geometry           |  |
| English                |  | English            |  |
| Medieval history       |  | Medieval history   |  |
| Political economy      |  | Advanced civics    |  |
| FOURTH YEAR.           |  |                    |  |
| Physics                |  | Physics            |  |
| English                |  | English            |  |
| U. S. history          |  | U. S. history      |  |
| Solid geometry         |  | Advanced algebra   |  |

Perhaps the most striking feature of this course is its lack of dovetailedness. It ought to suit, and probably does suit perfectly, the lover of isolation in the high school. Nothing but the English seems to have any reference to or connection with anything else, and a more careful internal examination of the English courses from year to year reveals little or no attempt of any antecedent course to prepare for, or in any organic way to connect with, a subsequent course. Algebra does not prepare for or relate itself to the arithmetic, nor does either take any cognizance that geometry is to follow. Physical geography does not relate itself to botany, nor does either to anything to come later. The only connection of the history courses is chronological. The course is a veritable hodgepodge of unrelated units, none of which can be claimed to relate itself vitally to the psychological state of the learner in the year in which it is placed. Now contrast with this the typical German secondary program on the next page.

The most obvious feature of this program is the continuity of the work from year to year. Though it does not concern the point under discussion here, it is almost as obvious that the prevailing course is a fractional course.

The justification of a movement to increase the all-around connectedness of the high school subjects of our curricula is clear enough. The attempt to organize a body of general mathematics,

TYPICAL PROGRAM OF A GERMAN GYMNASIUM.

|                              | VI. | V. | IV. | IIIB. | IIIA. | II. | IA. | IB. | IA. | Total. |
|------------------------------|-----|----|-----|-------|-------|-----|-----|-----|-----|--------|
| Religion .....               | 3   | 2  | 2   | 2     | 2     | 2   | 2   | 2   | 2   | 19     |
| German and hist. topics .... | 4   | 3  | 3   | 2     | 2     | 3   | 3   | 3   | 3   | 26     |
| Greek .....                  | ..  | .. | ..  | 6     | 6     | 6   | 6   | 6   | 6   | 36     |
| Latin .....                  | 8   | 8  | 8   | 8     | 8     | 7   | 7   | 7   | 7   | 68     |
| French .....                 | ..  | .. | 4   | 2     | 2     | 3   | 3   | 3   | 3   | 20     |
| History .....                | ..  | .. | 2   | 2     | 2     | 2   | 3   | 3   | 3   | 17     |
| Geography .....              | 2   | 2  | 2   | 1     | 1     | 1   | ..  | ..  | ..  | 9      |
| Mathematics .....            | 4   | 4  | 4   | 3     | 3     | 4   | 4   | 4   | 4   | 34     |
| Natural Science .....        | 2   | 2  | 2   | 2     | 2     | 2   | 2   | 2   | 2   | 18     |
| Writing .....                | 2   | 2  | ..  | ..    | ..    | ..  | ..  | ..  | ..  | 4      |
| Drawing .....                | ..  | 2  | 2   | 2     | 2     | ..  | ..  | ..  | ..  | 8      |
| Totals .....                 | 25  | 25 | 29  | 30    | 30    | 30  | 30  | 30  | 30  | 259    |

(From J. E. Russell's *German Higher Schools*.)

properly graduated and progressive from year to year, with close regard to the maturing abilities of the pupil, is also plainly enough in harmony with the larger educational movement. As high school teachers are now being trained for the special subjects, they are capable of dealing skilfully with a range of diverse subjects of the sort called for in general mathematics. Indeed, it would seem that the general movement will succeed, if at all, only through this type of correlation within the domains of the several special subjects, at least as a first step.

A second noteworthy movement in general education is the psychologizing of the high school subjects. During the last year a text, entitled *The Psychology of The High School Subjects*, by Charles Hubbard Judd, has appeared from the press of Ginn and Company, and at least two other men have told me since October 1st that they were at work on manuscripts for texts on the same subject. This almost virgin field is being quite vigorously worked just at present. The writers are raising such questions as what are the mental processes involved in knowing this definition, or concept, or algebraic form? This must result in a much clearer perception of the inherent difficulties of mathematical learning, and a more rational adaptation of the high school studies to the powers and aptitudes of high school pupils. Studies of this sort show clearly the incongruities and artificialities implied by treatment of the several subjects separately and are pointing to the desirability and even the necessity of some sort of reorganization of mathematics into the form of general mathematics, more like the sort given in German curricula. General mathematics is thus being pointed out as a psychological necessity of the time. Certainly there is no question of lack

of harmony here between the general and the specific movements toward reorganization.

These writers are raising also such queries as: What is there in child nature that requires formal algebra and nothing else mathematical for him in the thirteenth year of his life, then in his fourteenth year of life, geometry, or arithmetic, and nothing else of a mathematical nature, and so on? What demand of adolescent psychology makes physical geography the exclusive scientific interest in the thirteenth year of life and of no value to the pupil anywhere else in the curriculum? What in the nature of childhood or youth makes botany as a self-contained subject, treated with no regard to anything to come later, the peculiarly appropriate thing for the fourteen- or fifteen-year-old? These are only a few of the troublesome queries the people who are working on the psychology of the high school studies are formulating, and no one yet has had the boldness to step forth to answer them. Queries such as these make a clear call for a reorganization of high school programs and of the special subjects and point in the mathematical domain to general mathematics developed on a sound psychological basis. Surely there is the very opposite of a quarrel between general mathematics and this significant movement in general education.

A third important movement in general education is epitomized by the advent of the junior high school. Realizing that most improvement that gets into the curriculum comes from the administrative domain downward, and not from individual initiative upward, school men are attempting to effect a better adaptation of learning to learner by more intensive administration of smaller program units. The irritating inappropriateness of the late grade and early high school work which, in spite of all criticism and attempted reorganizations of subject-matter of standard textual literature, still persists, is bearing its fruitage in the form of a rapidly spreading belief in the promise of the "six-three-three" plan of administration. This movement is destined to early wide adoption in our school systems and it must make the evil of the existing type of material that is being commonly employed in the seventh, eighth, and ninth grades, glaringly apparent. As has been already pointed out by students of the movement, general mathematics is the only feasible kind of mathematics for the new administrative plan.

In some places the movement has gone only so far as partially to departmentalize the work of the seventh and eighth grades and

to incorporate the ninth with the two preceding grades as an administrative unit. A superintendent, who has carried the junior high school plan to this stage, recently remarked to the writer that the new plan is not likely to accomplish much until the character of the work is much more thoroughly reconstructed and generalized than is implied by mere departmentalizing. He then added we are in sore need of a thoroughly well-organized course in general science, and that this plan is going to force the adoption of union, or general, mathematics. In other words, the thing fusion mathematics is attempting to accomplish for mathematics is just what the leaders of the junior high school movement are urging shall be done with all the studies of this part of the curriculum. Clearly then, we are in fullest harmony with this particular educational movement. The vital question is, are we working along right lines toward general mathematics? Those of us who find ourselves somewhat implicated in the movement for general mathematics claim to be working only in the light that has been vouchsafed to us, and if our critics that approve our ultimate purpose, but deny the suitability of our particular effort, will only use their superior insight to do a better piece of work, we shall be only too glad to give them the lime-light.

A fourth movement is the elimination of the "lockstep" in advancing pupils through the grades. School people are coming to accept Mr. Hanus' view that every child has the inalienable right to go forward as fast as he can and as slowly as he must. As subjects are now administered, suppose a bright pupil finishes the course in first-year algebra before the end of the year. What profitable work in this line shall he go on with to the end of the year? He cannot take up the next subjects for they belong to the next year's course and often to other teachers. While his slower colleagues are completing the rest of the year's work, he may do nothing, or review, which at best is a new view and at worst a rehash, or do work extemporized for him that leads nowhere but is supposed to fill his time which he has earned for himself by meritorious achievement, and which too frequently only kills both his time and his enthusiasm for the subject. General mathematics builds right along gradually and progressively, with no hiatus, from year to year, every step both catering to the stage of his attainment and preparing for the next thing, whether in the general plan for the average pupil it is programized for this year or the next. To a very considerable degree, general

mathematics will be found to facilitate the educational movement to provide for individual differences in ability and rate of progress. This has been found to be a fact in the work of The University High School.

There is much interest today in what is called supervised study, the term connoting very much the same as some of us thought we meant but a short while ago by the laboratory method, or plan. The class works during a part, or all, of the class period on the assigned material and under the supervision of the teacher. It is perhaps truer to the legitimate offices of the teacher in a class-study period to think of him as a *supervisor* than to think of him as a *foreman*, which was always strongly suggested by the terms laboratory, and workshop. As a matter of fact a foreman pretty poorly epitomizes the real teacher in a class-study period. The right sort of work for the high school student of mathematics will furnish him opportunities for working with much help, for working with only necessary help, and, finally, for working with no help at all. When a class is getting up its work under the eye of the teacher, as it does in the work of supervised study, the teacher, if he be expert, may judge accurately the extent to which pupils need and are getting the three kinds of necessary experience. He may also get a good line on individual peculiarities and differences and plan better.

The point to be made here is that general mathematics facilitates the use of supervised study. Whether the pupil be geometrically, or arithmetically or algebraically minded, he may attack the problem in hand with whatever tool he finds himself best able to wield. After having gotten the difficulty under control with any one tool, it is not so difficult to master it with another, if that is desired. In the fashion of a true student, the pupil learns to try first this way and then that, until he finds a successful way. Again, general mathematics furnishes a broader and richer field to draw illustrations, applications, and motivations from than does any one of the subjects alone. So far as an adaptable subject-matter can aid in the work of administering instruction that aims to make of the pupil an independent worker, general mathematics facilitates the work of supervised study. It makes possible many better ways of helping pupils to learn how to study and how to think.

The general movement toward economizing human energy and enthusiasm in school can find nothing but assistance in school mathematics from an organization of the material for teaching

into a form under which each important topic is taken up and taught thoroughly, once and only once, and then kept in function continually thereafter. This is of the very essence of economy. The present plan of teaching ratio and proportion, for example, once in arithmetic, then in first-year algebra, then in plane geometry, and in almost the same way every time, finds its excuse for existence in the spurious principle of repetition, not in the principle of economy. The only true economical plan of organization of mathematics is the once-for-all plan of general mathematics.

All these educational movements against which, as a background, we have been attempting to judge of the timeliness of general mathematics, seem to be in agreement with the general plan, if indeed they are not in full harmony in detail. The lack of a varied literature on general mathematics seems to be the chief stock argument against its adoption. That this is not a valid argument will be readily admitted. If we have succeeded in convincing some that general mathematics is no longer a fad, and that it is merely attempting to aid in doing what the leading educational movements are striving to bring about, may we not hope that general mathematics may get a little freer access to the actual problems of the classroom than has yet been given it?

I have been asked to say something about general mathematics in The University High School. As some of you know, this type of material has been in continuous use in this school for a dozen years. I need not report upon phases of the work that have been fully reported upon heretofore.

A revision of *First-year Mathematics* by Mr. E. R. Breslich, head of mathematics in The University High School, appeared from the University Press last August, and it is now in use as the text for the first-year classes. The revised form is working in these classes with excellent satisfaction to all concerned. Mr. Breslich also tells me that the manuscript of the revision of *Second-year Mathematics* will be ready for the publisher by January 1, 1916. Thus the good work is moving on with us.

Two years ago the requirement in mathematics for graduation from the high school was reduced to one year's work. All mathematical courses beyond the first year's work have since then been optional. As matters now stand with us, about 125 students have to take mathematics. Statistics from the principal's office show that of a total enrollment of 420 students, 350 are taking mathematics. Deducting the 125 from the 420 gives 295 students who do not have to take mathematics, and 225 of these are elect-

ing mathematical courses. Stated a little differently, in our school at present a little better than three out of every four students who do not have to take mathematics for graduation, are nevertheless electing mathematical courses. Can any representative of a school using old-line material in mathematics make a better showing for the popularity among its students of the mathematical courses? I am not claiming there are none, but if there are any, I should be delighted to aid such a school to get a little publicity for so meritorious a performance, just now when we are being told that the mathematical courses would be crying for students if they were not required. Indeed, I make the request still broader by asking whether in any sort of school any of the subjects can show a larger percentage of pure election of its courses?

Replying to a *questionnaire* sent to other schools recently as well as to ours, asking students in the mathematical courses whether they liked their mathematical work *very much, a little, or not at all*, out of our 350 mathematical students only fifteen said they did not like it at all. A study of these fifteen cases showed that these fifteen students were generally very weak, or that their work had been so seriously interrupted by sickness or other causes as to put them far behind. They were in no state of mind to know whether they liked appropriate work or not. I have not yet learned the numbers in the other two classes suggested by the *questionnaire*.

The failures in mathematics are being kept in the neighborhood of five per cent, and practically no students at all are falling out before the completion of a year's work.

The teaching in our school we think is excellent and special aid is being given to backward students. It is also true that very explicit attempts are being made by all the teachers to take proper cognizance of individual differences. Accordingly, not all the credit for these pleasing results by any means is to be given to general mathematics. General mathematics is only one, but it is claimed that it is an important one, of several factors operating with us for the amelioration of the standard difficulties of mathematical students.

In conclusion, it has been said frequently, and we have again heard it today, that it is very difficult to get a chance to see any real correlating being done in actual mathematical teaching. We are told that many teachers claim to be doing some correlating, but that when their work is inspected, no correlation is in evi-



dence. Let me say that mathematical correlation is now, and for a dozen years has been, a part of the systematic plan for mathematics in The University High School, and that as I do none of the teaching here myself, I very freely invite any of you who care to see it, to visit us at any time. I am almost ready to assure you that you will see correlation, if you can recognize it on sight, any day, and that if you will let it be known that correlation is what you came to see, you will not have to go away disappointed. Finally, you are hereby invited to visit our work at any time, and you will not be required to express your opinion of it for either private or public use, but you may understand that we willingly grant you the privilege to any use of it you may care to make, either public or private. I thank you.

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#### MATHEMATICAL NOTE.

The United States Bureau of Education at Washington has recently issued Bulletin 1915, No. 39, by Dr. I. L. Kandel, on *The Training of Elementary School-teachers in Mathematics* in the countries represented in The International Commission on the Teaching of Mathematics. This is issued with the co-operation and under the direction of the American members of the International Commission on the Teaching of Mathematics, Professors D. E. Smith, W. F. Osgood and J. W. A. Young.

This Bulletin shows the excellent preparation of teachers of elementary mathematics in several of the leading countries in contrast to the meager academic preparation in certain other countries. It is sure to be of interest and value to all who have to do with elementary education in mathematics in the United States.

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#### A METRICAL TRAGEDY.

In the *Scientific Monthly*, December, 1915, Dr. Jos. V. Collins presents in an able and interesting article the good points in the metric system and the great advantages that would accrue to this country if the metric system were adopted. Among the ten good points mentioned are these: The metric units have uniform self-defining names; every reduction is made almost instantaneously by merely moving the decimal point; there are only five tables in the metric system proper; the subject is so much easier for children that a conservative expert estimate of the saving is two-thirds of a year in the child's school life; every ordinary practical problem can be solved conveniently on an adding machine.

After elaborating some of these points of excellence, Dr. Collins discusses the reasons why the metric system has not been adopted in the United States, and indicates how the change can be made, and how the cost of the change is counterbalanced by greater efficiency and economy in the commercial and manufacturing industries.

H. E. C.