Evidence-Based Reform in Education: Success for All, Embedded Multimedia, and the Teaching-Learning Orchestra

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Every year, four million children enter our nation's kindergartens. These children are bright, curious, and highly motivated. They expect to succeed in school, and are eager to do so. As time goes on, however, many of these children fall by the wayside. Some had poor preparation at home or in preschool, and are already at risk. Some will fail to learn to read in the early years. Some will succeed in the early years but fail in the upper elementary or secondary grades as learning demands increase. Some will fail due to motivational or behavior problems. By high school, only a fraction of those bright, eager kindergartners is still succeeding and fully engaged as learners.

The winnowing process from kindergarten to high school happens in all communities, but it is most relentless for the children of the poor. At each developmental hurdle, disadvantaged children are more likely to fail, and there are fewer forms of rescue if they do.

For the past 25 years, the academic performance of poor and minority children has been largely stagnant. On the National Assessment of Educational Progress, reading performance of fourth and eighth graders in 2005 was almost identical to that in 1980, and while mathematics performance has risen, substantial gaps between poor and non-poor children remain (NAEP, 2005).

Since the early 1980's, the dominant approach to education reform has been to increase levels of accountability. Accountability is important in focusing attention on the outcomes of education, not just the inputs. However, increasing accountability alone is not an effective approach. To increase achievement, we need to improve the programs and practices used every day by teachers at all levels. This, in turn, requires a focus on research and development to create and rigorously evaluate new approaches capable of making a substantial difference in student outcomes, and then establish policies that encourage educators to use programs and practices with strong evidence of effectiveness. This chapter discusses the concept of evidence-based reform, describes the history and future plans of the Success for All comprehensive reform model and embedded multimedia as an example of evidence-based reform in practice, and proposes new research on instructional designs to meet the needs of all students.

Evidence-Based Reform

Imagine that each year, every hospital in America received a rating based on its success rate with 100 key types of operations, and hospitals with low success rates would be subject to various sanctions until they met adequate yearly progress goals in each area. Now imagine further that at the same time, funding for medical research were slashed by 90% and the FDA were abolished!

This situation roughly describes the condition of education. Accountability may or may not be a good idea for hospitals, but what drives progress in medicine is not accountability, it is R&D, and policies (such as those enforced by the FDA) that ensure that the results of high-quality research are immediately consequential for practice. In education, there is plenty of accountability, but investment in R&D is miniscule compared to that in medicine, agriculture, technology, or other successful fields. Further, when rigorous research does validate educational programs, there is little incentive for schools to use them, or to stop using programs found to be ineffective.

The role of evidence is increasing in education, but only at the margins. The Comprehensive School Reform legislation in the late 1990’s provided funding for “proven, comprehensive” school reforms, but the “proven” part was soon forgotten. Legislation establishing No Child Left Behind, and especially Reading First, made constant reference to programs “based on scientifically-based research,” but Reading First ended up instead with more than 95% of funded schools using traditional basal textbooks lacking evidence of effectiveness. The Institute of Education Sciences of the U.S. Department of Education has been funding many more high-quality evaluations of practical programs, and it has established the What Works Clearinghouse, which is intended to review scientific research on educational programs. Eventually, evidence will be the engine that drives educational reform, as it is in so many other fields, but we are far from that situation today.

Success for All: Evidence-Based Reform in Practice

One example that illustrates both the potential and the pitfalls of evidence-based reform in practice is Success for All, a comprehensive reform model for elementary and middle schools focused primarily on reading. Begun in 1987, Success for All was designed from the outset to assemble practices that had been validated in research into a coherent approach to schoolwide reform (see Slavin, Madden, & Datnow, in press). For example, the program makes extensive use of effective forms of cooperative learning (Slavin, Hurley, & Chamberlain, 2001; Slavin, 1995). Proactive classroom management and a rapid pace of instruction (Evertson, Emmer, & Worsham, 2003), systematic, synthetic phonics in the early grades (Adams, 1990), and metacognitive reading comprehension skills in the upper elementary and middle grades (Pressley, 2003). It uses one-to-one tutoring for struggling students (Wasik & Slavin, 1993), frequent, curriculum-based assessment (Fuchs, Fuchs, Hamlett, & Stecker, 1991), and a cross-grade grouping strategy called the Joplin Plan (Gutiérrez & Slavin, 1992). Each school has an on-site facilitator who uses coaching strategies adapted from Joyce & Showers (1995). Each of these elements was selected for the model after a careful and continuous review of scientific research in each area.

After the program itself was assembled and implemented, it has been evaluated in more than 50 experimental-control comparisons, 30 of which were third-party evaluations, and a national, randomized evaluation in 35 schools found positive effects on reading outcomes (Borman, Slavin, Cheung, Chamberlain, Madden, & Chambers, in press). Reviews of research on comprehensive school reform have uniformly concluded that Success for All is one of just two programs with the strongest evidence of effectiveness (the other is Direct Instruction) (CSRQ, 2005; Borman, Hewes, Overman, & Brown, 2003; Herman, 1999). A longitudinal study followed Baltimore students in five Success for All and five control elementary schools to eighth grade, when they had been out of the program for at least three years. Former SFA students were still significantly higher in reading achievement, and were far less likely to have been retained or assigned to special education (Borman & Hewes, 2003).

Success for All has been widely disseminated. In 2006-07, it is in about 1200 elementary and middle schools in 47 states, serving mostly high-poverty Title I urban and rural schools. It is generally used in the highest-poverty schools in a given district, rather than district-wide, but it is used throughout a few districts, including Kansas City (MO), Hartford (CT), Lawrence (MA), and Long Branch (NJ).

Embedded Multimedia and Computer-Assisted Tutoring

The research on Success for All finds the program to be highly effective on average, but there remains great variation in outcomes among schools, due to variations in quality and completeness of implementation (see Nunnery et al., 1996). Since 2001, the non-profit Success for All Foundation has been working on applications of technology intended to make the outcomes of Success for All both larger and more reliable.

The essential concept behind these applications is the use of technology to enhance the performance of teachers and tutors, not to replace them. This "lesson-embedded technology" has two forms. *Embedded multimedia* refers to video[*] segments threaded into teachers' lessons, used to give students a clear mental image of the concepts being taught. Computer-assisted tutoring refers to computer software designed to help a human tutor work with struggling children, providing assessment, multimedia content, scaffolded practice activities, record keeping, lesson planning, and professional development.

A key attribute of lesson-embedded technology is the intention to help the teacher or tutor do a better job of teaching, rather than substituting for the human teacher. In fact, one explicit purpose of lesson-embedded technology is ongoing professional development for the teacher. The idea is that by showing *students* content and processes every day, *teachers* are also seeing them, and are receiving constant reinforcement of ideas they learned about in workshops. For example, in lessons involving cooperative learning, embedded multimedia can show cooperative groups working effectively on

[*] The term "video" is used to refer to content on VHS, DVD, or CD.

many objectives and in many contexts, clarifying for teachers as well as students exactly what students are expected to be doing in cooperative groups. The video also models a playful but task-oriented affective tone within cooperative groups, and a focus on giving groupmates elaborated explanations rather than just answers (Webb & Palincsar, 1996). Similarly, embedded multimedia can show actors or puppets modeling use of metacognitive skills, talking through their thinking or problem-solving processes, or modeling creativity. Video threaded into daily lessons and tutoring sessions models the content in a compelling and pedagogically valid way, but more than this it gives both students and teachers daily visual models of how to effectively play their respective roles.

Seen as professional development, lesson-embedded technology solves a key problem of transfer from the developer of a classroom or tutoring program to the children who experience it. Traditional professional development resembles the children’s game “Telephone” or “Whispering Down the Lane,” where a message is garbled as it is passed from person to person. Developers train trainers who work with teachers who teach children, and the original message is diluted at each point of transmission as illustrated in Figure 1. Lesson-embedded technology permits developers to send a clear and consistent message to trainers, teachers, and students. This does not replace workshops, coaching, teacher’s learning communities, or other forms of professional development, but it is likely to maintain the integrity and effectiveness of the entire process.

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Figure 1 Here

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Beyond the professional development aspects of lesson-embedded technology, the direct message to students takes advantage of powerful cognitive effects of linked visual and auditory instruction. Mayer (2001) and his colleagues have demonstrated in dozens of experiments that combining visual content (still pictures or video) that reinforce text or auditory content greatly increases learning and retention. This work builds on Paivio's (Clark & Paivio, 1991) dual coding theory, which holds that content learned in two memory systems is retained better than content learned in only one. Further, each memory system has limits in terms of how much it can handle at any given time, so use of linked visual and auditory material "off-loads" memory requirements from the auditory system, which is usually overloaded in classroom instruction, to the less overloaded visual system (Mayer & Moreno, 2003). In particular, research is increasingly finding that animations closely linked to text or auditory instruction greatly increase learning and retention (Hoeffler & Leutner, 2006). Neuman's (2006) theory of synergy in multimedia postulates that different media enhance different cognitive strategies, which together support comprehension.

Research on Lesson-Embedded Technology

Three year-long randomized experiments have evaluated outcomes of lesson-embedded technology in first grade reading. One evaluated embedded multimedia, one computer-assisted tutoring, and one a combination of the two. These are described in the following sections.

Success for All with Embedded Multimedia (Reading Reels)

A study of embedded multimedia was carried out by Chambers, Cheung, Gifford, Madden, and Slavin (2006). First graders in ten high-poverty, Success for All schools in Hartford, CT, were randomly assigned to use either the SFA beginning reading program with the embedded multimedia or the standard SFA beginning reading instruction.

The multimedia content consisted of 30-second to three-minute skits embedded within the teachers' daily 90-minute lessons. No additional time was added to the lessons to accommodate the multimedia. The purpose of the multimedia content was to directly present to students compelling demonstrations of key elements of beginning reading: letter sounds, sound blending strategies, and vocabulary. In addition, it was hoped that by showing multimedia content in class, teachers would have constant reinforcement of effective teaching strategies.

The multimedia material, called Reading Reels, includes the following elements.

The Animated Alphabet. Animations teach and reinforce sound/symbol relationships. For example, the animation introducing the /d/ sound features a dinosaur in the shape of a lower case "d", in a cave, with drops of water dripping on his head. Each drop makes a /d/ sound. After a few drops, the dinosaur roars and the water stops dripping. The pairing of the memorable images, the letter sound, and the letter shape gives students many mental pathways to link the letter with its sound.

*The Sound and the Furry***.** Brief skits, using SFA puppet characters, model the word blending process, phonemic awareness, spelling, fluency, reading strategies, and cooperative learning routines. For example, a puppet sees a sign, "Watch out for stick." He sounds out the word "stick" phonetically. Then he notices a stick, which he picks up.

The stick sticks to his fur, and in trying to get it off he bites it—and then realizes he's in real trouble. More than a hundred such vignettes illustrate sound blending strategies from simple CVC words to multi-syllable words.

Word Plays. Live action multimedia skits dramatize important vocabulary concepts from the Success for All beginning reading texts. These skits are particularly designed to help English language learners build the specific vocabulary for the books they will be reading. For example, when children are about to read a story called "A Trip to the Inca Kingdom," they first see a skit that introduces words such as "coast," "llamas," "volcanoes," and "messengers."

Between the Lions. Puppet skits and animations from the award-winning PBS program help teach phonemic awareness, sound/symbol correspondence, and sound blending.

The pretests were the Peabody Picture Vocabulary Test (PPVT) and the Word Identification subtest from the Woodcock Reading Mastery Test-Revised (WMRT-R). The posttests included the reading fluency test from the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) and three scales from the WRMT-R: Word Identification, Word Attack, and Passage Comprehension.

Analysis using hierarchical linear modeling (HLM) showed that the experimental group scored significantly higher than the control group on the Word Attack subtest (ES= +0.47). Although the experimental group also scored higher than the control group on Word ID (ES=+0.23), Passage Comparison (ES=+0.20), and DIBELS (ES=+0.29), these differences were not statistically significant in the HLM analysis.

The results partially support the expectation that the addition of embedded multimedia content to a beginning reading program would enhance children's reading achievement. Using a conservative HLM analysis, only one of the four outcome measures, Word Attack, showed significant experimental-control differences, but this is in line with theoretical expectations. Three of the four multimedia segments dealt primarily with letter sounds and sound blending, which are key components of Word Attack.

Computer-Assisted Tutoring (Alphie's Alley)

The Chambers, Abrami, Tucker, Slavin, Madden, Cheung, & Gifford (2006) study was undertaken to determine the independent effects of the Alphie's Alley computer-assisted tutoring model. It used random assignment of tutored children within schools to receive tutoring with or without Alphie's Alley. The study took place in 25 SFA schools located in eight states throughout the U.S. In each school, the lowest forty per cent of first graders on curriculum-based measures were identified as potentially eligible for tutoring and randomly assigned to participate in either Alphie's Alley or control tutoring. The tutors themselves were randomly assigned to either use Alphie's Alley or to continue their usual tutoring strategies, as specified in the SFA program.

Subjects were 412 low-achieving first graders who received tutoring. Twenty-three percent of all tutors were certified teachers and seventy-seven per cent were paraprofessionals.

The tutoring activities in both conditions covered the following skills: phonemic awareness, concepts about print, letter skills, sight words, vocabulary, tracking, fluency, comprehension, and writing. Students in both conditions who experienced difficulties in reading were assigned to daily 20-minute one-to-one tutoring sessions. In the control condition, tutors use paper and pencil activities. In the experimental group, tutors used Alphie's Alley, the computer-assisted tutoring program, designed specifically to align with the SFA curriculum. The use of the technology was the only difference between the groups.

The Alphie's Alley program has three components: assessment, planning, computer activities, and embedded professional development to support implementation.

Assessment. Alphie's Alley assesses children's reading strengths and difficulties in the areas of phonemic awareness, phonics, fluency, and comprehension. It communicates this information on an assessment report for each student, continuously updating information relevant to the student's progress.

Planning. The program suggests a two-week tutoring plan based on the child's assessment. From the tutoring plan, the student and tutor choose a goal for the student to focus on each week.

Computer Activities. Students work on Alphie's Alley computer activities specifically designed to reinforce skills taught in their core reading program. In some activities, students respond directly on the computer. If they cannot produce a correct answer, the computer gives them progressive scaffolding until they can reach the right answer. In other activities, the student responds to the tutor, who records whether the student's response was correct or not, and then the computer provides scaffolding. Sample activities that students encounter are as follows:

1. <u>Letter Identification and Writing.</u> The computer gives a sound, and the student must select or type a letter or letter combination that makes that sound.

2. Auditory Blending and Segmenting. The computer presents sounds for words, which the student blends into a word for the tutor or the student breaks down simple words into separate sounds.
3. Word-Level Blending. The computer displays a word and the student uses sound blending to decode it to the tutor.
4. Spelling. The computer says a word (or at higher levels a sentence) and the student types it.
5. Tracking and Fluency. The student reads a story book on the computer to the tutor, and uses an arrow key to track work by word and the tutor notes errors and the computer computes words correct per minute.
6. Comprehension. The computer displays questions about the stories and graphic organizers that the student completes.

Performance Support for Planning and Tutoring. Alphie's Alley offers performance support for tutors in the form of video vignettes and written suggestions on how to help remediate students' particular problems.

Students were administered scales from the Woodcock-Johnson III Tests of Achievement (Letter-Word Identification [pre- and posttest], Word Attack [posttest]) and the Gray-Oral Reading Tests, Fourth Edition (Fluency and Comprehension [posttest]). Implementation fidelity of both the regular SFA tutoring and Alphie's Alley tutoring was rated on a three-point scale: fully implementing, partially implementing, and poorly implementing.

Implementation was variable. Tutors in 13 schools, teaching 203 students (49% of the student sample), were rated as "fully implementing." Those in 9 schools were rated "partially implementing" and 3 schools were rated as "poorly implementing." Separate analyses by implementation rating showed no program impacts for partial and poor implementers. However, for fully implementing schools, results were generally positive.

Using ANCOVAs, significant positive effects on three of the four independent measures were found with effect sizes and p-values as follows: Woodcock Letter-Word Identification (ES = +0.45, $F(2, 203)=12.77$, $p < .001$), Woodcock Word Attack (ES= +0.31, $F(2, 203)=3.76$, $p < .05$), and GORT Fluency (ES= +0.23, $F(2, 203)=3.87$, $p < .05$). There were no significant differences on GORT Comprehension (ES = +0.05, n.s.).

This finding suggests that when implemented with fidelity, integrating technology to enhance the work of human tutors can lead to greater reading impacts than those likely to be achieved by tutors alone. Over time, tutors using the tool are likely to come to resemble the high implementers who achieved excellent outcomes in the first year.

Combining Embedded Multimedia and Computer-Assisted Tutoring

A third study evaluating the effects of embedded multimedia was carried out by Chambers, Slavin, Madden, Abrami, Tucker, Cheung, and Gifford (in press). This study used random assignment of individual first graders to conditions. Low-achieving students were assigned to receive tutoring with or without computer-assisted support and embedded multimedia. Students who did not qualify for tutoring were randomly assigned to embedded multimedia or control conditions within Success for All schools.

The study took place in two large, multi-track year-round schools that had been implementing Success for All for several years. On entry to first grade, 159 children in the two schools were assigned at random to one of four tracks. Then tracks were randomly assigned to treatments (technology or no technology). Within the sample, the 60 lowest-achieving students received tutoring. The remaining 99 students were the subjects for the multimedia-only study.

In the experimental group, all students were instructed in reading using Success for All with embedded multimedia (Reading Reels), and for the tutored students, computer-assisted tutoring (Alphie's Alley), as described previously. Students in the control treatment experienced Success for All, without any multimedia content.

Students were pre- and post-tested on the Letter-Word Identification scale of the Woodcock-Johnson III Tests of Achievement and post-tested on the Word Attack scale, in addition to the Gray Oral Reading Test.

On analyses of covariance, controlling for Letter-Word Identification pretests, tutored first graders who received both technology enhancements scored significantly higher on all four measures (median ES= +0.53). Non-tutored students who experienced just the embedded multimedia scored significantly higher than non-tutored control students on two measures (median ES= +0.27). The results suggest that using technology to enhance rather than replace teacher instruction may accelerate children's learning.

The results of these three studies on lesson-embedded technology justify optimism about the potential of technology to play a different role in education, one of enhancing rather than replacing teachers' lessons. Threading multimedia content throughout class lessons and tutoring sessions appears to help make concepts clear and memorable to children, taking advantage of the well-established finding that linked visual and auditory content is retained better than either type of content alone.

The effects of the computer-assisted tutoring in these studies provide more positive support for the use of computers in teaching reading than reviews of computer-aided instruction have generally found (Kulik, 2003). Perhaps the role of assistant to the tutor, rather than a replacement for the tutor, might be a more effective application of the technology.

Other Applications of Lesson-Embedded Technology

Three additional applications of lesson-embedded technology are currently in development and are being evaluated in large-scale experiments.

Writing Wings. Writing Wings (Slavin & Madden, in press) is a creative writing program for grades 3-5 based on a writing process model (Calkins, 1983; Graves, 1983; Harris & Graham, 1996). Its major focus is cooperative learning, with students in four-member teams who help each other plan, draft, revise, edit, and “publish” compositions in many genres. The Success for All Foundation is developing embedded multimedia to accompany Writing Wings, primarily to model the cooperative learning process and metacognitive writing skills for students and teachers. Two series of videos are being produced. “The Write-On Dudes” shows a four-puppet team and their human teacher working through the writing process with narrative, factual, persuasive, business letters, newspaper articles, and other genres. Each 5-8 minute vignette models teacher instruction, and then a pair of puppets focuses on a particular writing problem. Each puppet character has his or her characteristic problem; one thinks she has nothing to say, one is excessively verbose, one is poorly organized, and one writes nothing but facts without description. The puppets work with each other to overcome their problems in many contexts, along with their offbeat teacher, Ms. Inkwell.

“The Language Mechanics” is a series of 3-5 minute vignettes in which actors humorously explain parts of speech, complete sentences, subject-verb agreement, commas, apostrophes, quotation marks, and other issues of mechanics.

Writing Wings with embedded multimedia is currently being evaluated in a randomized experiment involving 25 schools nationwide.

Reading for Knowledge. Reading for Knowledge is a program designed to teach reading of informational texts. It is an adaptation of the Success for All Reading Wings program (Slavin & Madden, in press). In it, students see live action vignettes of about 10-15 minutes that illustrate metacognitive reading strategies such as summarization, clarification, prediction, questioning, and comprehension monitoring (Pressley, 2003). For example, a group of students visiting Africa finds themselves having to write a summary of a report on leopards that an absent-minded naturalist forgot to complete. The dialogue is designed to model the thinking processes that go into writing summaries, as the students debate what to include and what to exclude and how to phrase their summary. A randomized evaluation of Reading for Knowledge is under way.

Team Alphie. Drawing on the dual coding and heightened student engagement of Alphie’s Alley, the individualized computer-assisted tutoring program, Team Alphie, adds the power of cooperative learning. In Team Alphie, struggling readers, reading at the same level, work in pairs to complete practice activities on the computer. They take turns checking each other’s accuracy, and when the pair has reached mastery, a flag goes up on their computer screen notifying the teacher that the students are ready to have their mastery verified. The computer tracks the students' progress and presents them with activities at their level of functioning.

Three to five pairs of students work together in half-hour sessions with a teacher who monitors partners working on the computer, verifies students' mastery of skills, and reteaches concepts where necessary.

Instructional Design and Evidence-Based Reform

Research on Success for All and on its recent extensions into lesson-embedded technology are examples of approaches that have potential to fundamentally change education. Other examples include comprehensive school reform models (CSRQ, 2005; Borman et al., 2003), especially those with extensive student materials, such as Direct Instruction (Adams & Engelmann, 1996). From the perspective of effective uses of technology, the concept of lesson-embedded technology appears to have potential in creating more effective instructional and tutoring environments for children. Studies of technology applications have overwhelmingly evaluated computer-assisted instruction models that supplement classroom instruction but have little role for the teacher. Although such applications have modest benefits in mathematics (Kulik, 2003; Slavin & Lake, 2006), they have few if any effects on reading (Kulik, 2003). Trailing-edge video technology appears to have particular promise for helping teachers do a more effective job in the classroom, but all sorts of technology—computers, interactive whiteboards, and so on—need to be designed into the fabric of classroom instruction, not just used to provide occasional supplements.

Success for All, lesson-embedded technology, and other forms of systematic instructional design have transformative potential because they are replicable across a broad range of circumstances. If national educational policies began to encourage schools to adopt programs with strong evidence of effectiveness, there could be an enormous demand for programs in every subject and at every grade level. More importantly, building on many developments in technology, multimedia, instruction, cognition, and comprehensive school reform, we could begin a process of R&D, evaluation, and dissemination of effective programs that could create a dynamic for progress in education capable of progressively solving its longstanding problems. The remainder of this chapter discusses some ideas about how instructional designs of the future might creatively unite many technologies and pedagogies to increase student achievement.

The Teaching and Learning Orchestra

In the classroom of the future, teachers might play a role like that of the conductor of an orchestra (except that they would also be virtuoso performers), calling on a variety of human and technology “instruments” to accomplish lesson objectives. Computers, multimedia, and other technology might be infused in the lesson structure at points where their strengths add instructional value, but the teacher would teach the main lesson and lead the instructional sequence. Cooperative learning groups, or pairs of children, would also take a major role in each lesson, in helping provide each other effective practice, one-to-one feedback, elaborated explanations, and motivation. The teacher/conductor would call on each of these “instruments,” be they technology or human, to accomplish tasks for which each is best suited.

Imagine, for example, classrooms in which all children have wireless keypads linked to a computer on the teacher's desk, and a large video screen is available at all times. Students could be seated in small teams that receive recognition based on the learning of all team members. Multimedia content would be readily available to help the teacher explain or model content, skills, and processes.

In any didactic lesson in any subject, there is a set of functions that must be fulfilled (see, for example, Slavin, 2006):

- Orient students to lesson
- Present conceptual overview
- Solidify understanding
- Ask questions for clarification and initial assessment
- Provide opportunities for practice
- Assess understanding
- Re-teach if necessary
- Re-assess if necessary
- Provide feedback to students on progress

Embedded technology could play a role at each stage in the lesson. The teacher/conductor has an entire orchestra of human and technological instruments to convey the lesson content and ensure that all students master it, with each instrument used where it is the optimal solution to a particular lesson function, as illustrated in the following examples.

1. Orient students to lesson: Teacher. Teachers have the relationships with students, and may be best suited to explaining why a given lesson is important, exciting, and worth learning.
2. Present conceptual overview: Video. For many lesson objectives, video could be the ideal medium for initial explanation. Well-designed video can present compelling images, graphics, skits, demonstrations, and so on, not to teach the lesson but to kick it off in the right direction, using paired visual and auditory content that is likely to be comprehensible, memorable, and motivating.
3. Solidify understanding, ask initial questions: Teacher, teams. After a well-designed, lesson-embedded video begins a lesson, the teacher might review the key ideas and begin to ask questions of students. Rather than only calling on selected volunteers, teachers might pose questions, including questions pre-loaded on the computer and shown on the video screen, that students answer on their keypads. The teacher would immediately see a color-coded graphic that summarizes the percent of students that have the right idea, and might indicate common errors. Immediately, in the flow of the lesson, the teacher could use this information to decide to reteach a difficult concept or to skip forward if the content appears too easy. The computer could give advice on this strategy, but the teacher would make the pacing decision.

   Frequently, the teacher might ask students to discuss answers within their teams, using a procedure called "Think-Pair-Share," in which students work in pairs to discuss a question and then the teacher calls on students at random to represent their pairs. Alternatively, teachers could use "numbered heads together" (Kagan, 2001), in which students practice together to prepare all team members on a given concept, and then one student is chosen at random to respond for the group. This ensures that students focus their time working with teammates on explaining ideas to each other, rather than just giving answers (see Webb & Palincsar, 1996).

4. Provide opportunities for practice: Teams. After the lesson has been presented, students need an opportunity to master the lesson's content. Cooperative teams are the right format for this lesson function. Four-member teams might be given electronic or paper worksheets to practice with. Their goal is to ensure that every team member can answer similar questions independently, so they have to work with each other to explain lesson content and to asses each other's understanding. Teams receive recognition (e.g., certificates) based on their success, as measured by the sum of independent assessment that follows teamwork. Team members may also receive a small bonus on their grades if their teams do well.
5. Assess understanding: Computer. Questions pre-loaded on the computer might assess students' mastery of the lesson objective. Students use their keypads to take brief quizzes. At this point, team members may not help one another. Immediately, the teacher knows whether or not the class has reached a sufficient level of mastery, and either moves on to the next

lesson, reteaches to the whole class, or identifies a subgroup that will need additional assistance.

In reteaching, the entire cycle may be repeated, beginning with the video content, or video material specifically for reteaching may be available, or the teacher may informally reteach.

For situations in which a subgroup needs additional help, computerized remedial units may be designed targeted to the specific objective, to be used individually, in small groups with a teacher, or individually with a tutor, as appropriate to the content and resources.

Beyond the lesson itself, computers would be used to help teachers prepare for each lesson. A general structure, graphics, videos, PowerPoints, practice items, and assessments would all be pre-loaded on the computer for a given lesson, but could be supplemented or modified by the teacher in advance or skipped over or reviewed in the course of lesson presentation. Preparation materials might include explanations of key lesson objectives or pedagogical principles, as well as videos of expert teachers teaching key parts of the lesson or of other demonstrations to help with difficult issues likely to come up, as exist in the Alphie's Alley computer-assisted tutoring software (Chambers et al., 2006).

The Teaching and Learning Orchestra lesson structure would obviously be different for less didactic lessons, as in the teaching of creative writing or non-routine problem solving in mathematics, and the length of the lessons may be quite different depending on whether the content lends itself to many brief lessons or a smaller number of lengthy ones. Further, there may be many ways different from these to integrate teachers, cooperative teams, video, computers, and other technology to best effect. However, the point is that there appears to be much to gain from integrated lesson design, using the best of the entire orchestra of possibilities a teacher might have available to teach each lesson.

Conclusion

The best hope for significant and lasting changes in education is the implementation of policies that favor the use of programs with strong evidence of effectiveness, and the development of programs of research and development capable of designing, rigorously evaluating, and disseminating proven programs. Once this evidence-based reform dynamic takes hold, educational programs and material will constantly be improved and student outcomes will improve, just as progressive change in medicine, agriculture, and technology constantly makes old solutions obsolete and improves outcomes for all of society.

This chapter describes a program of R&D that serves as one example of evidence-based reform, beginning with the Success for All comprehensive school reform model and continuing with embedded multimedia, computer-assisted tutoring, and other lesson-embedded technology. It outlines a vision for the lesson of the future, in which the teacher serves as the conductor of an “orchestra” of human and technological “instruments”: His or her own instruction, cooperative learning teams, embedded multimedia, computerized lesson elements, on-the-spot assessments, and so on. There is an enormous amount of work to be done to capture the potential of technology and skilled teachers working together to enhance achievement, but the evidence and experience we have to date suggests that this is an avenue that could lead to major improvements in the practice of education for all students.

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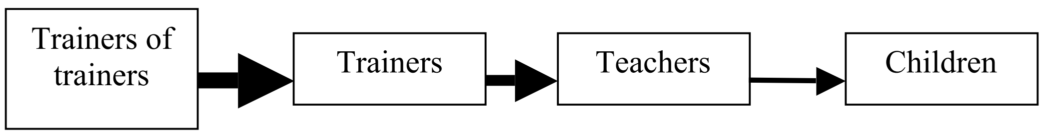
Figure 1 – Embedded Multimedia Professional Development

Traditional Professional Development



Embedded Multimedia Professional Development