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Mental Arithmetic and Conceptual Understanding: The Pedagogical Struggle for the Deaf in the Late Nineteenth Century

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Abstract

This paper contributes to the historical examination of the pedagogical struggle in teaching arithmetic to deaf children in schools for the deaf during the late nineteenth century. By using primary sources (e.g., American Annals of the Deaf and Proceedings of the Conventions for American Instructors of the Deaf), this study brings to light a new understanding of mathematics instruction and curricula for the deaf during the late nineteenth century through a detailed analysis of the struggle at the time. The founding of the National College for the Deaf-Mute in Washington, DC, and the emergence of vocational programs in schools for the deaf in response to the rapid advance of the Industrial Movement in the late nineteenth century brought educational professionals of the deaf together, and the debate on mental arithmetic and conceptual understanding ensued.

In terms of teaching arithmetic to deaf students, the pedagogical pendulum swung back and forth. As teachers of the deaf attempted to define effective pedagogies in teaching and learning for mastery in arithmetic, some supported mental arithmetic as the best avenue to mental discipline, accuracy and rapidity. On the contrary, others argued that the visual avenue to conceptual understanding first would bring appreciation of mathematical knowledge and relationships between the concrete and the abstract. The majority of the teachers of the deaf concurred that understanding practical mathematical applications was as important as the knowledge of arithmetical concepts in order to enter higher school institutions or to secure a job, as society moved from the agricultural-business sphere toward the industrial-business sphere. Mastery in arithmetic and applications of arithmetic to the workplace were the gravitational forces that pulled the pendulum to the center.

Introduction

In the early nineteenth century, the intellectual shift, prompted by philosophical writings of Enlightenment scholars, such as Diderot, Voltaire, Rousseau, and Locke, aroused curiosity about and pedagogical experiments on children with sensorial impairment. It was realized that blind children could compensate for their blindness by using their fingers to read. Similarly, deaf children can compensate for their deafness by learning how to speak and lip-read, or to use visual, manual sign language. Such philosophical writings led to the notion of educating children with sensorial impairment to compensate for their disabilities with their other working senses to gain information (Calhoun, 1984).[1] As a result of intellectual shift and increased societal attention to assist people in need through social service programs, more than a hundred schools for the deaf and the blind were founded, across the East Coast, in the Midwest, and then in the Western United States.

In a 1910 presentation to the national organization of the deaf, George Veditz (1912), a deaf mathematics teacher at Colorado School for the Deaf and Blind and president of the National Association of the Deaf, implored educators to not perceive deaf people simply as those who cannot hear, but to see them as the people of the eye:

> Wherever the deaf have received an education the method by which it is imparted is the burning question of the day with them, for the deaf are what their schooling make them more than any other class of humans. They are facing not a theory but a condition, for they are first, last, and all the time the people of the eye. (p. 30)

Along the same vein for children without sensorial impairment, Calhoun (1973) explored the increase of visual imagery in the early nineteenth American society, contrary to the European culture that emphasized verbal intelligence, as a means to learn about and understand the world. Teaching geography at American Asylum for the Deaf in Hartford, Connecticut in the early nineteenth century, Woodbridge, for example, developed teaching methods that incorporated teaching through the eye, one of which included geographical mapping (Calhoun, 1984). David Greenberger (1882) wrote, "we cannot strictly follow any of the numerous methods which have been devised for teaching this branch to hearing children, but have to modify these systems to suit the peculiar condition of our pupils" (p. 12). How should deaf children be taught? Or to be more specific, how should they learn arithmetic? Such questions raised by school professionals brought the debate for mathematics instruction to schools for the deaf, in order to serve deaf children whose primary means of relating to the world was visual, and who shared a language that was visually received and produced (Kurz, 2006; Lane, Hoffmeister, and Bahan, 1996).

Kliebard (2004) described the educational struggle for the American curriculum and instruction during the late nineteenth century and the early twentieth century as a time when various interest groups debated the chief aims of education for young children in the Industrial Era. Such struggles include

innovative and traditional pedagogies, controversies on methods and learned concepts, and inquires and illustrations in curriculum development. The struggles and, for some, reforms of mathematics education for deaf children in the country continued as their teachers tried to find a perfect one-size-fit-all instructional methodology for teaching mathematics, swinging back and forth between the traditional and modern paradigms of teaching during the nineteenth century.

Two educational forces called for changes in curriculum and instruction in mathematics for the deaf during the late nineteenth century. First, the founding and implementation of a college for the deaf in Washington, DC, in 1864 sparked college professors and classroom teachers to call for increased expectations and standardization in the mathematics curriculum for pre-college deaf students across the country (Kurz, 2008). Progressive in educational thoughts and curricular reforms, Amos Draper (1880), a deaf professor of mathematics and Latin at the college, stressed the importance of arithmetic education for the deaf, elevating the subject to the level of language, since deaf graduates who possessed advanced mathematical knowledge would significantly contribute to society and benefit themselves when they became full-fledged, constructive workers in the world. Draper believed that mathematics was as much a visual language as sign language. One of his numerous recommendations to redress the problems found in deaf schools and in colleges included teaching mathematics to young children as early as possible using objects and illustrations.[2] He also recommended the development of vocational training programs for the deaf to meet the need for job specialization in industrial companies, especially manual trades, since the country was progressing through the industrial movement, leaving behind dependence on agriculture for economic growth (Reid, 1958; Robinson, 1900a, 1900b). Both forces called for increased mastery in arithmetic and, later, algebra, before graduates entered either college or the workplace.

The struggle concerning how to teach the deaf mathematics effectively and prepare them for college and/or the workplace continued as teachers of the deaf brought to the field different perspectives and, in turn, criticisms of teaching and learning arithmetic in the field of deaf education. Manual training for industrial trades, at the time, called for changes in school curriculum in order to infuse necessary skills and knowledge for deaf students to acquire and develop before they entered college or the workplace (Convention of American Instructors of the Deaf, 1899; Kurz, 2006). This paper illuminates the pedagogical struggle between mental arithmetic and conceptual understanding during the last half of the nineteenth century, in a rough chronological order. By using primary sources, such as *American Annals of the Deaf* and proceedings of past nineteenth century conventions for American Instructors of the Deaf (CAID), this historical research study brings to light a new understanding of the struggle in mathematics instruction and curricula for the deaf during the late nineteenth century, especially the struggle between the teaching of mental arithmetic and conceptual understanding.

Warren Colburn's Sphere of Influence

Before the beginning of the nineteenth century, students were expected to discipline their minds by rote memorization; therefore, arithmetic was only learned by memorization (Colburn, 1826, 1830).[3] A young Harvard graduate, Warren Colburn (1821) wrote an earth-shattering book on teaching arithmetic, *First Lessons in Arithmetic on the Plan of Pestalozzi, with Some Improvements,* addressing his concern about the teaching of mathematics through memorization. He promoted teaching mathematics with understanding whereas, he believed, teachers should partake of the constructive approach, where children would learn arithmetic with understanding and discovery. In his book, Colburn advocated and defended understanding and discovery, or conceptual knowledge, as the best avenue to learning mathematics, let alone arithmetic. He later claimed that with the old system, the learner was presented with a rule that specified the procedures to solve problems without explanations. Larger numbers were often used in such problems, which could be overwhelming and mechanical for the learner to follow the rule. Although his ideas were a breakthrough in mathematical instruction, it was not until later, after the nineteenth century, that they became widely accepted. This was indicative of an educational sphere that was not ready for reform in school mathematics. The most popular avenue to learning arithmetic and higher branches of mathematics during the nineteenth century was drill and rote, for it was often believed that mathematics was a tool for reason, exercising the rational faculty and promoting mental discipline (Calhoun, 1973).

Since mathematics education did not begin as a discipline until the mid-1800s, the pedagogical instruction of arithmetic varied among teachers. It was a common practice that teachers relied on the teaching advice provided on the arithmetic textbooks at the time. Teachers, during the early and mid-nineteenth century, often did not receive formal training in pedagogy. Instead, they either followed the directive or suggestions for teaching that could be found in textbooks or used the exact method they learned when they were younger. The teachers' beliefs about how much mathematics should be taught had a great impact on the students' knowledge and skills in mathematics. Teachers of deaf students in the nineteenth century believed mastery in arithmetic was crucial to mental development and knowledge building for advancement in education or the workplace. The question was, how should arithmetic be primarily taught to the deaf?

The Pedagogical Struggle Between Mental Arithmetic and Conceptual Understanding

John Robinson Keep (1854), of the American School for the Deaf and Dumb, urged that teachers should take great care to start associating numbers with objects, first by teaching counting, then addition. After the student mastered the counting process via writing, then the student should be encouraged to substitute counting with memorizing. Keep believed that the deaf student should

learn addition facts from experimentation and observation and should then construct an addition table for the purpose of memorization.

Similarly, Thomas Gallaudet (1857), son of Thomas H. Gallaudet who founded the American School for the Deaf, made suggestions for the first year classroom:

> Upon the wall of the room opposite to the teacher's and over the pupil's large slates, might be displayed the addition table, upon which the class could be frequently drilled with great facility. In connection with this table the class should have a small arithmetical treatise, unfolding the principles of numeration and addition and nothing else. During the first year they should be thoroughly drilled in adding figures. (p. 74)

Deaf students in the first-year classroom would learn numeration and addition operations through drill and rote, and Gallaudet urged that teachers help reduce their students' habit of counting their fingers while performing addition operations.

On the contrary, George McClure (1858), of the Kentucky Institution for the Deaf and Dumb, proposed some ideas on the teaching of fractions:

> When the pupil has become familiar with all this [fractions], he will be prepared to generalize the rules he has learned, and to apply them to all fractions, of whatever denominations. He will at least understand what is the intent and meaning of the several operations, and will have formed habits of thinking clearly and closely on arithmetical subjects. He may be expected afterwards to proceed rapidly enough to make up for all the delay occasioned by laying thoroughly the foundation, and will have the increased pleasure of seeing the way clearly, instead of groping blindly he knows not whither. (p. 253)

McClure showed his support for Warren Colburn's conceptual understanding instruction, from which students would construct knowledge through conceptual understanding, instead of drill and rote. McClure suggested deaf students should do the drill and rote practice only after they understand the concept and its implications, and then their computational rate would increase significantly.

Like McClure, Richard Storrs (1871) cautioned against teaching arithmetic as mere mental gymnastics without having the students understand arithmetic concepts at the same time. Furthermore, "numbers should be chiefly considered by the deaf-mute, in their relations to life and language," he wrote (p. 144). The very first steps in teaching numbers, in the concrete sense, should be to teach the name of the number as an adjective, in terms of its word form, and associate it with as many concrete items in deaf students' daily lives as possible. Furthermore, Storrs suggested that the teacher should spend less time teaching rules to memorize and allow the student to make his or her own rules, since "this would tend to cultivate sharpness of thought" (p. 153). In this case, the deaf student was encouraged to discover or create mathematical concepts and rules with support of visual illustration, so the student's visual memory would be optimally stimulated for success in gaining and retaining principles.

William L. Bird (1879), instructor at the American Asylum, was a strong advocate for drill and rote in order to prevent mistakes, rather than correct them. The motto of Bird was "one step at a time and complete mastery of each and every step as far as taken" (p. 1). His justifications for drill and rote in arithmetical operations were as follows:

> The pupil can be so well drilled that it becomes more like play than work to him; he finds it a pleasure instead of a task to perform operations in figures. Fewer mistakes are made and less time is lost in future operations. The pupil, feeling himself perfect so far, is encouraged and confident. He walks firmly along, instead of stumbling and soon falling hopelessly in the rear. (pp. 1–2)

Bird felt that, through rote memorization, deaf students would eventually master the basic facts and become accurate and rapid arithmeticians. Urging that the student should be drilled in addition until mastery, Bird wrote, "Not till he is able to repeat in every instance, without hesitation or error, ... and the teacher has had an opportunity to find out his particular deficiencies. He must keep striking at the knots, which is the best way in dealing with logs—and blockheads" (p. 5).

Along the same vein, David Greenberger (1882), principal of the New York Institution for Improved Instruction of Deaf-Mutes, proposed that during the first two or three years the children learn the fundamental operations for all combinations under ten by rote memorization mentally. He wrote of mental arithmetic: "I devote so much time and attention to mental arithmetic because it is more frequently applied in real life than written arithmetic. Pencil and paper are not always conveniently at hand, and the mental processes do not occupy so much time as the written ones. Hence, the former are preferred in business transactions" (p. 13).

In discussing the students at the National Deaf-Mute College, Dr. Edward M. Gallaudet (1887), president of the college and brother of Thomas Gallaudet, stated that the students who did not do well in mathematics had been taught by drill and rote and were not taught the principles upon which the rules were based. He further stated that mathematics was no pleasure for them, but was a great bore and a trial and a terror.

Jonathan H. Eddy (1887), of the New York Institution for Improved Instruction, quoted Francis Bacon when discussing the importance of instilling logical reasoning in deaf children's minds by teaching arithmetic: "If a man's wits be wandering, let him study arithmetic" (p. 94). He felt deaf children needed to learn arithmetic in a logical way, instead of by rote, to prepare and construct their brain faculties to deal with practical situations appropriately. In addition, Eddy affirmed that Froebel's "knowledge precedes name" concept was important in teaching arithmetic to the deaf child:

> Every principle or process should be introduced by such simple exercises that the idea is made plain before it is technically named. In this way all

> the simple principles of arithmetic and the four simple operations can be made to suggest themselves. If there are three books on one desk and two on another, ask a pupil how many he sees; he will count, and answer five books. Thus he adds without knowing it, and, by means of a multitude of such simple exercises, in time the sums of different numbers will become fixed in his memory. Would any pupil thus taught write, 'Three books and four desks make seven *books?*' If you say so yourself, he would at once challenge the correctness of your statement. So the principle of addition, that only like numbers can be added, is brought out of his own mind. (p. 95)

Instead of introducing terms of arithmetic, which he believed would trap deaf students into a limited imagination, he believed the teacher should act it out by role-play, hypothetical situations, and hands-on applications, rather than drill and rote.

In the same year, Charles N. Haskins (1887), an instructor at the Ohio Institution, noted the revival of the use of mental arithmetic in institutions for the deaf, although there was a blanket banishment to employing mental arithmetic in public classrooms at the time. After discouraging teaching experiences with students who had no sense of mental arithmetic and took many hours to compute simple operations of arithmetic, he one day decided to throw "aside the book for the first two or three months of the term, and devoted the hour for arithmetic to drilling the students mentally in the fundamental rules involving numbers from one to one hundred, in the following manner, with the satisfactory result of accomplishing twice as much during the year twice as easily and twice as well as the year before" (pp. 157–158). He continued with the description of his method, in which the class would learn to count by twos to one hundred and then to count backward by two, and:

> Thus all the combinations and relations of one number after another can be exhausted until the pupil can mentally compute the largest numbers with ease, accuracy, and dispatch. By this method the pupil will himself perceive the relationship existing between the fundamental principles—a thing that comes rather by the slow process of assimilation through practice than by any explanation the teacher can give; he not only becomes more rapid and accurate in his computations, but by perceiving the relationship of things he also vastly improves his solutions. (p. 158)

Haskins described how he had the class drill on roots and powers of numbers "until it becomes a second nature—until *two times thirty-seven* is as easy as *two times seven;* or the square or cube of seventeen is almost if not quite a matter of intuition" (pp. 158–159). He pointed out the importance of employing mental arithmetic so that deaf children would develop a habit of computing and remembering numbers as the foundation of knowledge and mental habit for practical use, both to save time inside the classroom and outside the school. He related the process of mental arithmetic in the classroom for the deaf to the blind students' study of arithmetic: "I have seen them [blind students] rapidly and

accurately compute long problems in partial payments involving half a dozen dates or more" (p. 159). Furthermore, Haskins stressed that numbers used in computations should be within the deaf student's comprehension. Otherwise, the deaf student would be labeled "a mental murderer," working in the dark, without understanding (p. 160).

George M. McClure (1890) echoed C.N. Haskin's call for mental arithmetic when he presented a paper at the twelfth meeting of the Convention of American Instructors of the Deaf. He stated that he would drill his students in writing numbers up to ten, and then to thirty, before going into addition and subtraction with tables.

> I would drill the pupils thoroughly on these tables, giving meanwhile practical problems, and before passing on, I would make sure of three things—that the pupil could do his work with accuracy, with a reasonable degree of rapidity, and that he could state it in correct, if simple form. I would teach the tables of the other two rules in the same manner, and the principles themselves on the same plan, using objects at first with all of them, drilling unsparingly, and insisting on the three points of accuracy, rapidity, and correct form of expression. (pp. 71–72)

He believed every student should master all four rules with three conditions: accuracy, rapidity, and clear and correct form of expression in printed English. Furthermore, he penned: "After the four rules have been taught, there should be a review extending over a period of several months, during which every part of the foundation should be tested, and the weak spots, if any be found, strengthened. The dry bones, so called, of arithmetic, need not be so very dry, if the teacher will only throw a little life into his instruction, and set the pupils to figuring out such live problems as the cost of the clothes he wears and the food he eats" (p. 73). Like Haskins, McClure called for the old-fashioned method of learning arithmetic, that is, by mental drills, to promote accuracy and rapidity. However, McClure encouraged his students to discover the basic four rules with appropriate guidelines and use of practical problems that were connected to their daily lives.

In regard to the primary teaching of numbers and their combinations, Weston G. Jenkins (1892), of New Jersey's State Institution for the Deaf and Dumb, criticized the mental discipline approach. He cautioned, "it may teach adroitness; it may be useful as a training for games of jugglery; but whatever its usefulness may be, it is of no use worth mentioning in teaching arithmetic to deaf-mutes" (p. 11). Additionally, he urged that mathematical concepts must be accessible to the sense of sight, for it is the only primary channel means of acquiring arithmetical knowledge for deaf-mutes.

Effie Johnston (1895), of the Illinois School for the Deaf in Jacksonville, gave a presentation on number work. In her presentation, she discussed the importance of numbers in daily life, the fact that they are everywhere and in every step of human progress, let alone practical life activities in the workplace, home, and school. She supported the notion that learning should be active: "a normal child

is active and loves to be doing something, that he learns words relating to activity more readily than other words, and that his greatest interest is aroused when he is the actor. Therefore, the more we can make the children the actors in daily lessons, the greater their interest will be" (p. 115). She suggested that teachers make their number work lessons look like play with various classroom objects in order to grasp students' attention and interest. Furthermore, she also suggested that deaf students act out arithmetical problems with objects to solve for unseen facts by discovery. The activity in concrete form allows deaf students to discover mathematics by using objects and acting out the problems. She wrote:

> The pupils, observing these conditions, think and reason for themselves, forming their own conclusions. They are actively engaged in the free use of their own powers. They see, handle, experiment and discover for themselves, and are not memorizing numerical facts which the teacher is giving forth from his store-house of knowledge. They are teaching themselves, the teacher guiding and supplying names and technical language when it is needed. They are developing their reasoning powers, forming correct modes of judging, finding out that there is something unknown, something which they must discover which depends upon existing conditions for facts already known, and it gives them confidence in their own powers of observation and discovery. (p. 116)

Her motto, which followed the modern paradigm, was "principles and process first and mechanical rapidity will follow when they see the necessity for economy of time" (p. 116). Johnston made recommendations for teachers that they should include, but were not limited to, the following: restraining from repeating problems, lest lazy members memorize instead of using their reasoning skills; repeating arithmetical processes and language; using real objects in lessons; inventing new conditions for arithmetical problems; using as much illustration as possible with classroom materials, such as books, pencils, students' articles of clothing; and, monitoring the students' understanding.

According to Superintendent David C. Dudley of the Colorado School for the Deaf in Colorado Springs, there were two parts to arithmetic instruction: "the mechanical work and the application of mechanical work in the solving of problems" (1895, p. 329). Deaf students, he believed, should focus on the former in their early years and on the latter after their reasoning minds were developed and trained in mental arithmetic with fluency. He cautioned, "There is nothing so exasperating to a teacher of an advanced grade as to find his pupils capable so far as judgment is concerned, but incapable of accurate mechanical work" (p. 330).

At the end of the fourteenth meeting of the Convention of American Instructors for the Deaf in 1895, William H. DeMotte of the Indiana School for the Deaf cautioned against mental arithmetic as the educational objective:

> I have observed a certain securing and holding of the educational result, by the use of words—in the language of the question, "making a language lesson" of it ... if you first lead him, by actual count of objects, to

> recognize a group of four objects, and then that five of these groups taken together are twenty, you are giving him not merely the fact, but what is of infinitely greater value, the mental exercise involved in discovering the fact, with the gratification and skill following. The "rapid mode of operation" in the question is a resultant of the clear perception attained from the drill. If not secured at once, just go over the drill again. A mechanical rapidity may be secured to a very limited extent by memorizing. "Four times five are twenty," *memorized*, will serve only in case of multiplication. Four groups, of five individuals each, *recognized*, will make the pupil to group and handle four, five, twenty, wherever they may occur. (CAID, 1895, pp. xlii–xliv)

Memorization, DeMotte suggested, interfered with an understanding of the concept. He asked that deaf students learn the four rules thoroughly, with explanations and applications: "The effort to learn develops the mind" (p. xliv). With that conceptual understanding method, rapidity and accuracy would come.

Affirming McClure's stance on mental arithmetic, James L. Smith (1897), principal of the Minnesota School for the Deaf, felt that the preponderance of time should be given to mental work to increase rapidity with accuracy. He stressed the importance of rapidity and accuracy in mental operations when it came to small numbers and fractions of small denominators. According to him, the duty of the teacher is to ensure that the students acquire rapidity and accuracy in mental operations. The Minnesota School for the Deaf established a committee to review their curriculum (Smith, Tuck, and Layton, 1888). Under his rule, the committee of the Minnesota School recommended more attention to mental work, a full written analysis of word problems, and the banishment of finger counting. They argued that mental arithmetic would assist students in the acquisition of language in the most effective way, as it was thought that the cultivation of the memory had direct association with the acquisition of education (Smith, 1899).

An avid reader of works by Rousseau, Pestalozzi and Froebel, Edward S. Tillinghast (1898a, 1898b), of California School for the Deaf in Berkeley, criticized the instruction in schools for the deaf at the time, claiming it was all but defective, for it dealt with abstractions excessively and, from the teacher's point of view, not the other way around. He emphasized the importance of environment on instruction and on the education of the deaf: "education is the process of bringing life into the fullest possible correspondence with environment" (1898a, p. 22). Any method of instruction not based upon life experience, Tillinghast cautioned, would result in mechanical or careless thinking with no interest, such as the memorizing of arithmetic rules. He asserted "overwhelming evidence proved that the tendency of such methods was towards mental stagnation and dyspepsia, rather than to such healthy growth as proceeded in spite of them. It is seen that unanalyzed truth cannot profitably be boxed up in words and packed away in memory's chambers for future use, because the mind, in its efforts to reach and maintain unity in its processes and their results, tends continually to throw out all such uncorrelated elements of knowledge" (pp. 23–24). In this case, he condemned the educational movement that promoted memory by drill and

rote, as seen at the Minnesota School for the Deaf. He believed instruction should be tied to students' knowledge and experience through object- and nature-study and brought to the next level, where the call for analysis and reasoning is reached and where students are able to construct associated thoughts socially and individually. Furthermore, Tillinghast (1898b) criticized Dudley's statement on the two parts to arithmetic:

> The intimation seems to be that the mechanical parts should be mechanically memorized without bothering much as to the "why." It seems to me that even in the first steps in arithmetic nothing can be more fatal to later sound and rapid progress than by our methods to give the pupil a fair chance to conclude that it is a pleasure, "but by no means an essential," to know the *why* of his work. (pp. 225–256)

Concerned with the spread of the mental arithmetic paradigm, which supported learning through memorization during the first three years of schooling, Tillinghast imploringly asked teachers to reconsider their position on the traditional paradigm, which, he believed, was rendering learning dull and dry, and to teach deaf students to understand the relationships between all four rules and their applications to the practical world. He believed learning and understanding the mathematical concepts thoroughly were crucial to building a strong foundation of knowledge upon which related new concepts could be best and effectively learned through association.

On the use and abuse of memory in education, Jenkins (1900) cautioned that memory, fragile as it can be, should be cultivated and used for good purpose and daily life applications. Oftentimes, students were asked to memorize information that was not usable or important, thus creating a case of memory abuse. "The phenomenon of 'cramming,' of rapidly acquiring facts and holding them for a brief time, for a definite purpose, is a curious one, but not of special value to us as teachers of the deaf, except as a danger to be avoided. In some professions however, it serves a useful purpose, and it deserve careful study as a mental curiosity" (p. 9). Jenkins urged that teachers of the deaf teach meaningful concepts that their students could commit to memory for the benefit of rapidity and accuracy in order to save time.

Conclusion

Questions, such as, How should arithmetic be best taught to the deaf? Should deaf students be drilled for rapidity and accuracy in arithmetical calculations, lest it leads to bore students and encourage a negative disposition toward mathematics? and, Can conceptual understanding be primarily taught at the expense of mental arithmetic and procedural skills? were on many teachers' minds throughout the history of deaf education. They shared their introspective thoughts on different areas in the field and their teaching experiences in *American Annals of the Deaf*, one of the oldest educational journals, and conventions for American Instructors of the Deaf, where professionals in deaf education convened at schools for the deaf every two to three years.

Teachers for the deaf had two main approaches to teaching arithmetic: mental arithmetic versus conceptual understanding. Some argued that mental arithmetic could lead to accuracy and rapidity, which may result reduction in time spent on tasks. Like Colburn, others suggested that conceptual understanding could lead to appreciation for knowledge and relationships between concrete things and abstract ideas. Some felt that deaf children should use mental arithmetic first in order to develop automatic calculations and confidence before they understand the concept. Others felt that deaf children should understand what is covered first through visual illustrations, object teaching or discovery activities before they go into drill and rote for accuracy, lest students become bored and learning becomes drudgery. The learning process became important, as opposed to memorization of facts. Combining both approaches, as McClure (1890) and Jenkins (1892) proposed, may produce better results. The pedagogical pendulum swung back and forth since the foundation of the permanent American School for the Deaf in 1817, as teachers of the deaf struggled to define effective pedagogies in teaching and learning for mastery in arithmetic. Mastery in arithmetic is the gravity that pulled the pendulum to the center. Even today, the Colburnian debate remains unresolved. The closing of the nineteenth century brought no consensus around how to instruct deaf children in arithmetic; however, there was a consensus that mastery in arithmetic had become a necessity for deaf graduates as they prepared for the college or the industrial workplace.

Notes

[1] In the early nineteenth century, Emma Willard founded schools for young women in Vermont and then in New York. Samuel Gridgley Howe founded the first school for the blind in Massachusetts. Thomas Gallaudet founded the first permanent school for the deaf in Connecticut.

[2] Amos G. Draper, "The Discontinuance of the 'Lower Preparatory' Class," *American Annals for the Deaf and Dumb* 25, no. 4 (1880): 251–54.

[3] In his address delivered before the American Institute of Instruction in Boston, August 1830, Colburn produced a window to the old system of teaching arithmetic: "At least, fewer made any considerable progress in it. Very few females pretended to study it at all, and the number of either sex that advanced much beyond the four primary rules was very inconsiderable. And the learner was seldom found who could give a satisfactory reason for any operation which he performed. The study of it used to be put off to a very late period. Scholars under twelve or thirteen years of age were not considered capable of learning it, and generally they were not capable. Many persons were obliged to leave school before they were old enough to commence the study of it."

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