



New Century Education

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***The Research History of the  
New Century Learning System***



New Century, once a division of Appleton-Century-Crofts, based its educational system on solid scientific educational research, and the Company has continued to do so for the past 40 years of its independent corporate existence. All of its existing computer-presented curricula in reading, mathematics, and writing, have embedded this long and successful research-based approach to product development. The thrust of New Century's basic and applied research largely has been to improve and accelerate learning behavior. The following is an outline of this research, and how it has been incorporated into the design and refinement of the Company's products for reading, writing, language arts and math.

## **RESEARCH FOUNDATIONS**

### *B.F. Skinner and Basic Research*

Appleton-Century-Crofts, New Century's parent until 1973, was B.F. Skinner's academic publisher. In 1960, Appleton-Century-Crofts, with Skinner, initiated a program of basic research into verbal behavior and how it is learned. The lab had a research director, Dr. Larry Mace, from UCLA and a team of four skilled researchers. The steering committee for the research program was headed by Skinner and included Dr. Fred Keller of Columbia, Dr. Earl Stevick of the Defense Language Institute and Georgetown University, Dr. George Spache of Florida State University, Dr. John Carroll of Harvard, Dr. James Holland of Harvard, and Dr. Leonard Newmark of The University of California at La Jolla.

The questions investigated by the research team were often those issues first raised in Skinner's controversial 1957 book, *Verbal Behavior*. Many experiments were directed towards learning about behaviors of readers. Audio technology was developed to provide a means of studying such variables as the effects of immediate and delayed verbal feedback on a reader's textual choices. Reader eye movements were studied using some advanced technology developed for the Company by General Instruments. In addition, new ways of providing immediate visual feedback for written responses were commissioned by the Company to a technical team at Arthur D. Little and Company in Cambridge

The research effort turned to an applied program in 1964. The steering committee continued to give direction to the group, who had by this time taken the name, New Century. The goal was now to effectively use what had been learned at Appleton. Knowledge about learning that was emerging from the new federally sponsored R & D centers was also sought and acquired.

### *Robert Glaser and The Learning Research and Development Center (LRDC)*

By 1964, Appleton had begun to rely increasingly on the output of the Learning Research and Development Center at the University of Pittsburgh. Its founder, Dr. Robert Glaser and his team had a unique idea: students often benefited from work assigned to them individually, according to their individual needs. An experimental school in a section of suburban Pittsburgh, headed by its young principal, Dr. Robert Scanlon (who later became Commissioner of Education for Pennsylvania), had prepared a model of instruction that tried to individualize instruction. The New Century Division of Appleton was assigned by Glaser and his colleagues to "reduce the model to practice." It did, and the first commercial program of individualized instruction in mathematics, IPI Math, was published and distributed in 1965 and remained a successful commercial product for 17 years.

New Century developed additional products in cooperation with LRDC. Dr. Audrey Holland, a researcher at LRDC had a concept and preliminary procedures for teaching (or re-teaching) aphasic patients to communicate. Using technology developed by Skinner and his team, that is, a patented invisible ink developed and tested for New Century by Arthur D. Little, and audio technology needed for the earlier basic research conducted in the Company's New York offices, New Century published a successful product used by audiologists and speech therapists for 7 years. (It was in reviewing research at Bell Laboratories for this product that New Century learned of the ineffectiveness of the technique of "comparing" one's own recorded voice to that of an expert speaker. In attempting to train telephone operators in standard English

(operators were in much more demand then than they are today), Bell researchers found that until one could discriminate correct from incorrect pronunciations and inflections, speakers will simply practice incorrect oral behaviors when recording. To their untrained ear, their speech "matches" that of the expert voices.)

#### *The Center for Applied Linguistics (CAL)*

In 1964, New Century became a subcontractor to CAL, the Washington-based leader in linguistics and language research, in a contract with the Defense Language Institute, a component of the Department of Defense, to teach French. Dr. Catherine Garvey was the principal researcher for this project. Through New Century, however, she had access to the verbal skills steering committee and her course development was carefully reviewed by them.

One of the technical requirements for the development of *CAL French*, as it was called, was functionality delivered by a radical new "teaching machine." Named the Portable Lab System, this device used transistors and the most modern switching technology to teach second languages. It was revolutionary in that it could be transported to the learner, a requirement that the Defense Language Institute considered critical. The French course was completed in 1965.

#### *Educational Research, Inc.*

By 1972, armed with its own research outcomes and benefiting from the work of others, New Century had developed materials for its first learning centers. Learning centers presented individualized materials that used the technologies and pedagogy developed by Skinner as well as the IPI model of LRDC. The second-language teaching techniques that were used in the project with CAL were also embedded into learning center teaching materials.

One of the conclusions the Company reached in its work with *IPI Math* was that a new approach to managing individualized instruction, one that simplified record-keeping and other non-teaching functions, would be needed if the product were to be successful. New Century prepared a system of management that was remarkably efficient. But the Company needed to know exactly how teachers and administrators regarded the streamlined system. For this purpose, New Century contracted with a young Cambridge company, Educational Research, Inc., headed by Dr. Allan Ellis and Dr. Leonard Wright. ERI attended New Century training sessions and did follow-up confidential interviews with over 100 users of the new learning centers. Two reports were published by ERI: one study was of student productivity; the other was a report of teacher satisfaction and recommendations for improvement. These, and subsequent studies were utilized by New Century to fine-tune its management system.

#### *Skinner's Motivational Principles Employed*

By 1974, New Century Education had begun to selectively adopt cognitive approaches to learning. However, at that point there was little in the educational literature about motivating students. Moreover, traditional approaches to motivation in the psychological world focused upon active interested learners, and not those who had experienced considerable failure in school. Since this was New Century's target population, it needed to use techniques that kept students with a background of failure highly motivated. One of B. F Skinner's generally unrecognized accomplishments was the creation of principles and practical techniques for learner motivation. Two of the direct applications of his work are still present in the current New Century program: these are the point system and the student progress chart.

#### *Adaptive Diagnostic Tests*

For New Century, having a rich and successful printed curriculum in place, the new personal computer was first viewed as an instrument that could quickly match student proficiencies and deficiencies with the right sequence of lessons. Dr. John Carroll, then senior researcher at Educational Testing Service, helped the Company with its approach to adaptive diagnostic testing in reading and mathematics. Item response theory, then in its infancy, was carefully examined and deliberately discarded. A proprietary algorithm was developed and tested and found to be the ideal compromise between time and reliability. Although these diagnostic tests have been updated and modified several times since 1984, the governing algorithm has remained, as an effective mechanism for aligning individual student needs with the New Century curriculum.

### *Mastery Tests and Embedded Criterion Items*

In early 1985, New Century applied the techniques that had been modeled in the LRDC/RBS IPI Math program utilizing networked personal computers to effectively assess progress. First, it developed computer-presented mastery tests. These were used to periodically assure teachers and administrators that students have indeed acquired the skills and concepts that lessons presumed to have taught. Second, as lessons were improved and transposed to computer formats, embedded criterion items were added. Thus, evaluation was made both episodic and continuous, or from the student's perspective, visible and invisible.

## **READING CURRICULUM DEVELOPMENT**

As work with foreign language instruction was being conducted, research on teaching reading in English was also conducted in the laboratory. The same steering committee that was involved with foreign language research lead this project as well, but Dr. Mace and Dr. Stuart Margulies led the actual research. Realizing that the expensive equipment used in the lab could never be practical in a school setting, inexpensive technologies were developed for such implementation. One of these was called the "Audio Frame" machine. Audio was student managed but the audio stopped, waiting for student response, by an inaudible signal on the tape. The Arthur D. Little company, located in Cambridge, MA, developed a feedback for written responses: a printable invisible ink made visible by individual student constructions or choices.

Lesson development using the simpler technology, was initiated by Dr. Mace. After reading and other language objectives were written and reviewed by the committee, Dr. Margulies and his team of experienced lesson writers would prepare lessons. Dr. Mace would then test lessons in the lab, and lessons were revised on the basis of formative data collected by the system, followed by evaluative tryouts in several schools in the New York area. To be sure that the lessons were effective, criterion-referenced mastery tests were developed and administered. Lessons were again revised if they failed to produce the intended results.

The New Century approach to beginning reading instruction was (and is) founded on phonemic awareness and synthetic phonics. Much of the guidance for early reading came from two Harvard professors, Dr. Jeanne Chall and Dr. Helen Popp. Both were consultants to New Century and would, independently, visit the New York facility and conduct workshops on the scientific principles of phonics instruction. (As a result, in the New Century reading program, unlike some phonics programs, letters do not "make sounds:" Instead, letters or groups of letters *represent* sounds.) Phonemic understanding was essential. For example, after teaching the morpheme/graphemic "it," students are asked if they hear the sound of "it" in "sit," or "pit," or "fit."

New Century consciously and very deliberately elected systematic synthetic phonics over analytical phonics for several good reasons. Not only did the company's advisors favor this approach but the data from both laboratory and school tryouts confirmed this choice. Also, every early lesson, while beginning with phonemes, moves quickly to morphemes and words, thus allowing the construction of meaning at the earliest point in time. A handful of so-called "sight words" are taught (e.g., "the," "and," "who,") so that complete sentences can be used, but the emphasis is on synthetic phonics.

Whenever possible, graphics were (and are) used as stimuli to generate student response. For example, a student will type "dam," or select it from alternatives, in response to a picture of a dam. In this example, audio (the phonetic stimulus) has faded away and is replaced by a meaningful graphic. If a graphic may not be easily understood, it is first introduced by an audio explanation ("This is a dam."). The approach, in general, is audio (phonetic), to phoneme, to grapheme, to morpheme, to word (including vocabulary instruction, when needed), to pictorial representation, to meaning, and to reading fluency.

In levels K-3, reading stories, and responding to story questions, is a component of hundreds of lessons. The stories contain, of course, a liberal number of words that exemplify the phonic principles

taught in that lesson and the immediately preceding ones, but by reading stories students use their cumulative phonic knowledge to derive meaning from texts.

In each lesson, reading fluency is enhanced by both audio help and by continuous feedback. While student reading is silent, the feedback to questions asked and answered is usually both audible and visual: both fluency and comprehension are the outcomes. Vocabulary instruction is embedded in every lesson and novel, or likely to be novel, words are taught by sound/graphic/text/ combinations wherever possible. Interwoven questions are responded to by students and feedback, both error and correct answer feedback, always follow each answer.

Reading comprehension for grades 4-10, following decoding mastery, fluency, and story comprehension, was also researched and developed under the direction of the steering committee and directly by Drs. Mace and Margulies. Formative evaluation, however, and revisions therefrom, took place in selected schools and not in the company's research laboratory. The curricular emphasis was on expository reading and the literature component was not added until decades later. But data-based revisions were made to all reading components throughout the 1970s and the early 1980s.

#### *Literature Review and Reading Curriculum Development*

Throughout the years between 1984 and 1993, developers at New Century reviewed the literature of educational and psychological research and applied much within its instructional system. Of great interest was the publication of *Beginning To Read*, by Marilyn Jager Adams in 1990. This federally sponsored work, done in conjunction with the Reading Research and Education Center at the University of Illinois, recommends a balanced approach between phonics and reading for meaning. New Century has adhered to this approach since its earliest days.

### **A COMPUTER DELIVERED READING CURRICULUM**

In 1983, New Century recognized that the personal computers, operating in a local area network configuration, could deliver individualized reading instruction more effectively than paper lessons provided two new components were added. A management system had to be developed, freeing teachers to work with individual students, and an adaptive diagnostic test that placed individual students in lessons that were within their zones of proximal development.

Having had 20 years of experience in teaching teachers how to manage individualized instruction delivered on paper, the company wrote the management system completely in-house. It tested the program, at first using a Texas Instruments computer and paper lessons, in selected schools, interviewed teachers about features they found valuable and helpful, and those that were not useful, and revised the program several times. When local area networks became practical for schools, New Century adopted an IBM platform and the management system then freed teachers from entering or recording any significant amount of student data about lesson and test performance.

The diagnostic test for reading was developed under guidance of Dr. John Carroll, then a senior researcher at Educational Testing Service. Students were tested in topic areas, or strands, as the company called them, and placed in each strand. Since lessons and criterion tests had always been produced by referring to the specific lesson learning objectives, the diagnostic test was also objectives-based. This provided a consistency between the diagnostic test, lessons, and criterion-based embedded tests of new reading masteries.

As lessons were converted (and a new constructed response spelling program added) to computer formats, data-based revisions continued. Rutgers University professor, Dr. Jeffrey Smith, conducted research that compared the effectiveness of the older system and the new one. He used standardized test results in his study of two New Jersey schools in the same district and found, not surprisingly, that students using the computerized system experienced larger gains on standardized tests. More impressively, when Dr. Smith analyzed the demographic composition of the two schools, he also found that the school using the computerized system had a greater minority population and considerably more transience.

### *The Report of The National Reading Panel: Teaching Children to Read*

The present New Century reading program has been utilized in schools for almost forty years. Although it has been around for decades, the program is continually updated and edited using school-generated data. The program has been through dozens of updates, and even though it was not developed to mirror the most recent government panel's report the program is currently very much in line with the suggestions of the panel. New Century's use of systematic synthetic phonics, for example, follows the most recent government panel's suggestions almost to a tee. However, this is not a coincidence. New Century conducted its own research in both laboratory and school environments and developed its program based upon research outcomes.

## **MATHEMATICS CURRICULUM DEVELOPMENT**

Having had considerable success in its reading program, in 1969, New Century commissioned Dr. Lewis Eigen, of Educational Design Incorporated to develop a new mathematics program. Dr. Eigen had had considerable experience in product development and he had been a key figure in providing programmed instruction at a New York private school. New Century also had a close advisor, Dr. Jerome Kaplan, who worked at Columbia Teachers College and later as professor mathematics education at Seton Hall University. Eigen's team used the basic IPI Math model as a curriculum plan but new objectives were written and lessons used audio and had immediate student feedback. Criterion tests, called mastery tests in the new system, were woven in with instruction and, again, results on these were used by the company for basic decisions on whether a lesson, or lesson sequence, was effective or needed improvement. A simpler management system was produced and implemented after several rounds of testing and teacher consultations.

In 1971, New Century produced, sold, and implemented its own mathematics program. Titled *Math Achiever*, it was widely used and was destined to become the model for later updates to computer lessons and tests. Improvements were continuous and data-based. *Math Achiever* remained in print until 1990 when the company decided to convert all lessons to computer format.

The National Council of Teachers of Mathematics standards document altered New Century's plans to convert *Math Achiever* lessons to a computer format. First, that program was not entirely consistent with the NCTM standards. Second, *Math Achiever*, while effective in raising student achievement on most progress measurements, had been designed for learners who were mostly on grade level. Lessons had extensive story content and they were perceived as somewhat whimsical by older students whose math skills were below, often far below, grade level...the latter, increasingly New Century's dominant client base. The company decided in 1990 to use the NCTM standards as the foundation for a new and more content-focused mathematics curriculum. For this, New Century turned to Princeton Center for Educational Services, headed by Dr. Peter Rizza, a mathematics educator and author of several mathematics programs.

In late 1989, Dr. Rizza assembled a group of mathematics educators under PCES to produce a 44-page Design Document for a mathematics program for grades K-8. This document was the foundation for the new curriculum: everything therein was linked directly to the NCTM standards. But in addition, a new curriculum philosophy was derived. To quote from the document:

The changes brought to mathematics by the advent of computer technology have sharpened the need for students to develop strong conceptual knowledge. The need for extended skill in computation with numbers having many digits or extraordinary fractions has diminished due to the availability of technology that does these computations quickly and quite accurately. The important question has become, "What computations, if any, need to be made in a problem situation?" The New Century mathematics curriculum is being built consistent with those statements (*Dossey, 1989*).

Exactly how were the NCTM standards used? Here is an example from grade two. The NCTM standard is stated and the related New Century objectives follow:

**2.1. Mathematics as Problem Solving**

- 2.1.1 Read information from graphs.
- 2.1.2 Solve one-step practical problems requiring addition, subtraction, and/or multiplication.
- 2.1.3. Select operation to be used in problems involving addition, subtraction, and/or multiplication.
- 2.1.4. Read distances on maps and complete problems involving travel.
- 2.1.5 Given information about a problem, decide whether it is too little/too much.
- 2.1.6 Solve simple  $<$  and  $>$  problems.
- 2.1.7 Predict answers to simple word problems.
- 2.1.8 Check answers by determining their reasonableness.

Following formative tests in its offices, The first New Century Mathematics lessons were made available to schools in the fall of 1990. The K-8 program was completed in time for school use by the fall of 1991. However, based upon collected school data and its analysis, many lessons were revised during the 1990s. The program has been particularly successful in improving standardized test scores.

## **WRITING CURRICULUM DEVELOPMENT**

The New Century Writing Curriculum, developed in 1994, employs a unique approach that is aligned with contemporary constructivist cognitive findings, with cooperative interaction, with cross-curricular thought, and with current theories of assessment. One of the features that the Writing Curriculum exemplifies is that of presenting students with authentic writing tasks. Writers create text for peer readers and this text is used by the reader to accomplish a realistic but simulated objective, such as following written directions to reach a location. The writer's task is always one that Thomas M. Duffy, constructivist theorist and researcher at Indiana University, would identify as "...an ability to function successfully in the environment." In this program, writing is purposeful.

Another principle discovered by contemporary cognitive science is that of assuming ownership of tasks that are within the "zone of proximal development," as Vygotsky put it. In applying this finding to writing, where it is most critical, New Century lessons asks students to choose topics from a set of several. They are encouraged to "buy in" and control as much of their working environment as they can, but still have help when they need it. If they succeed on their first writing attempt, all the better. If they fail, useful peer reader feedback is available for a revised effort. (As might be predicted, the powerful point system is effective here for both readers and writers.)

Contents and contexts of writing lessons are not restricted to literary topics. The real world requires communications of a diverse, complex and integrated nature. Therefore, students learn to communicate mathematical procedures, to use a drumbeat syntax to create a decodable message, to describe musical selections so that they can be chosen from a large set listened to by a reader, to write instructions for creating a spreadsheet, and to develop a cereal advertisement for a particular target audience. Science, technology, art, politics, and propaganda become domains for a writer's palette, but always with learner choice and control.

## **CORRELATION TO STATE STANDARDS**

As individual states developed their separate defined standards of curriculum content to be taught and tested, New Century aligned its program to those different standards. The New Century curriculum's clear strand and objective structure allowed identification of the specific lessons that address a given state objective. Through this correlation, educators are assured that a student's individualized curriculum path is aligned to state standards established for that curriculum and grade level. As a consequence, improvement in learning is aligned to maximize results on tests administered to confirm adherence to individual state standards. New Century's assessments have been found to correlate highly with state standardized tests. For example, New Century's math assessment has been found to be significantly correlated ( $r=.761$ ,  $p<.01$ ) with FCAT Math Developmental Scale Scores. In addition, a .675 correlation ( $p<.01$ ) was found between New Century's reading assessments and FCAT Reading Developmental Scale Scores. Students can also be assessed according to the tested standards on state proficiency tests by New Century's Test Focused Instruction (TFI) program diagnostic tests. These TFI tests are specifically blueprinted to the state proficiency tests and are predictive of student performance.