Thesis,

Need of Mathematical Training
to the Literary Student,

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by

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Need of Mathematical Training to the Literary Student.

The form of my subject determines, in large measure, the plan of its discussion, while the purpose of my paper suggests the subject, matter and marks out the mode of its treatment. In a thesis, the subject should be treated from the standpoint of the investigator rather than from that of the essayist. And, if the present paper aspire to the dignity of that term, research and not theory must be the prevailing characteristic of its pages. Pursuant to this thought, in this production, the writer has endeavored to embody some of the fruits of his classroom experience, as well as a few results of careful personal observation; rather than to attempt a proof of the necessity of mathematical study to literary students from general principles and on theoretical grounds.

The plan of discussion is evidently fixed by the form of statement of my subject; for to demonstrate the need of a science, it is sufficient to show by trustworthy evidence that its truths and uses are indispensable to the attainment of the chief end in view. Two questions, then, must be answered.

(1) What is the chief end sought? and (2) Are the truths and uses of Mathe-
That a student is pursuing one of the Literary courses may be considered satisfactory evidence that his object is what is stated in the U. of I. catalogue under the caption, "Object of the Land I. Schools." For whether these courses of study attain their avowed object or not, he evidently believes they will in his particular case, at least, and his persistent efforts in these lines are made in expectation that his hope will be realized. If his belief were not substantially this, it is safe to conclude that his educational destiny would not have been put under the influence of these courses.

To answer then, the first of the questions propounded above, I will revert to the catalogue. On p. 30 of the catalogue and circulars of the University of Illinois for 1889-90, I find: "The object of the Schools of this (the Lit. and Science) college is to furnish a sound and liberal education, to fit students for the general duties of life, and especially to prepare them for those business pursuits which require a large measure of literary and scientific knowledge and training. They meet the wants of those who wish to prepare themselves for the labors of the pue
1. Climate agencies that make and modify
2. Relief and Drainage - Elements and systems and relations in both
3. Soil and lower layers - Source Composition Contents
4. Products - Kinds - Why? - Values - Centers
6. Trade and Commerce - Basis of - Direction Why - Centers?
7. People - Their education form of Gov. Religious - Stage of advancement
as editors and publishers, for teachers in higher institutions, or for the transaction of public business. In the following discussion, it will be taken for granted that these are the aims sought by students in this college.

Next let us inquire into the importance of Mathematical study to the highest and completest achievement of these ends.

After a somewhat careful examination into the matter, I am prepared to assert, without venture, that 75-75% of graduates from these schools are engaged in one or other of the four vocations of business, teaching, law, or journalism. Of the remaining 25%, perhaps as large a proportion as 15-75% are married ladies. The remainder are in various vocations, and may be regarded as exceptions and need not be considered in a general treatment of this question.

The fact that, by far the larger proportion of Literary graduates pursue lines of work for which it is the professed object of these schools to fit them, besides furnishing evidence that the end sought by these students is the object aimed at in planning these courses of study, affords a means of answering the question of importance of Mathematical study. And the answer will be secured when the degree of importance of such study to devotees of these profes-
time is determined.

Of the acquired faculties essential to success in business vocations, none would probably receive more general assent from those engaged in these pursuits than quickness of perception, accuracy in details, and depth of insight. Mathematics, being an exact science, accuracy and dispatch are qualities which it is its peculiar office to evoke and cultivate. During the few years of my class-room experience, I have been led to think it one of the most urgent duties of the teacher of mathematics to develop and strengthen these special faculties of the student's mind. An exhortation for which I have found frequent and recurring use is "Be accurate; then be quick." I am more and more impressed with the thought that it is not primarily results we work for in the mathematics, but that the great desideratum is the practice—the drill, afforded by their determination. The basic reason that this is the chief function of this science, is in the fact that all other considerations may be set aside and un

divided attention bestowed upon the one thought—accuracy or of rapidity. The results of other sciences are so definite, so clear-cut, relatively free from personal bias. To illustrate, in science, a student, whether by naïve exper-
In the fallacy of his position clearly and unmistakably; for while Astronomy and Meteorology prove the negative by implication and analogy, yet neither can absolutely demonstrate it. On the contrary, for mathematical questions there are always fixed and definite answers, which student, as well as instructor can see and comprehend for himself, so that without process of argumentation by the teacher, he may realize, not merely assent to the statement of someone assumed to know, that he has or has not solved an exercise completely. Moreover, this fact has value for another reason; viz., we acquire accuracy and rapidity by using these qualities and it is evident that to be accurate and rapid, one must know precisely the object at which he aims, as well as the exact instant on which he reaches the goal. In other words, definiteness of results affords the only means of obtaining a standard of accuracy and rapidity.

Again, the student of mathematics is continually called upon to project the objects of his consideration into space, to investigate them by means of
their spatial relations, and to hold them up before the mind's eye for examination and discussion. Even while doing this, he is also impressed, at every turn of thought, with the importance of keeping in view, and making proper allowance for every circumstance, the ignoring of which would vitiate and thereby render invalid the conclusion. This sort of exercise, long continued, grows into habit in process of time, and thus imparts to the mind, skill in disposing and weaving into the fabric of deduction, in due proportion and exact impartiality, the thread of influence of various tints and shades, furnished by a multiplex and variegated assortment of circumstances; recognition ever being freely given to the fact that every minuteness must be awarded a place of honor and consideration in ascertaining the individual effects whose combination is to produce deductive warp and woof. But not only does this practice enable the mind to throw its attention forward in space but it also empowers it to project its objects of thought forward in time with equal facility, so that the mind, familiarizing itself with the present circumstances and laws of business, and reasoning on the basis that the laws of cause and effect in the business world are unchanging under like conditions, satisfies itself.
as to the probable conditions of the future, and hence anticipates the outcome of a proposed enterprise. Discipline of the sort is the foundation upon which power of penetration—depth of insight—reliability.

Assent can never be given to the foregoing statements with so little reserve and with a consciousness of their veracity from mere theoretical grounds as can be done when this phase of the process of mental growth has been undergone in personal observation for a considerable time.

History reinforces my own conclusion in this regard, for there we are given many concrete examples of instances in which the mathematical faculty has been of great value to men in business vocations. Bessel, renowned both as the Mathematician and Astronomer, was equally successful in business, his shrewdness and capacity resulting from his mathematical study from his own testimony accounts for his success in the three spheres. Gauss was made successful in business than in mathematical pursuits. Our own Franklin, one of the shrewdest, most far-seeing men in business affairs our country has ever produced, was an excellent mathematician. Many of those whom we call 'masters of finance' are good mathematicians and not a
few ascribe much of their success in business to the development and discipline of the kind described above. These facts, then, together with processes of mental development secured from day to day in my own class-room, which from their peculiarly abstract, and strictly technical character compel me to attribute their development in large measure at least, if not altogether, to mathematical drill, force me to the conviction that mathematics has a place of no inconsequential import—a place which cannot in the nature of things, be supplied by discipline derivable from any other science—in the educational preparation of the man of business, for his life work. From presenting the different topics, it is the endeavor of the true teacher, and I seek to make it my constant aim, to strengthen the powers of insight, judgment, and origination, rather than to require much memorizing.

Among the most valuable qualifications, educationally considered, of the successful teacher are vigorous conceptions, periphrastic statement, logical presentation, and power of verification. Vividness of conception on the part of the teacher is an indispensable requisite to the impartation of knowledge. How often is it too painfully apparent that the difficulties of the truth-seeker are magi-
If teachers were true, in every case to their own consciences, and to those persons under their tutelage, many times would their self-respect find just cause for mortification by confession of guilt in this regard.

Mathematical science deals wholly with concepts, so that the exercise of the faculty of concept building is being continually called into requisition. True, the quantities and values under investigation are represented by characters, but the student is compelled to see with mental vision the relations as to position, value etc. of these abstractions. The effort to see these subjective representations enhances the vigor and vividness of conception.

Furthermore, the power of clear and strong conception acquires an added value from the fact that it is the most active agent of clear and forcible statement, the lever by which the competent teacher removes many a boulder of difficulty from the learner's path. In the typical demonstration, the student must first state in language, clear and concise, the principle proposed for proof, following the statement with a well worded and carefully studied explanation of its meaning referred to the particular case, illustrating where no
necessary by diagram; whereupon the demonstration proper is then given, again in carefully chosen and clear-cut phrases, strictly exclusive of all the essential concepts and exclusive of all non-essentials after which the initial principle is restated as the conclusion of the argument. In this way, it is apparent that the study of mathematics is largely a study of language, and the exact nature of the science furnishes an excellent corrective for loose and disjointed sentence-making, the archetyp of perspicuity, our statement. Properly studied, mathematics is a drill in language as well as a means of developing skill in the use of the faculty of reason, the last function being too frequently regarded as the peculiar and exclusive role of this study. Vagueness is the direct antagonist of perspicuity and thus for the indirect enemy of clear thinking. The pruning knife of mathematical study has to perform the health-giving function of removing this encrassence from our linguistic habit.

In the classroom it is many times necessary to caution the student in his study of demonstrations, to seek to understand not only what a statement means but also why it is said where and when it is. To demonstrate is
not merely to state facts and principles, but to state them in orderly sections in logical sequence. That is, one statement should lead up to, and substantiate the next succeeding. By studying carefully and repeatedly these sequences, the laws of demonstration are eventually seen to agree with the laws of mind itself and thus the most easily apprehensible form of explanation are found to be logical statements. If then, the teacher would be of the greatest possible service to the pupil, he must avail himself of the canons of demonstration in the presentation of all material knowledge. In mathematics, these rules can be studied to the best advantage, for facts are here of subordinate concern, and the processes of the logician are paramount. The act of inference, stripped in large measure of details, is thereby more conspicuous and hence may be attended to with greater facility and energy. Obliged continuously, and unconditionally to render ready obedience to the rules of demonstration, adherence to them in time becomes the normal state of mental procedure and disobedience it is which has become irksome. By unremitting attention to the principle that only such things are true as can be proved true, the necessity of verification is continually emphasized.
ed. That these assertions are true in theory, few will be inclined to ques
tion. That they are alike true in practice may not be generally concur
red in. An examination of records warrants the statement that the
best students in my classes in mathematics, that is to say, those who
comprehend the processes, and understand the meaning of results but,
also stand highest in those branches of science in which scientific ver
ification is a feature of chief consideration. And whether or not this
be accepted as practical proof of the educational value of mathe
matics as a means of emphasizing the need and at the same time, de
veloping the faculty of verification, it must be conceded that these re
sults are just what would be expected if the study did have practical
utility in this respect.

Another reason for the study of this subject by prospective teachers is
that it is small a proportion of those professing to teach it, High Schools
are fully qualified for their labor. This fact will be unpleasantly ap
parent to anyone who will take the trouble to investigate the records
of examinations for applicants seeking admission to the University.
search cannot fail to impress one with the poor preparation of students in the Mathematics. It is my judgment, and I believe I am safe in the assertion, that it is the judgment of all who have been connected with the department of examination in mathematics in the University, that persons applying for admission are more poorly prepared in these subjects, from Arithmetic up, than in any other. I do not believe this unhappy condition of affairs can be attributed to the inordinate difficulty of the subject; neither do I think it due to the prevailing and it seems to me, superficial belief that in this science, text-books, fully as lucid, comprehensible as easily as are text-books in any science, cannot be obtained. Observation and experience have induced me to think that the chief cause of what seems to be difficulty is to be found in an anticipatory dread on behalf of teacher and pupil, that the study will be of extraordinary difficulty. In one respect, studying Mathematics is like handling a nettle; touch it timidly and lightly, and it stings with uninviting points, but grasp it firmly and boldly, and the terrifying thorns have been transformed to honey velvet. It is a little learning which is a dangerous thing in mathematics. Deep
draughts are bracing, health-giving and invigorating to mental activity. I believe the most powerful agency, conducive to a happier state of affairs in the direction of better mathematical preparation, would be secured if those who are expecting to enter the profession of teaching would equip themselves properly in the mathematics—would fit themselves to impart instruction in it, then when our graduates go into the schools of our state, this discipline may be used in laying broad and firm in the minds of the youth of our commonwealth, the foundations for higher attainment and greater possibilities in this study. Should literary students pursue such a plan, I am confident the time would soon arrive when the requirements in the way of preparation in this subject might be raised and the ends reached set for in advance of the possibilities of today.

In a newspaper issue a few weeks since, was published the opinion of from fifteen to twenty five of the most conspicuous legal practitioners of the day concerning the qualifications most essential to success in their chosen profession. With but three or four exceptions, all agreed in placing at the head of the list of required qualifications, the ability to ab-
Let us now consider the disciplinary value of mathematical drill to the prospective student of law. If the end of mathematical instruction in the University of Illinois can be stated in a single sentence, I believe it could not be better done than by the following assertion. The instruction offered by this department is directed first, toward developing certain powers and habits needed by every good citizen; second, toward presenting the fundamental relations of space, number and sequence in comprehensible form; and third, toward supplying the needs of students anticipating work in those special professions which require the exercise of the faculty of logical thinking. It is the object of the course to produce independent thinkers, original investigators, strong reasoners. The ability to reason independently even when the subject matter becomes abstract, to grasp an extended scheme of thought, to apply theory to practice, and to enhance clearness and precision in stating one's convictions and the grounds upon which he has based them are the chief aims of this department. Out of
the attempt to reach these aims, relies, grows the peculiar educational
worth of the study of the study of this subject to the prospective lawyer. It
is the ever-present purpose of the barrister to convince judge and jury of the
validity of the proposition propounded for demonstration, and he must not
for a moment, drop the logical sequence of statement, without which he can
not hope to produce conviction. "Clearness, earnestness, and force" may be qua-
lities which produce the conviction that a man believes what he says, but
unlike kept under the guiding index of unerring reason, they cannot carry
conviction to the minds of judge or jury of the justice and legitimacy of
the particular conclusion under question. The habit of mathematical dem-
stration should be second nature to the lawyer, and in amount of histori-
cal reading and inference therefrom can atone for the lack of the study of
mathematics in making him a skillful reasoner. It was said, by Lincoln,
that when he began the study of law, he was so frequently and so deeply im-
pressed with the great need of a thorough knowledge of the laws of demonstra-
tion, that one of the first books he set himself was to master Euclid's Geometry
at the end that he might fully understand when he had demonstrated a
principle. He testifies to the great value of this, to him in his legal practice in later years, for he got so clear a knowledge of what demonstration means that he found no difficulty in stating his thoughts logically and clearly, and it is on his own statement, the assertion is made that it was to this study much of his success at the bar was due. If other examples along this line were needed, they would be readily forthcoming. These statements will, without doubt, be assented to on theoretical grounds, but they are replete with truth to one with practical experience in teaching the subject and who has observed how much former grasp the student gets of a principle he demonstrates over that gotten by mere explanation.

But on what ground can mathematical study claim to be of value to the journalist? It must be freely granted that the publication of many current press articles whose editors lay questionable claim to the titular rank of journalist, would not require even a partial familiarity with mathematical precept and process. But if sound judgment, broad understanding, unbiased purpose and unswerving loyalty to right may (as I think they should) be reckoned among the working qualifications in the journal
istic field, then whatever variety of intellectual discipline bet con-

ducts to the development of these qualifications may be regarded as fit and

even compulsory subjects of study by those seeking competency for this

profession, I will now consider the first of the four.

Judgment has been well defined as the act, or faculty, of compar-

ing objects of any kind, and discerning their relations, attributes, or pro-

perties. These objects may be objects of thought and hence purely subjective,

more abstractive as it the case in mathematics. In this science, the mind

may draw itself away from all other considerations and rivet its atten-

tion upon relations alone. This exercise of the mind is valuable almost

exclusively as a means of strengthening and clarifying the faculty of

discussing relations; i.e., judgment. For this particular phase of discipline,

mathematics stands at the head of the curriculum of scientific study. It

is my belief, moreover, that the habit, of the student in mathematics,

if his efforts be kept under proper discipline and surveillance, cannot

fail to teach the value of compulsory observance of truth. For he learns

that if he deviate from the straight line of scientific truth by a hair
breadths, his results will be, not merely impaired, but absolutely worthless, because unsound. We realize that a result is either true or it is false; there is no halfway station between truth and falsity. To admit a conclusion containing a grain of falsehood, proves its worthlessness. He cannot escape the lesson that truth and error cannot mix; that unwavering allegiance to truth is the price which must be paid for correct results.

But should the student in these courses, failing to find the ars vocatam congenial, aspire to fitness for the profession of authorship, he is again confronted with the need of close, consecutive, sustained thought, and to acquire the greatest amount of drill toward this end, in the least time, he must again look to mathematics. Says Bacon, if a man is not be wandering let him study the mathematics; for in demonstrations, if his wit be called away never so little he must begin again. To hope for honor as an Author, the aspirant must use continually those faculties which it is the function of mathematical study to develop and unfold. This discipline may be gotten in other ways.
but in none so quickly and thoroughly as in mathematics. Since mathematical process and principle are forms of procedure, native to mind, and in accordance with which the mind must act, if it act at all, in investigation in any science, Author in any didactic, there must be familiar with, and observant of them.

It has been my endeavor in the foregoing paper, to set forth some of my reasons for believing in the great need of the study of mathematics by literary students whether they be expecting to embark in the special profession of business, teaching, law, or journalism or to labor in the real life of Authorship. To attempt to consider exhaustively and individually my whole category of reasons for this belief, or even to dilate with measurable completeness upon all, would force me beyond the compass of the present paper. Such a mode of discussion would result in a treatise and not in a "thesis". I will therefore, only take space to say that although my personal experience and observation enforce in me an abiding and ever-growing belief in the inestimable value of this sort of drill to students in the course, yet there is a stronger reason for believing in
its efficacy, in the historical truth that from earliest times mathematics was studied and taught in state of advanced study, and in these institutions it has held its place uninterruptedly in the curriculum of study down to the present; stronger, since this fact embodies the cumulative opinions of sages of the past and is the consummate flower of wisdom, blossoming out of the experience of all ages. These facts alone indicate that the place of mathematics in the college course will not only never be either vacated, or filled by any other subject of study at present known, but also that as its value comes to be more fully understood and appreciated and hence more carefully and accurately estimated, it will be studied more generally in time to come by literary students than has been the case hitherto. The man who, today, asserts that the science of mathematics is not entitled to the place it now holds in college curricula, or that it deserves a position inferior to the one it now claims, disobeys the cumulative testimony of more than two thousand years and the dictum of multitudes of men of eminence in the past as well as in the present.
Yet, though I firmly believe the sentiment stated in this paper, I do not fully give credence to the proposition that the kind of study for which I
have contended, cannot, even in any considerable degree, supplant the
study of other sciences. The study of the exact is correlative to the study
of the inexact sciences. The one investigates relations of similarity or
dissimilarity as to position, extent, etc. between the materials of know-
ledge derived from the other. So that a man learned only in math-
ematics is as abnormal a development as the specialist educated ex-
clusively in any other sphere. For the human constitution is such that
the impairment of any of its parts produces proportionate infirmity of
the whole. That this has obtained as extensively, operatively as unfailingly
and obligatively as bindingly in the psychological as in the physiologi-
cal realm, is past question. Permit one faculty of mind to become atro-
hied and the entire mental organism suffers in consequence. Mental
incompetency in any direction be it narbon or inbred, hampers mental
possibility in every direction. Suffer the reasoning faculty to be dormant, and
intellects in any form is there by crippled. It follows, then, that the hi-
est attainable degree of intellectual vigor and vitality, demands the complete and symmetrical development of all faculties of the mind. To argue then, that mathematical study could be substituted for that of other subjects, would be not only foreign to my purpose, but also futile, because superfluous. I commit myself merely to a proposition that the highest mental attainment cannot be reached in any direction without the discipline and development of those peculiar faculties of mind which the study of the mathematics calls into requisition. And it is clearly apparent from this, that I am claiming for the study of pure mathematics, that is, mathematics viewed as an exact science, only the same need of consideration I accord to linguistics, history, natural philosophy or the so-called "inexact" sciences. Both have an important function to perform in the development of mind, and neither can fill the office of the other. I claim this not as knowledge merely from the lips and pen of others, but as truth gleaned from the fertile fields of personal experience. In what has preceded I have endeavored to set forth the main reasons upon which I base this claim. If, in the foregoing article, I have expressed my view
with sufficient clearness and order to lead anyone whose purpose may incline him to pursue these pages, to see these reasons and believe these things, and as I feel their magnitude, if presented justly, will entitle them to be seen, the earnest wish and ardent hope of the writer shall have been attained.