Integrated or interdisciplinary curriculum—the terms are used interchangeably in this collection, though there are various distinctions made by others within the field—has enjoyed renewed attention in recent years. Many fine small schools have worked hard to develop an integrated curriculum that is contextualized for their students, their community, and their school, district, or state standards. Small school staff are drawn to integrated curriculum because they believe it both reflects real-world experience more accurately and better fits newer understandings about how people learn best.

Integration is around us everywhere in society and in nature. Most contemporary jobs require the integration of a range of skills. In today’s workforce, we are given a problem and asked to solve it, often with guidance but infrequently with direct instruction. The “test” is whether or not the problem gets solved. In traditional schools students are given a set of facts, asked to memorize them, but then are not given the opportunity to apply them in a way that is applicable to life outside of the school. Disconnection breeds apathy while integration thrives on connections. Integrated learning more accurately approximates the lives of human beings when they are not in schools.

What sometimes comes to mind when teachers think of integrated curriculum is two teachers combining their classes and teaching their subject-specific material in the same room at the same time. Although team teaching is an effective way to familiarize oneself with the work of a colleague and to begin helping students make connections between subjects, it is only a beginning to the integration process. A fully integrated curriculum combines disciplines in a synergistic manner that makes the knowledge of one subject inseparable from that of another subject, with division occurring only in the teaching of sophisticated content or vocabulary.

Disciplines—the “subjects” we teach—are artificial constructs that serve effectively as organizers and reservoirs of human knowledge. Most people, however, learn in quite different ways. Three key understandings seem critical here:

- We learn by connecting new information to familiar information, which is almost always organized idiosyncratically by individuals, not neatly in a discipline.
- For almost everyone, learning is social—it requires watching and interacting with others—before it is individual.
- Relevance is critical for most learners—that is, we need to see something useful in new information before we expend the energy to integrate new information with existing knowledge.

Integrated curriculum—because it is frequently presented in the form of thematic approaches, often requires project-based learning and flexible student groupings, and usually highlights relationships between and among important concepts that cross disciplinary lines—can serve as a powerful aspect of a school’s approach to learning.

Schools that have had little exposure to integrated curriculum have much to gain. By mapping out the current curriculum and sharing with one another, revelations are likely to occur. Overlap of materials will be found, gaps in content will become clear, and opportunities for cross-disciplinary work will become apparent. Once teachers are aware of one another’s work, and the science curriculum is no longer a mystery to the English teacher, the space for integrated teaching and learning is created.
This section is divided into three parts: Why Integrate, How to Integrate, and What Integration Looks Like. Why Integrate focuses on the history of integration, different models of integration, and what practitioners in the field have to say about integration. How to Integrate takes the reader step-by-step through the planning of an integrated curriculum, from four of the leading voices in curriculum integration. What Integration Looks Like is a sampling of integrated projects from schools across the country that have effectively utilized integrated teaching.
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Integration of the Disciplines: Ten Methodologies for Integration

Dr. Mark L. Merickel
Oregon State University
http://oregonstate.edu/instruction/ed555/zone3/tenways.htm

Adapted from Integrating Curricula with Multiple Intelligences: Teams, Themes, and Threads, By Robin Fogarty and Judy Stoehr (1995)

This resource is based on the work of Robin Fogarty and Judy Stoehr from their book, Integrating Curricula with Multiple Intelligences: Teams, Themes, and Threads. Dr. Merickel’s expansion on their work gives detailed descriptions of the ten models and helps the reader visualize the difference between the methodologies.

Fogarty and Stoehr’s ten views for integrating curriculum are the most frequently used planning models in the field. The ten views define different types of integration examples and various configurations for designing integrated curriculum. As a teacher, a teaching team, or a whole staff, the models are a means of assessing current practice, mapping out a course of action for future integration, and evaluating a new integrated class or unit.

Form One: Within a Single Discipline

**Fragmented**

The fragmented methodology is a traditional curriculum design which separates topics and courses into distinct disciplines. In this model courses are separated into traditional areas of study: mathematics, science, humanities, social studies, art, technical arts, etc. Each area is defined as an independent course of study. At the middle, secondary and post-secondary levels these courses are generally taught by different teachers, in different locations or rooms, and students commonly move from classroom to classroom.

Despite the fragmentation of this methodology, integration can begin by listing and ranking topics, concepts, and skills to systematically organize curricular priorities within each subject.

**Connected**

A connected methodology focuses on the details, subtleties, and interconnections within an individual discipline. It is this focus on making connections...
INTEGRATING CURRICULUM: Why Integrate

(i.e., one topic to another, one skill to another, or one concept to another) which makes this methodology a simple form of integration. To make this an effective integration methodology, it is recommended that the instructor assist students with connecting one day's work, or a semester's work and ideas, to the next.

It is important to the concept of integration that this methodology directly relates ideas within a discipline. Teachers help students make connections by explicitly making linkages between subject topics, skills, and concepts.

Nested

Nested integration takes advantage of natural combinations. Integration is performed by overtly making connections or creating combinations. This could be accomplished in a lesson on the circulatory system by having the lesson focus on both the circulatory system and the concept of systems.

Form Two: Across the Disciplines

Sequenced Model

Topics and units are taught independently, but they are arranged and sequenced to provide a framework for related concepts.

Teachers arrange topics so that similar units articulate. For example, a graphing unit can coincide with data collection in a weather unit. In higher education, the teacher could plan units so that students can study the stock market in a math class at the same time that these same students are studying the Depression in their history class.

In order for this type of integration to take place, it is often necessary that the teachers in both classes plan the sequence of their units so that they will be synchronized. This may mean that the teachers will need to change the sequence of topics contained in the courses textbooks.

"The textbook is not a moral contract that teachers are obliged to teach...teachers are obliged to teach [students]."

- John Adams
INTEGRATING CURRICULUM: Why Integrate

Shared

The shared model brings two distinct disciplines together into a single focus. The shared methodology overlaps concepts as the organizer.

In this shared approach to integration it is necessary that the teachers of the two disciplines plan their teaching, which will take place in the individual classes together.

The two members of this "partnership" (possibly cross-departmental) plan the unit of study by focusing on common topics, concepts and skills. As the "team" identifies these commonalities, they identify overlaps in content.

The partners should examine what concepts and skills the topics and unit(s) have in common.

Webbed

Webbed curricula commonly use a thematic approach to integrate subject matter. Broad themes such as change, cultures, discovery, environments, interaction, inventions, power, systems, time and work provide a greater opportunity for teachers of various disciplines to find common topics, concepts and skills.

Themes may be created which address different concentrations. Three of these are concepts, topics and categories. A few examples include:

Concentrations for Integration

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Topics</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>Community</td>
<td>Adventure</td>
</tr>
<tr>
<td>Culture</td>
<td>Partnerships</td>
<td>Biographies</td>
</tr>
<tr>
<td>Discovery</td>
<td>Relationships</td>
<td>Medieval Times</td>
</tr>
<tr>
<td>Freedom</td>
<td>Society</td>
<td>Science Fiction</td>
</tr>
</tbody>
</table>

Webbing:

Webbing is a systematic process for recording brainstorming. The process involves all the members of the integrated team, and is used to determine the topics, concepts and skills to be addressed in the curriculum.
INTEGRATING CURRICULUM: Why Integrate

The illustration shown below is a simple example of a web for the theme:

CHANGE

Brainstorming:

There are many procedures for brainstorming and recording the process. No matter which process is used, there are a few guidelines which make brainstorming more effective.

- Generate as many ideas as possible.
- Accept all ideas.
- Seek clarification, if necessary, but do not edit at this stage.
- Encourage people to brainstorm on their own before contributing to a common pool of ideas.
- Remember that brainstorming is an open-ended exercise. At any time, new ideas or directions may be introduced.
- Do not close down the process too soon. Provide ample thinking time.

Threaded

The threaded approach to integration is a metacurricular approach where big ideas are enlarged. This methodology threads thinking skills, social skills, study skills, graphic organizers, technology, and multiple intelligences (see Howard Gardner) approach to thinking throughout all disciplines.

The threaded approach supersedes all subject matter content. Using this approach, interdepartmental teams can focus on thinking skills to integrate with content information.

The threaded approach takes learning to a synthesis level. That is, teachers incorporate into their teaching strategies such techniques as inquiry and self-
reflection. For example, a teacher may ask the student: what do you think about that? Or, what thinking skills did you use and find most helpful in solving the problem?

**Integrated**

In an integrated methodology interdisciplinary topics are arranged around overlapping concepts and emergent patterns. This process blends the disciplines by finding overlapping skills, concepts, and attitudes found across the disciplines.

Much like the shared methodology, integration is a result of shifting related ideas out of the subject matter content. An important process of the integrated methodology is that teachers work together on the topics or themes as commonalities emerge.

**Form Three: Within and Across Learners**

**Immersed**

The immersed methodology focuses all curricular content on interest and expertise. With this methodology, integration takes place within the learners, with little or no outside intervention.

For example, students such as doctoral candidates are generally immersed in a field of study. These students integrate all information and data to answer a question or interest or solve a problem. This immersed study is often undertaken in a field of intense interest or passion.

Similarly, a young child will immerse themselves in drawing pictures or writing stories about subjects which they are extremely interested. This is normal behavior which is often viewed by teachers as obsessive and therefore diverted.

Just as most artists and writers have a passion for their field, immersed learners continually make connections between their chosen topic of interest and subjects. Immersion takes advantage of this intense interest and allows students to make these connections and self-direct their learning based on those interests.

**Networked**

A networked methodology creates multiple dimensions and directions of focus. Like brainstorming, it provides various ideas and ways of discovering.
The networked methodology is totally student centered. It professes that only the learner can direct the integration process. The methodology proposes that the learner knows their topic and can self-direct their focus on the necessary resources both within and across subject areas.

Networks are created between the learner and various information systems, subject matter experts, and others who have an interest, experience or knowledge of the topic or theme.

“Only in education, never in the life of the farmer, sailor, merchant, physician, or laboratory experimenter, does knowledge mean primarily a store of information aloof from doing.”

- John Dewey
“The integrated curriculum is a great gift to experienced teachers. It's like getting a new pair of lenses that make teaching a lot more exciting and help us look forward into the next century. It is helping students take control of their own learning.”

- M. Markus, media specialist, quoted in Shoemaker, September 1991, p. 797

“I'm learning more in this course, and I'm doing better than I used to do when social studies and English were taught separately.”

- Student, quoted in Oster 1993, p. 28

This teacher and student express an increasingly widespread enthusiasm for curriculum integration. While not necessarily a new way of looking at teaching, curriculum integration has received a great deal of attention in educational settings. Based both in research and teachers' own anecdotal records of success, educational journals are reporting many examples of teachers who link subject areas and provide meaningful learning experiences that develop skills and knowledge, while leading to an understanding of conceptual relationships.

Definitions

Integrated curriculum, interdisciplinary teaching, thematic teaching, synergistic teaching... When attempting to define integrated curriculum, it is also necessary to look at related terms. Several definitions are offered here. As this paper is narrowed to K-12 integrated curriculum, definitions from vocational and higher education are not included, although there is a growing interest in both of those areas in the interdisciplinary, integrated curriculum. The reader interested in specifics about interdisciplinary work in those fields is invited to consult the General References at the end of this report.

A basic definition is offered by Humphreys (Humphreys, Post, and Ellis 1981) when he states, "An integrated study is one in which children broadly explore knowledge in various subjects related to certain aspects of their environment" (p. 11). He sees links among the humanities, communication arts, natural sciences, mathematics, social studies, music, and art. Skills and
INTEGRATING CURRICULUM: Why Integrate

knowledge are developed and applied in more than one area of study. In keeping with this thematic definition, Shoemaker defines an integrated curriculum as

...education that is organized in such a way that it cuts across subject-matter lines, bringing together various aspects of the curriculum into meaningful association to focus upon broad areas of study. It views learning and teaching in a holistic way and reflects the real world, which is interactive. (1989, p. 5)

Within this framework there are varied levels of integration, as illustrated by Palmer (1991, p. 59), who describes the following practices:

- Developing cross-curriculum sub-objectives within a given curriculum guide
- Developing model lessons that include cross-curricular activities and assessments
- Developing enrichment or enhancement activities with a cross-curricular focus including suggestions for cross-curricular "contacts" following each objective
- Developing assessment activities that are cross-curricular in nature
- Including sample planning wheels in all curriculum guides.

Dressel's definition goes beyond the linking of subject areas to the creation of new models for understanding the world:

In the integrative curriculum, the planned learning experiences not only provide the learners with a unified view of commonly held knowledge (by learning the models, systems, and structures of the culture) but also motivate and develop learners' power to perceive new relationships and thus to create new models, systems, and structures. (1958, pp. 3-25)

Another term that is often used synonymously with integrated curriculum is interdisciplinary curriculum. Interdisciplinary curriculum is defined in the Dictionary of Education as "a curriculum organization which cuts across subject-matter lines to focus upon comprehensive life problems or broad based areas of study that brings together the various segments of the curriculum into meaningful association" (Good 1973). The similarity between this definition and those of integrated curriculum is clear. Jacobs defines interdisciplinary as "a knowledge view and curricular approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (1989, p. 8). This view is supported by Everett, who defines interdisciplinary curriculum as one that "combines several school subjects into one active project since that is how children encounter subjects in the real world-combined in one activity."

These definitions support the view that integrated curriculum is an educational approach that prepares children for lifelong learning. There is a strong belief among those who support curriculum integration that schools must look at education as a process for developing abilities required by life in
the twenty-first century, rather than discrete, departmentalized subject matter. In general, all of the definitions of integrated curriculum or interdisciplinary curriculum include:

- A combination of subjects
- An emphasis on projects
- Sources that go beyond textbooks
- Relationships among concepts
- Thematic units as organizing principles
- Flexible schedules
- Flexible student groupings.

Several authors have gone beyond a single definition of curriculum integration to a continuum of integration. Fogarty has described ten levels of curricula integration (1991). The following chart summarizes some of her work. The reader who is interested in a more complete explanation is referred to Fogarty’s book, *The Mindful School*.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmented</td>
<td>Separate and distinct disciplines</td>
<td>Clear and discrete view of disciplines</td>
<td>Connections are not made clear for students, less transfer of learning</td>
</tr>
<tr>
<td>Connected</td>
<td>Topics within a discipline are connected</td>
<td>Key concepts are connected, leading to the review, reinforcement, utilization and assimilation of ideas within a discipline</td>
<td>Disciplines are not related, content flows remain within the discipline</td>
</tr>
<tr>
<td>Blended</td>
<td>Social, finishing, and content skills are targeted within a subject area</td>
<td>Close attention to several areas at once, leading to enriched and enhanced learning</td>
<td>Students may be confused and lose sight of the main concepts of the activity or lesson</td>
</tr>
<tr>
<td>Sequenced</td>
<td>Similarities are taught in context, although subjects are separate</td>
<td>Facilitates transfer of learning across content area</td>
<td>Requires ongoing collaboration and flexibility, as teachers have to ensure that thematic connections are maintained throughout</td>
</tr>
<tr>
<td>Shared</td>
<td>Team planning involves teaching that involves two disciplines; focus on shared concepts, skills or attitudes</td>
<td>Shared instructional experiences; with two teachers on a team it is less difficult to collaborate</td>
<td>Requires time, flexibility, communication, and compromise</td>
</tr>
<tr>
<td>Webbed</td>
<td>Thematic teaching, using a theme as a base for instruction in many disciplines</td>
<td>Motivating for students, helps students see connections between ideas</td>
<td>Theme may be carefully and thoughtfully selected to be meaningful, with relevant and rigorous content</td>
</tr>
<tr>
<td>Threaded</td>
<td>Thinking skills, social skills, multiple intelligences, and study skills are “threaded” throughout the disciplines</td>
<td>Students learn how they are learning, facilitating future transfers of learning</td>
<td>Discipline remains separate</td>
</tr>
<tr>
<td>Integrated</td>
<td>Principles that overlap multiple disciplines are organized for common skills, concepts, and attitudes</td>
<td>Encourages students to see interconnections and articulations among disciplines, students are motivated as they see these connections</td>
<td>Requires interdisciplinary teams with common planning and building teams</td>
</tr>
<tr>
<td>Immersed</td>
<td>Learner integrates by seeing all learning through the perspective of one area of interest</td>
<td>Integration takes place within the learner</td>
<td>May reverse the flows of the learner</td>
</tr>
<tr>
<td>Hyperlinked</td>
<td>Learning directs the integration process through selection of a network of inputs and resources</td>
<td>Pro-active, with learners stimulated by new information, skills or concepts</td>
<td>Learning can be equal too thin, efforts become ineffective</td>
</tr>
</tbody>
</table>
INTEGRATING CURRICULUM: Why Integrate

This work has been supported by others involved with the implementation of curriculum integration (Jacobs 1989; Shoemaker 1989). These differentiations may move from two teachers teaching the same topic but in their own separate classes (e.g., both English and history teachers teaching about the same period of history), to team design of thematic units, to interdisciplinary courses or thematic units, to a fully integrated curriculum, which is also referred to as synergistic teaching. Bonds, Cox, and Gantt-Bonds (1993) write:

Synergistic teaching goes beyond the blurring of subject area lines to a process of teaching whereby all the school subjects are related and taught in such a manner that they are almost inseparable. What is learned and applied in one area of the curriculum is related and used to reinforce, provide repetition, and expand the knowledge and skills learned in other curriculum areas. This process of synergistic teaching allows the student to quickly perceive the relationships between learning in all curriculum areas and its application throughout each of the school subjects.... Synergistic teaching does more than integrate; it presents content and skills in such a manner that nearly all learning takes on new dimensions, meaning, and relevance because a connection is discerned between skills and content that transcends curriculum lines. In a synergistic classroom, simultaneous teaching of concepts and skills without regard to curriculum areas would have a greater effect that the sum of learning skills and concepts in individual subject areas.

Background

It is taken for granted, apparently, that in time students will see for themselves how things fit together. Unfortunately, the reality of the situation is that they tend to learn what we teach. If we teach connectedness and integration, they learn that. If we teach separation and discontinuity, that is what they learn. To suppose otherwise would be incongruous. (Humphreys 1981, p. xi).

The subject of curriculum integration has been under discussion off and on for the last half-century, with a resurgence occurring over the past decade. The "explosion" of knowledge, the increase of state mandates related to myriad issues, fragmented teaching schedules, concerns about curriculum relevancy, and a lack of connections and relationships among disciplines have all been cited as reasons for a move towards an integrated curriculum (Jacobs 1989). Almost every teacher has experienced the feeling that "there just isn't enough time to get it all in" or "the school day just isn't long enough for all that I'm supposed to do; it seems that every year there are more things added to the curriculum." This feeling of frustration is one of the motivations behind development of an integrated curriculum. Teachers see this as part of the solution to the requirements that pull teachers in different ways.

These forces in contemporary schools are reinforced by Benjamin (1989, pp. 8-16), when he cites the trends towards global interdependence and the interconnectedness of complex systems, the increase in pace and complexity of the twenty-first century, the expanding body of knowledge, and the need
INTEGRATING CURRICULUM: Why Integrate

for workers to have the ability to draw from many fields and solve problems that involve interrelated factors.

Each of these trends is relevant to the discussion of integrated curriculum, as schools move away from teaching isolated facts toward a more constructivist view of learning, which values in-depth knowledge of subjects. This view finds its basis in the work of Piaget, Dewey, Bruner, and others who hold a holistic view of learning. Each of these theorists is concerned with children having an understanding of concepts and underlying structures. Proponents of the progressive education movement of the 1930s advocated an integrated curriculum, sometimes identified as the "core curriculum" (Vars 1987). The movement towards integrated curriculum is a move away from memorization and recitation of isolated facts and figures to more meaningful concepts and the connections between concepts. The twenty-first century requirement for a flexible use of knowledge goes beyond a superficial understanding of multiple isolated events to insights developed by learning that is connected or integrated. Perkins advocates teaching for transfer and thoughtful learning when he states:

A concern with connecting things up, with integrating ideas, within and across subject matters, and with elements of out-of-school life, inherently is a concern with understanding in a broader and a deeper sense. Accordingly there is a natural alliance between those making a special effort to teach for understanding and those making a special effort toward integrative education (1991, p.7).

This view supports the notion of curriculum integration as a way of making education more meaningful. Concerns about national achievement levels and high dropout rates have put the spotlight on any educational change that can lead to increased student success. In addition to the realization that curriculum integration may be an effective element in making education both manageable and relevant, there is a body of research related to how children learn that supports curriculum integration. Cromwell (1989) looks at how the brain processes and organizes information. The brain organizes new knowledge on the basis of previous experiences and the meaning that has developed from those experiences. The brain processes many things at the same time, and holistic experiences are recalled quickly and easily. "The human brain," writes Shoemaker, "actively seeks patterns and searches for meaning through these patterns" (p. 13).

This research is supported by Caine and Caine (1991) when they connect neuro-psychology and educational methodologies and state that the search for meaning and patterns is a basic process in the human brain. In fact, the brain may resist learning fragmented facts that are presented in isolation. Learning is believed to occur faster and more thoroughly when it is presented in meaningful contexts, with an experiential component. Of course, every brain-every student-is unique. While the search for patterns and context may be universal, every learner will have his/her own learning style. To meet these diverse needs means providing choices for students.
Put to use in the classroom, the brain research points toward interdisciplinary learning, thematic teaching, experiential education, and teaching that is responsive to student learning styles. These findings are summarized by Shoemaker (1991, pp. 793-797).

The current movement toward an integrated curriculum, then, has its basis in learning theorists who advocate a constructivist view of learning. There is a body of brain research that supports the notion that learning is best accomplished when information is presented in meaningful, connected patterns. This includes interdisciplinary studies that link multiple curricular areas. There are many examples in the literature of such efforts by K-12 teachers, as well as those teachers involved in vocational education and higher education.

Another rationale for curriculum integration finds its basis in the commonsense wisdom of teachers, who are coping with an increased body of knowledge, large classes, and many mandates related to everything from drug awareness to AIDS to bus safety. When all of these requirements are added to the traditional body of knowledge for which teachers feel responsible, integration is seen as one way to meet both the needs of the students and the requirements of the state. The integration of curricular areas and concepts allows teachers to assist students as they prepare for the next century.

Finally, the movement toward a global economy and international connections, as well as the rapid changes in technology, are pushing education toward integration. The ability to make connections, to solve problems by looking at multiple perspectives, and to incorporate information from different fields, will be an essential ingredient for success in the future.

An enduring argument for integration is that it represents a way to avoid the fragmented and irrelevant acquisition of isolated facts, transforming knowledge into personally useful tools for learning new information (Lipson, et al. 1993, p. 252).

Key References


INTEGRATING CURRICULUM: Why Integrate


Edgerton, R. *Survey Feedback from Secondary School Teachers that are Finishing their First Year Teaching from an Integrated Mathematics Curriculum*. Washington, DC, 1990. (ED 328 419)


INTEGRATING CURRICULUM: Why Integrate


Ten Reasons to Teach an Integrated Curriculum

10. Unless you have 50 hours a day to teach, you'll never get it all in.

9. An integrated curriculum allows science and social studies to frame your reading, writing, and math.

8. The brain thrives on connections.

7. Life is not divided into neat little blocks of time called science, math, reading, writing, social studies, and recess.

6. Problem solving skills soar when all of our knowledge and higher level thinking from all curriculum areas are tapped.

5. Real literature in real books provides an authentic diving board into learning all subjects. Award-winning literature provides models for problem solving, peer relationships, character development, and skill building as students are captivated by exciting adventures with realistic characters who go through problems very much like their own or problems (like war) from which they will learn historical truths.

4. School's got it backwards! In real life you are tested with a problem and then must scramble for answers, but in traditional school you are given the answers and asked to... regurgitate them.

3. Group interaction and team building inherent in an integrated curriculum depend on using various strengths and skills to create bridges to understanding.

2. Your standardized test scores will hit the top! By inspiring students to think, to love learning, and to put their learning to work in authentic ways, your kids will be equipped for whatever curves they might be thrown...on standardized tests and in life!

1. Students LOVE an integrated curriculum and thrive on its challenges!

- The Little Red Schoolhouse, 2002
Integrated Curriculum:
A Driving Force in 21st-Century Mathematics Education
Judy Spicer
http://www.enc.org/

Judy Spicer has written a succinct study on integrated mathematics that covers the history of integrated mathematics, the controversy surrounding it, the testimony to its effectiveness, its challenges, and the outcome on student learning and teacher satisfaction. Often, the lines dividing the segments of the high school mathematics curriculum (algebra, geometry, calculus, etc.) are just as static as those between history and science, or English and art. The work of Judy Spicer, and others, is about blurring those lines to create a holistic model for mathematics education.

An integrated high school mathematics curriculum offers an approach to teaching and learning that is vastly different from the compartmentalized mathematics curriculum (arithmetic, algebra, geometry, more algebra, and pre-calculus/calculus) commonly found in U.S. classrooms. The idea is not new. Major national education groups have issued reports--from the 1893 Committee of Ten Report to NCTM's April 2000 Principles and Standards for School Mathematics (PSSM)--that have encouraged greater integration of these subjects. Textbooks that integrate mathematics have been around since the 1920s (NCTM Yearbook, 2000, p. 2). Support for an integrated curriculum is strong among leaders in mathematics education.

The controversy comes not from theory but from practice. The arguments began in the late 1980s and early 1990s, when the National Science Foundation (NSF) funded several major projects to provide models for integrated mathematics curricula. Implementation of these integrated curricula raised objections from those to whom the traditional curriculum was sacrosanct. Disagreement about the integrated curriculum became interwoven with other controversial issues such as cooperative learning, the use of technology, alternative assessments, and the teacher-as-a-guide model of teaching. Thus, the integrated curricula became a focus point of what came to be known as the math wars.

Many critics of integrated mathematics point out that few teachers are prepared to handle that kind of curriculum. Teachers who lack a deep knowledge of the mathematics content may struggle and as a result are accused of teaching fuzzy mathematics. Lack of teacher preparation is the principal reason many school districts hesitate to adopt an integrated mathematics program (Dialogues, 2001).

Nevertheless, calls to the publishers of five NSF-funded integrated curricula listed on the COMPASS (Curricular Options in Mathematics for All Secondary Students) web site (www.ithaca.edu/compass/frames.htm) revealed that these programs were used in more than 1,200 schools in at least 39 states during the 2000-2001 school year. Clearly, teachers all over the
United States have responded positively to the challenge of teaching an integrated high school mathematics curriculum. They firmly believe in the benefits of showing students that mathematics is an integrated whole and how mathematics relates to the world beyond the classroom. In researching this article, I corresponded with eight teachers who are finding success with NSF-funded and publisher-developed integrated mathematics curricula. Their enthusiasm contradicts today's embattled math-wars environment.

Re-energized Teachers

A veteran of 35 years of teaching, Rosalie Griffin reports that during the last 10 years she has been re-energized and inspired by a dynamic integrated curriculum that provides challenges for all students. Griffin notes, "The changes that occurred from using this curriculum were beyond our expectations. Not only did student grades improve, but we also received feedback from students that they finally understood math and could see how it was used in real life."

The curriculum Griffin uses begins each unit with a real-world word problem that "really engages students and makes math relevant to daily life. The use of the graphing calculator made math come alive and provided the power of visualization of what had previously been presented as a system of symbols that were abstract and meaningless to students."

She continues, "The thematic threads that weave through the curriculum push students to look for patterns, make conjectures, and validate findings. This process enables students to develop higher-level reasoning skills and to become critical thinkers."

Barbara MacDonald, mathematics department chair with 27 years of experience, enjoys the student engagement: "Use of real life data allows for interesting discussions. An integrated curriculum also causes our students to think more. The hands-on activities make it more difficult for students to just sit."

In only the second year using the integrated program, Jim Kearns, department head for math, science, and technology at his high school, is enthusiastic, "Students who didn't have an understanding of what slope was in the old curriculum are now describing angle measure by the slope. They are making connections that I thought were beyond them."

The Challenges

Change is difficult for everyone involved--students, parents, and teachers. Yet, even as the teachers recognize the challenges, their focus is on the benefits.

For students, sometimes those who are most successful with traditional mathematics programs face the greatest challenges with the new. Sandie Gilliam, National Board Certified Teacher and winner of the Presidential
INTEGRATING CURRICULUM: Why Integrate

Award for Excellence in Mathematics Teaching, explains: "What I find is that for the students who have previously learned (or so they think) to follow the teacher's directions, do 20 practice problems, and memorize for the test, doing the integrated program actually is harder for them. Instead of thinking deeply into the mathematics to conceptually understand what mathematically is happening, they feel that the mimicking approach is actually easier. An integrated program is the best for all students, just like eating vegetables is very healthy for humans. Many humans hate vegetables and neglect eating them. In the end, it is their body's health that suffers."

Jim Kearns admits, "The students have had a difficult time transitioning to the new curriculum series since they were used to memorizing simple procedures, doing multiple practice problems, and taking tests and quizzes on a small selection of topics."

Sometimes parents resist the change, notes Helen Crowley. "This curriculum doesn't look like 'real math' (i.e., the algebra we used to memorize when we were in school) to parents. It is difficult for many parents to help their children because they can't find problems in the book that show them how to do the problems we assign. Also, some tutors find it difficult to tutor students because they have not been exposed to this type of curriculum before."

Gaby McMillian, a teacher with 10 years experience, describes the challenges faced by teachers, "Pretty much everything had to change. We had to change our role in the classroom from in-front lecturer to classroom facilitator. We had to learn to incorporate technology, specifically the graphing calculator. We had to manage groups, lead whole-class discussions, change our questioning techniques, change our ideas about assessment, change our ideas about how students learn, change our expectations of their capabilities--and work harder!"

Helen Crowley says, "The real challenge to teaching this way is that you must be very familiar with the material and willing to risk having students take you in a direction other than the one you had planned for the lesson. This is also the most exciting part of using the curriculum because we are really doing math more often, as opposed to pushing around numbers and variables."

"Our teachers needed to learn more mathematics," says Barbara MacDonald. "We needed to work together to explore different topics. The integrated curriculum forced teachers who taught predominately algebra or geometry to combine skills. Yes, it takes more work to make the transition, and yes, I am sure some teachers would like to return to a traditional program. However, in working through the challenges, our teachers have become a more cohesive staff with common goals."

The Payoff

Despite the challenges of making the change, the teachers feel that the integrated curricula are making it possible for them to meet two tightly..."
INTEGRATING CURRICULUM: Why Integrate

intertwined goals--helping all students achieve mathematics success and demonstrating that success on high-stakes assessments.

Sandie Gilliam comments, "For the gifted students, who by nature may want to know why things are happening and how formulas or equations develop, this program enables them to get deeper into the mathematics than they would in a traditional program. For the lower-level students who need a hands-on approach and real-life problems in mathematics to work with, this program best serves their needs."

Mathematics department chair at the University of Illinois Laboratory High School, Craig Russell reports, "I see an important benefit to those strong math students who are committed to lots of non-math activities (music, sports, hobbies) and who tend to race through homework assignments. The integrated curriculum makes those students slow down and think about the problem setting and actually problem solve (the way adults solve problems) by trying to decide which tools to use."

Gaby McMillian says, "Right now we are seeing a huge increase in the number of students who opt for the pre-AP course and in the number enrolling in upper-level classes. We have gone from only seven students in AP Calculus to 32, and from 19 students in AP Statistics to 99 for the 2001-02 school year."

McMillian goes on, "All our test scores have gone up. We are seeing much better understanding of math concepts, as well as retention. Reading is better. 'Word problems' are so much a part of what students do daily that there is no struggle against them."

Pat McCarthy, a teacher with 12 years experience, observes, "Because scores for our general math population were low, we were looking to provide a curriculum to help boost scores at that level. These students are now taking four years of math. We had a couple of these students take the SAT this year-that never happened when we had just general math."

"As we analyzed the 1998 and 1999 results of our state tests, we noticed that we had a population of students who failed," says Jim Kearns. "These were the students who entered high school without completing algebra in grade eight. For both of these exams, 100 percent of these students failed. We felt that the traditional approach was not working. After we instituted our integrated curriculum, these same students found the state test reasonable. Just to have that feeling of confidence in their math ability is a change from the notion that they cannot do mathematics."

Rosalie Griffin describes the situation in her inner-city high school: "When I was named math department chair in 1990, one of my major concerns was to address the high failure rate of 'lower-level' students enrolled in our two-year Algebra I course. If a change in curriculum could make a difference, this group would surely be the test. My inner-city school has struggled with the challenge of raising test scores especially on the Connecticut Academic Performance Test (CAPT) given to all sophomores. With the second group of
students using integrated curriculum, the top two scores in math on the CAPT were from our students. Quite an achievement!"

According to Craig Russell, the benefit of an integrated curriculum for state-mandated testing depends on the testing program: "High-stakes tests in some states gear mathematics portions toward problem solving, with rubrics supporting thought process as well as skill development. To the extent that that kind of testing becomes prevalent, integrated curricula are well suited to preparing students for the tests without having to teach to the test. The opposite would be true for high-stakes tests focusing on low-level factual knowledge and rote skill demonstration."

Gaby McMillian concludes, "I used our results on our state test to argue for integrated mathematics. The test is becoming increasingly challenging. It is also being written to defy short-term test-taking strategies. A student must have a deeper understanding of the math and a larger toolbox of skills and problem-solving strategies."

References


The following teachers contributed to this article by responding to email from the author. Our thanks to:

- Helen Crowley, Southington High School, Southington, Connecticut
- Sandie Gilliam, San Lorenzo Valley High School, Felton, California
- Rosalie Griffin, Crosby High School, Waterbury, Connecticut
- Jim Kearns, Lynnfield High School, Lynnfield, Massachusetts
- Pat McCarthy, Portsmouth High School, Portsmouth, Rhode Island
On aligning curriculum across disciplines:

“We’re growing eucalyptus to see if eucalyptus extract stops the germination of different seeds like oat, rye, and diachondria. In math class we’re doing statistics for that experiment, and learning to use Excel so we can make a graph of our results. Through that I learned about statistics, which I can use in other things I do. In humanities we’re writing a paper about our project; and the writing is easier because I actually did it, I’m not just reporting what someone else did. You could do the experiment, but if you don’t have your statistics or results, or you can’t read them, then the project is worthless. Or if you can prove something but not explain it in writing, then what’s the point of doing it?”

- Monica, student at High Tech High.

Suppose you were teaching math and you said, "We are going to start math with calculus, and then after calculus, we will get down to adding and subtracting and multiplying and dividing." Anybody who proposed such a sequence would be arrested, locked up, or otherwise hustled off the scene.

Starting the high school science curriculum with biology is about like starting the study of mathematics with calculus. Biology is the most complex of all the basic sciences. An understanding of modern biology depends on an understanding of the structure of large, complex molecules.

The sciences have a hierarchy based on atoms. That was not known in 1893 when the present sequence--biology, chemistry, and physics--was installed in our high schools on the recommendation of the Committee of Ten. It is a comment on how slowly schools change that we are still teaching this 1893 sequence even though the sciences have rushed ahead.

Currently, students forget ninth-grade biology when the exam is over. For one thing, the course requires them to memorize and regurgitate thousands of new Latin words, and for another, they don't build on the concepts the following year. With Physics First ([http://www-ed.fnal.gov/arise/arise.html](http://www-ed.fnal.gov/arise/arise.html)), students use physics in the following year's chemistry class because almost every process in chemistry has a physics explanation for it.

There is a tremendous misconception about physics requiring advanced calculus. In reality, the Physics First sequence allows students to use learning from Monday's mathematics class in Tuesday's science class. The conceptual physics courses use ninth-grade algebra to explain, for example, that the parabolic path of Michael Jordan's basketball shot is the resolution between throwing the ball and having gravity pull on it. Students can appreciate that the math that they are learning is useful in their physics class.

In an ideal situation, every Monday, the science, math, and humanities teachers sit down together for several hours and discuss their coordinated strategy for the week. The collaboration of these teachers of different
disciplines is necessary because science is connected knowledge, and knowledge without wisdom is dry as dust.

In addition, the math, physics, chemistry, and biology teachers would sit down and make a solemn pledge to give up some fraction of the content of each of their courses. What you want to teach in addition to the content is the process of science; some of its history; why it works. What we want our young people to remember is the "science way" of thinking because they will forget many of the details.

Let me finally add that a slowly growing number of schools are experimenting with reordering the sequence. They overwhelmingly report greatly enhanced enrollment in science electives.

**Leon Lederman**, winner of the 1988 Nobel Prize for Physics, is director emeritus of Fermi National Accelerator Laboratory in Batavia, Illinois. In the field of education, he founded and chairs a professional development program for primary school teachers in the Chicago Public Schools. This initiative is now being replicated in inner-city schools in East St. Louis and Joliet, Illinois. Lederman has been instrumental in creating the Illinois Mathematics and Science Academy, a residential public high school for gifted children. For more information about the Physics First curriculum, visit the web site [www-ed.fnal.gov/arise/arise.html](http://www-ed.fnal.gov/arise/arise.html).

**References**


A District That Puts Physics First
Kenneth Roy
http://www.enc.org/features/focus/archive/horizons/document.shtm?input=F
OC-002313-index,00.shtm

Kenneth Roy, K-12 Director of Science and Safety for Glastonbury, Connecticut Public Schools, talks about how his district implemented the Physics First program (http://www-ed.fnal.gov/arise/arise.html). They started out with an initial pilot program in 1997 and have since expanded it to include the entire high school science program. Although Physics First is not a model that integrates across disciplines (it would be in the Nested or Sequenced stage of Robin Fogarty and Judy Stoehr’s Integration Models), it does align the 4-year high school science curriculum in a cohesive manner that would be a logical first step toward integration with other disciplines (particularly mathematics).

A Call to Change

Beginning with A Nation at Risk (1983), direction for change in science education has been provided by national educational reform movements and reports such as the American Association for the Advancement of Science (AAAS) Project 2061 (1989), National Science Teachers Association (NSTA) Scope, Sequence, and Coordination project (1996), and the National Science Education Standards (1996). One reform movement that directly addresses high school curriculum sequencing is the American Renaissance in Science Education (ARISE).

Based in part on the tenets of other national reform movements, ARISE asserts that knowledge of physics fosters learning in chemistry. In turn, knowledge in chemistry fosters learning in biology. In effect, ARISE proposes to reverse the traditional model of the secondary science curriculum sequence.

In 1996, my school district, the Glastonbury, Connecticut, Public Schools, explored the ARISE approach to secondary science education. Although this approach is controversial, we were convinced that it had merit. We felt it would expose students to major concepts in all the sciences in addition to fostering better understanding of the relationship between the sciences.

The science department began by designing a five-year pilot program for high-achieving students (see Table 1) compares the traditional program in grades 8 to 12 with the pilot program modeled after the ARISE approach. If the pilot proved to be successful, we planned to change to the science program for the entire school population.
Results of the Pilot Program

Since the initiation of the program, the first group of pilot program students has successfully taken Conceptual Physics in grade 8, level I Chemistry in grade 9, Advanced Placement (AP) Biology in grade 10, and AP Chemistry in grade 11. As of this writing, grade 12 students are enrolled in the new, two-credit AP Physics course.

The first three years of the pilot have produced positive results by increasing students’ exposure to the physical sciences. For example, the number of students taking AP Chemistry jumped from 22 in 1997-98 to 48 in 2000-01. The program also allows students to take more science courses. They now have the opportunity to take three years of AP coursework in science or other science electives (see Table 2).

Another benefit of the program is the increasing involvement of girls in our school's science program. Since we instituted Physics First, enrollment in the 10th-grade AP Biology class increased from 26 percent female to 54 percent female. AP Chemistry class enrollment for grade 11 increased from 33 percent female to 48 percent female students. I believe part of the reason for this change is that all students in grade 8 are now introduced to Conceptual Physics. This introduction allows girls to gain more confidence—they know they can do the work.

Various assessments have indicated that students in the pilot program have achieved well beyond anyone's expectations. For example, in 1999-2000, Glastonbury Public Schools was the sole recipient of the AP Regional Award for New England. This award was based on the facts that Glastonbury students had the highest increase in numbers taking the test and the highest increases in individual scores.

Plans are now being made to expand the Physics First program to include students at all achievement levels. Over the next three years, the total science program will take on the curriculum profile outlined in Table 2, providing all pilots are successful and approval is secured from the board of education. There is much optimism in our district about the new science curriculum model and its potential to improve science education for all students.

Table 1. Original Proposal: Science Sequence for High-Achievement Students

<table>
<thead>
<tr>
<th>Grade</th>
<th>Program Before 1997</th>
<th>Pilot Program (1997-2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 8</td>
<td>General Science</td>
<td>Conceptual Physics</td>
</tr>
<tr>
<td>Grade 9</td>
<td>Biology level I</td>
<td>Chemistry level I</td>
</tr>
<tr>
<td>Grade 10</td>
<td>Chemistry level I</td>
<td>AP Biology</td>
</tr>
<tr>
<td>Grade 11</td>
<td>Physics or elective</td>
<td>AP Chemistry</td>
</tr>
<tr>
<td>Grade 12</td>
<td>Physics or AP elective</td>
<td>AP Physics</td>
</tr>
</tbody>
</table>
Table 2. Second Phase: Physics-First Sequence for All Students

<table>
<thead>
<tr>
<th>Grade</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 8</td>
<td>Conceptual Physics</td>
</tr>
<tr>
<td>Grade 9</td>
<td>Conceptual Chemistry or College Preparatory Chemistry</td>
</tr>
<tr>
<td>Grade 10</td>
<td>Conceptual Biology or College Preparatory Biology or AP Biology</td>
</tr>
<tr>
<td>Grade 11</td>
<td>College Preparatory Chemistry or AP Chemistry or Science Electives</td>
</tr>
<tr>
<td>Grade 12</td>
<td>College Preparatory Physics or AP Physics or Science Electives</td>
</tr>
</tbody>
</table>

Electives include Anatomy & Physiology, Botany, Genetics, Geology, Meteorology, Oceanology, and more.

Resources


Kenneth R. Roy is K-12 director of Science and Safety for Glastonbury, Connecticut Public Schools. He also is an author/columnist for numerous professional publications; he and co-author Malcolm Cheney contributed the article "Teaching in an Equitable--and Safe--Science Laboratory" to a previous issue of ENC Focus.
**Why try interdisciplinary teaching?**

- **To Promote Collaboration:** Many teachers are seeking the opportunity to collaborate with others. Many teachers also value the chance to collaborate with their students and to get to know them better through a joint endeavor. Teachers are also searching for easy ways to get kids working with each other in healthy, cooperative learning in order to build social skills and class morale.

- **To Reflect the Real World:** Because an interdisciplinary study is a reflection of the real world, students become more interested and motivated in their learning. This kind of learning involves and engages students positively. They understand the need to learn a skill and to apply it. Thus students can readily develop a life-long love of learning.

- **To Try an Exciting Approach:** Many teachers responded that teaching in a new and different way is exciting. Teaching an interdisciplinary course is not only very interesting for them, but also engaging for their students.

- **To Connect School Subjects:** Making connections between a school's often artificial categories or disciplines makes sense to teachers and students. This “whole” topic approach can actually cover more in greater depth as well as fill in the gaps between subjects. The flow of study also provides meaningful continuity through an unlimited number of ongoing activities.

- **To Have Fun:** Some teachers noted that a good motivator for an interdisciplinary study is simply to have fun. This kind of course can regenerate enthusiasm for learning. Teachers and students can enjoy their unity activities, and celebrate learning.

- **To Motivate Self:** Just teaching an interdisciplinary study can be its own motivation. The challenge of developing something new can be an intensely rewarding experience. Improving oneself as a teacher is the goal.

- **To Involve the Community:** The opportunity to garner community support also encourages some teachers to pursue an interdisciplinary study. By involving community resources with the school in a special project, positive public relations can result for both.

- **To Respond to Collegial and Administrative Support:** A very few respondents indicated that their teaching situations already offered collegial support for teaching an interdisciplinary unit. To take advantage of that encouragement was a worthy reason to pursue this approach.

- Ken Bergstrom, Goddard College, Plainfield, VT
Heidi Hayes Jacobs is a leading voice in curriculum integration, and this article emphasizes the necessity to take things slowly so that curriculum integration becomes a lasting, strong, staple part of the school culture. Her four-phased integration plan outlines the time frame, tasks, and goals of the process in an uncomplicated, informed manner. Although Jacobs discusses integration at the district level, small schools have the opportunity to condense the 4-year timeline because of their ability to devote more time to planning and less time to developing proposals for district approval, resulting in quicker implementation.

To develop an interdisciplinary curriculum, a district needs an action plan. Here is such a plan, based on extensive field work. The plan’s four phases – conducting internal and external action research, developing a proposal, implementing and monitoring a pilot unit, and adopting the program – can be accomplished over a three-year period.

Phase I: Conducting Action Research

The time frame for carrying out research is six months to a year. During this phase, staff members concentrate on learning more about their current curriculum as well as about best practices from the field.

Internal research. Research is conducted internally by small groups of teachers assembled by grade levels, departments, or interdisciplinary teams. Using the school calendar, they plot month-by-month the units of study they teach. If each teacher comes prepared with his or her individual monthly outline, compiling the information takes only a few hours.

With information for an entire year at their fingertips, teachers can: (1) discover when students are studying various units in their subjects; (2) align subjects that would mutually benefit from concurrent teaching (Jacobs 1989); (3) eliminate repetition from year to year; (4) identify possibilities for multidisciplinary or interdisciplinary units of study (Jacobs 1989); and (5) target units that lend themselves to performance-based assessment of specific skills and concepts.

External research. External research extends staff members’ awareness of relevant work in the larger education community. Through conferences, readings, site visits, in-service courses, and voluntary study groups, they study best practices and options for curriculum reform. Regional service
INTEGRATING CURRICULUM: How to Integrate

centers, state education departments, national education organizations, and universities are excellent sources for learning about desirable practices.

Topics that teachers often choose for further research include team building, curriculum design, scheduling alternatives, evaluation approaches, and writing across the content areas.

Investigation of these areas can be helpful to teachers as they develop interdisciplinary programs.

Phase II: Developing a Proposal

Phase two, proposal development, usually take from two to four months during the first year of planning. One of the first tasks is to assess potential areas for multidisciplinary or interdisciplinary units.

For their first effort, most schools decide to upgrade an existing unit of study through collaboration between disciplines. The length of the pilot is usually from two to six weeks. If the proposal is to be effective, the most motivated and capable staff members should be involved in this design. Further, the proposal should specify evaluation procedures, budget, timelines, and teachers’ responsibilities.

Two dangers inherent in a pilot are its experimental cast and its peripheral nature (Jacobs 1989). A strong long-term agenda can allay these problems. Creating an interdisciplinary proposal should not be seen as an enrichment event; ultimately, the goal is for the pilot to become part of the program, not a passing experience. As a middle school teacher put it, “We’re going to try this science and English unit on the ethics of experimentation because we believe it’s better than what we’re doing now separately.”

After the proposal has been written and reviewed at the building and district levels, it’s time to try the unit in the classroom.

Phase III: Implementing and Monitoring the Pilot

The third phase, implementing and monitoring the pilot unit, take place during the second year of the plan. Most units run from two to six weeks.

During the pilot, teachers evaluate decision-making procedures, relationships between team members, time allotted for implementation, adequacy of resource materials, and political considerations. A frequent outcome of their efforts, according to teachers, is the satisfaction of collegial collaboration. As Leiberman and Miller suggest, “it is the personal interaction rather than instructional interaction that is most valued” (1990, p. 159).

The group members also meet regularly to assess the impact of the pilot unit on students. If they have devised outcome-based assessments for the pilot, they now have critical feedback about student growth.
The key to the pilot’s success is the data collected through the monitoring procedures. From this wealth of information, the staff then plans revisions to the unit’s design or to conditions that influence its effectiveness.

Phase IV: Adopting the Program

During the third year of the plan, staff members are prepared to make revisions to the program, based on the data collected in the pilot phase, and then adopt it as a permanent part of the curriculum. There is not time in a school year to add more curriculum. So, in order to adopt the pilot, they must replace whatever was offered previously. For example, the high school course guide will now state that there is a 9th grade Humanities course rather than separate English, social studies, and arts courses. A pilot can easily dissipate unless it is elevated to program status.

Looking Ahead

Eventually, staff members will want to examine the new unit for ways to expand it throughout the system. Over two to three years, schools can make steady and meaningful curriculum reform. A successful interdisciplinary pilot can spearhead systematic examination of scheduling, teaming, and evaluation procedures.

By following as action plan based on solid research, a powerful pilot, and thoughtful monitoring, district planners can guide a unit through to successful program adoption.

References


Dr. Heidi Hayes Jacobs, president of Curriculum Designers, Inc., has served as an educational consultant to thousands of schools nationally and internationally. She works with schools and districts, K-12, on issues and practices pertaining to: curriculum reform, instructional strategies to encourage critical thinking, and strategic planning. Her book, *Interdisciplinary Curriculum: Design and Implementation*, published by ASCD, has been a best seller. In spring of 1997, her book, *Mapping the Big Picture: Integrating Curriculum and Assessment K-12*, was released by ASCD.

### Example of Calendar Curriculum Mapping

<table>
<thead>
<tr>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English/ Language Arts</strong></td>
<td>Sarah, Plain and Tall</td>
<td>Wilson’s Letter and Diaries of Immigrants</td>
<td>Diary of Anne Frank</td>
<td></td>
</tr>
<tr>
<td><strong>Social Studies</strong></td>
<td>The Westward Movement</td>
<td>The Industrial Revolution; World War I</td>
<td></td>
<td>World War II</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td>Fractions</td>
<td>Metrics</td>
<td>Percents</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roman Numerals</td>
<td>Compare Bases</td>
<td>Geometric Shapes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scale Area</td>
<td></td>
</tr>
<tr>
<td><strong>Science</strong></td>
<td>Matter and Energy</td>
<td>Electricity</td>
<td>Magnetism</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td>Weather</td>
<td></td>
</tr>
<tr>
<td><strong>Art</strong></td>
<td>Color; Western Landscapes</td>
<td>Shape; Cubists, Picasso, Gris</td>
<td>Photography; Documentary Purposes</td>
<td></td>
</tr>
</tbody>
</table>

A 6th grade team begins interdisciplinary planning by plotting the topics teachers teach month-by-month.
San Diego’s Gary and Jerri-Ann Jacobs High Tech High (HTH) is founded on three design principles: personalization, adult-world connection, and a common intellectual mission. To actualize those principals in the classroom, HTH has made discipline integration a high priority because HTH believes integration fosters adult-world connections and a more realistic reflection of society and nature.

High Tech High’s Integrated Units: A Planning Guide for Teachers places an emphasis on the specific teacher preparation involved in integrating curriculum. Step One helps teachers define the learning goals to be met through the integrated curriculum. Step Two assists teachers in generating a theme, or themes, that align with the learning goals. Step Three includes a web diagram to assist in mapping out the components of multiple disciplines while keeping the generative themes developed in Step two at the forefront. While the guide is practical, it leaves space for staff to modify and cater the tools to their specific setting.

The Environment: Love it or lose it project example puts the planning steps into action and addresses six disciplines, but to varying degrees of challenge. The degree to which an integrated project covers discipline-specific content should be kept in mind so that if key concepts are not covered in one unit, they can be incorporated into another.

The guide concludes with teacher and student evaluations of the integrated unit to assess what went well and what can be improved on in future units.
INTEGRATED UNITS

A PLANNING GUIDE FOR TEACHERS

Overview

Student projects at High Tech High incorporate the HTH design principles of personalization, adult world connection, and common intellectual mission. As such, HTH projects cut across subject area boundaries and open the door to integrated curriculum planning. The aim is to help students to experience their studies as more coherent and more connected with the adult world. This planning guide offers teachers a method for working together to plan integrated units. It can be adapted by individual teachers, especially where the teacher is responsible for more than one subject area.

What Is an Integrated Unit?

Integrated units bring together academic and/or technical subject areas around a common theme. An effective integrated unit aligns with academic content standards. It follows from students’ needs and interests, and prepares students for success in college and career.
Integrated units:

- provide fertile ground for high-quality student projects
- help students and teachers make connections across academic disciplines
- link academic and technical content and skills
- foster professional growth by encouraging teachers to go beyond the boundaries of their academic and technical fields
- establish a culture of professional dialogue about student work
- connect students and their work to the larger community
- bring coherence to the curriculum by providing a thematic focus for a school program, a small learning community, or a classroom.

What Does it Take to Build a Successful Integrated Unit?

From teachers:

- Cooperation and teamwork
- Agreement on core learning goals
- Risk-taking and flexibility
- Focus on deeper structures and understandings of a discipline
- Willingness to forego some specific content goals
- Peer observation and feedback
- Encouragement of student ownership
From the institution:

- A common intellectual mission that cuts across curricular disciplines
- An intellectual focus that cuts across curricular disciplines
- A flexible schedule that allows integrated project work and involvement with the world beyond school
Designing an Integrated Unit

Step 1: Learning Goals

Working in teams or alone, teachers proceed as follows:

Identify Learning Goals

- List 5-15 learning goals, concepts, objectives, competencies, or outcomes for your particular discipline or course(s).

Create Learning Goals Map

- Hang a long piece of butcher block paper on the wall.
- Draw a two-column grid on the paper. Enter each course or discipline title in the left column and the corresponding learning goals in the right column.

Share Learning Goals

- Each teacher on the team explains his/her learning goals.
- Identify common themes, ideas, competencies, and student outcomes.
- Allow for questions, clarification, and general discussion.
- Clarify common core learning goals.
Step 2: Generative Theme

What Is a Generative Theme?

Generative themes:

- are the focal point of the integrated unit
- cut across disciplines and may be addressed from a variety of disciplinary perspectives
- lend themselves to student investigation and projects
- link with student interests
- link with community issues and needs

Sample Generative Themes (HTH examples here?)

- The Environment: Love it or lose it?
- Day of the Dead: Cultural perspectives on death and dying
- What Counts: What do we measure and how do we measure it?
- The Two-Edged Sword of Technology
- Immigration and Assimilation: What does it mean to be American?
- Building Bridges: Connecting history, culture, and time
- Nutrition and Health: What’s good to eat?

Brainstorm and Agree on a Generative Theme and Sub-Themes

- Brainstorm until you arrive at a generative theme that can accommodate the learning goals of the school and can be addressed through various disciplinary lenses.
- Brainstorm sub-themes that "unpack" the generative theme.
Establish “Essential Questions”
Identify four to six “big questions” that relate to the generative theme, address core learning goals, and may engage student interest.

Planning Backward: Set Goals and Objectives
Review the “essential questions.”

Develop a list of possible integrated unit outcomes, using the questions below as a guide.

At the completion of the integrated unit:

- What do you want students to understand? (Consider this question in relation to the HTH Habits of Mind)
- What do you want students to be able to do? (Consider this question in relation to the HTH Learning Areas.)
- What resources will students have used?
- In what ways will you have fostered student ownership?
- What interdisciplinary connections will you have made?
- What connections will students have made with the community?
- What roles will community partners have assumed?
- How will students demonstrate their learning?
Sample Generative Theme and Sub-Themes

Generative Theme

The Environment: Love it or lose it?

Generative Sub-Themes

- Global warming: rumor or reality?
- Environmental controls and roles: the government, corporations, and individuals
- The environment and developing countries: whose standards count?
- The global economy and the environment
- The local economy and the environment
- Wetlands preservation versus development
- Urban and suburban sprawl
- Pollution prevention
- Water quality
- Cars and the environment: from SUVs to electric cars
- Historical perspectives: effects of urban migration, the industrial revolution, and recent technological innovations
- The environment: teaching the next generation
- Endangered species
- Issues in recycling
- Nuclear power and the degree of risk
- Cultural perspectives on the environment: western, eastern, Native American
- Environmental illness: causes, symptoms, treatments
INTEGRATING CURRICULUM: How to Integrate

Essential Questions

- How can we preserve the environment for future generations?
- What is the overall impact of technological and economic progress on the environment?
- What are our priorities and who is responsible for the environment?
- Economic progress and environmental preservation: can they co-exist?

Sample Backward Planning

At the completion of the integrated unit:

What do you want students to understand? (ref. HTH Habits of Mind)
- Individuals and groups share responsibility for the environment (Relevance)
- Views of the environment are linked to culture, time, and place (Perspective)
- Everything we do affects the environment, for good or bad (Connection)
- Every solution generates new problems and opportunities (Supposition)
- There are human costs to ignoring the environment (Evidence)
- We have the power to effect change

What do you want students to be able to do?
- Demonstrate good habits with respect to the environment, e.g., recycle as appropriate, be mindful of waste, exhaust, etc. (Ethics and Responsibility)
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- Explain the theory of global warming (Communication)
- Help develop, analyze, or evaluate "environmentally friendly" products (Art and Design)
- Know and interact with environmental agencies (Collaboration)
- Explain how humans and their innovations impact the environment
- Recognize various cultural perspectives toward the environment
- Be aware of careers in environmental fields
- Prepare presentations of their thinking and work (Collaboration, Technology)
Step 3: Activities, Diagram, and Timeline

Generate Integrated Projects

- Working together or alone, review your learning goals, generative theme, and essential questions.
- Brainstorm integrated projects for students that address these goals and questions.
- Brainstorm activities that use community services, businesses, and families.
- Identify possible initiating, mid-point, and culminating activities.

Generate Discipline-Specific Activities

- Working alone, think of activities and projects for your classroom that relate to the generative theme and the integrated projects. You may want to consider the following components:
  - HTH Learning Areas and Habits of Mind
  - New Standards (University of Pittsburgh)
  - Materials, equipment, resources needed
  - Assessment strategies
- Share your proposed activities with your team.
- Brainstorm projects that link two or more academic or technical areas.
Connect with Community Partners

- Identify community resources, such as local professionals, businesses, organizations, or libraries that can assist students in their research and project work.
- Assemble an “expert panel” of local professionals with experience related to the generative theme. Ask panelists to assist in reviewing student work.
- Establish a network of “Critical Friends,” including colleagues from other schools who can offer feedback on curriculum development and activities.

Create a Diagram

Attach a large piece of butcher block paper to the wall, and draw a diagram similar to the example on page 12.

- Insert your essential questions, core learning goals and skills, generative theme, integrated projects, and discipline-specific activities into the diagram, drawing connections where appropriate.
- Refer to the diagram to generate new connections and projects.
- Discuss ways in which the theme and projects might connect to the community.
- Further develop the initiating, mid-point, and culminating activities.
- Reflect on your generative theme:
  - Is it focused enough? Is it too focused?
  - Will students find it meaningful and accessible?
  - Is there room for student input?
  - How can the community become involved?
  - How will it accommodate various content standards?
Make a Timeline

- Decide on the final activities.

- Hang a piece of butcher block paper to create a timeline:
  - Coordinate times and dates for activities.
  - Determine preparation time for mid-point and culminating activities.

Note: Remember to keep the integrated unit open to student input. The more students can generate their own sub-themes and project ideas, the greater the chance for student engagement and learning.
Sample Integrated Projects

Generative Theme
The Environment: Love it or lose it?

Integrated Projects

- Hold an environmental fair with presentations and visual displays
- Create a web site that focuses on environmental issues
- Hold an Earth Day event: develop songs, dances, plays, and games that celebrate the beauty of the earth and raise awareness
- Run a recycling campaign in the neighborhood
- Organize a whole-school activity where students and teachers "live naturally," e.g. refrain from using any form of technology for a day
- Write and produce an original drama that predicts the earth’s environment in the year 3000 from two perspectives: (1) if we do not change our actions; (2) if we implement more environmental controls
- Analyze the impact of specific technologies on the local environment
- Participate in an ongoing wetlands reclamation project
- Create a data bank of environmental jobs for students
- Plan and paint a mural about the environment
Sample Discipline-Specific Projects and Activities

**English Language Arts**

- Create presentations or brochures to teach the community about “eco-friendly” habits; present the information to other classes, schools, and community groups
- Read and discuss age-appropriate books on the environment
- Write a fictional story about the environment (e.g., a fable, a science fiction story about the colonization of another planet, a profile of a doctor who finds a cure for environmental illness)
- Write a persuasive essay on a particular environmental issue
- Write and produce a one-act play that addresses environmental quality

**Mathematics**

- Track and graph changes in pollution levels at a bio-remediation site
- Graph rates of hearing loss in different occupations
- Survey children’s attitudes toward environmental issues; compile results and interpret data

**Social Studies**

- Evaluate environmental quality of life across historical periods
- Hold a debate about free trade and the international call for environmental standards in developing countries
- Interview parents and grandparents on their views of the environment
- Study and discuss the present administration’s policies toward the environment; compare with past administrations
- Visit and interview environmental political action groups
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Science

- Study acid rain and its effect on local woodlands
- Investigate wetlands reclamation and beach preservation
- Interview health professionals about environmental illness
- “Adopt” an endangered species and develop a project to protect that species

Business

- Interview local industry leaders about their environmental policies
- Design and market an “eco-friendly” product

Computer Studies

- Build a web site on environmental issues
- Surf the Internet to create a resource booklet and/or web site on environmental agencies and resources
- Create a spreadsheet that calculates the average temperature of the earth over the next 10, 20, 50, 100, 1000 years
Step 4: Evaluate the Integrated Unit

Teacher Integrated Unit Evaluation

Use the questions below to reflect on your integrated unit.

1. What links did you make with among the subject areas?

2. What links did you make with the community?

3. In your view, what aspects of the integrated unit engaged and inspired the students?

4. How effectively did your unit incorporate the HTH Learning Areas and Habits of Mind?

5. What would you do differently the next time?
6. What ideas and suggestions do you have for improving the integrated unit process?

7. Thinking back, what two or three moments in the integrated unit process stand out for you? Why?

8. In what ways did your integrated unit team work well together? What were the biggest challenges?
Student Integrated Unit Evaluation

Use the questions below to reflect on your integrated unit.

1. What moments stand out as most meaningful to you? Please explain why.

2. What skills have you developed in the course of this integrated unit? (Refer, if you wish, to the HTH Learning Areas and Habits of Mind)*

3. What would you say is the major lesson you have learned about the theme of the integrated unit?

4. What suggestions do you have for the next integrated unit?

* HTH Learning Areas: Collaboration, Technology, Communication, Art and Design, Ethics and Responsibility, and Habits of Mind
HTH Habits of Mind: Perspective, Evidence, Relevance, Connection, Supposition
Chapter 1. Exploring the Process

For the past three years I have been deeply involved in the process of creating integrated curriculum as a developer, implementor, workshop leader, and researcher. Talking to people involved in similar endeavors, I invariably met rolled eyes, groans, and epithets such as "a nightmare," "impossible," or "a battle." The consensus seemed clear: developing integrated curriculum collaboratively was a challenge in the best sense of the word. But as I followed different teams at different points in the process, I was fascinated to discover that the "impossible nightmares" faded and were replaced by much more positive interpretations once a writing team actually began to implement integrated curriculum. The team could then go on to plan the next units with some degree of ease, and everyone could begin to talk about how rewarding the experience had been.

These teams seemed to have forgotten most of their initial struggles. Their stories matched my own experiences so well, I began to wonder whether there were universal aspects that most people might expect to experience when undertaking such an endeavor. By listening to others, could I identify commonalities that would lead to a clearer understanding of the problems involved in planning integrated curriculum? These questions intrigued me and led me to further explore the process of developing integrated curriculum.

Making Sense of Curriculum Integration

Is there really a need to develop integrated curriculum, or is it just another passing fad? This question deserves to be examined carefully. We live in a global world characterized by ever-accelerating change, technological advances, a knowledge explosion, changing economic and social realities, and, perhaps, impending environmental disaster. The educational system seems to be constantly under attack. Critics claim that students are dropping out at an alarming rate. Those who stay in school are not doing well enough to be able to compete in a global economy and maintain a high standard of living.
In many districts there has been a demand for a restructuring in education to shift it to decentralization and site-based management. Teachers have been empowered as decision makers; this includes curriculum development. This shift has often led teachers to integrate the traditional subject areas because it made sense to those educators at the grassroots level.

It is important to understand the context of integration as an idea with an intellectual history. Disciplines were artificially created by humans to organize their world, and were often defined by political needs (Beane 1991). Eisner (1992) points out that as early as the 1920s the progressive movement in education advocated curricular integration through themes because proponents believed the disciplines prevented students from seeing the relationships between subjects and therefore decreased the content's relevance. In the '60s, based on Jerome Bruner's (1960) concept of curriculum development, there was a shift to discipline-oriented curriculums where the structure of the discipline was considered to be the facilitator for the storage and retrieval of knowledge. Still, many students today move from science to history to math classes and are taught in a fragmented, disconnected way that has little resemblance to real life.

Today, some people criticize educators for not adequately teaching basic skills; others argue that the basic skills students will need for the 21st century are not the same skills that we are now teaching. The knowledge component of virtually every subject area is proliferating at an ever-increasing rate. Paradoxically, as distinct subject areas become overloaded, a surprising amount of duplication is occurring across classrooms. Educators are caught in a dilemma. Integration, by reducing duplication of both skills and content, begins to allow us to teach more. It also gives us a new perspective on what constitutes basic skills.

The concept of integrated curriculum makes sense for other reasons. Students who drop out perceive little relevance in school life. Integration connects subject areas in ways that reflect the real world. When we set curriculum in the context of human experience, it begins to assume a new relevance. Higher-order thinking skills become a necessity as students begin to grapple with real issues and problems that transcend the boundaries of disciplines. Current newspapers offer an abundance of real-life issues that could be explored from a problem-based perspective. Conscious of age-appropriateness and student interest, the teacher may design problem scenarios based on reality; for example, issues that pit jobs versus the environment, the influence of media in shaping reality, violence in our society, schools and sports, the ethics of genetic engineering, or social issues such as AIDS, poverty, or the war on drugs. Current problems in these areas can be explored from a content perspective, but in searching for practical solutions they also require higher-order thinking skills that transcend both the content and the procedures of disciplines.

Another important consideration is how people learn. Recent brain research indicates that the brain searches for patterns and interconnections as its way of making meaning (Caine and Caine 1991). If humans do learn by connection-making, it only makes sense to teach through connections.
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First Efforts

A rationale for curriculum integration seems clear; however, there are few models available to guide us in developing such curriculum. Those beginning the process often feel as if they are in uncharted territory. The purpose of this booklet is to explore some of the territory ahead.

This exploration involves a synthesis of the experiences of several different school districts in Ontario. However, through dialogue and working with others throughout North America, I have come to believe that the process of developing integrated curriculum is universal in many respects. The common experiences identified here will hopefully extend beyond Ontario to offer a helpful guide for others.

In response to some of the criticisms of today's educational system, Ontario chose to focus on increasing relevance in the "transition years" (grades 7 to 9) as explored in such documents as Hargreaves and Earl's (1990) Rights of Passage. Uncertain of how to go about this task, the government set up a consultation process. This process involved a committee headed by Gerry Connelly that traveled across the province to consult with community teachers, principals, students, and parents in an effort to rethink traditional models and values. The government funded 66 grass roots projects. The committee followed the progress of these projects during the consultation process.

As a part of this initiative, the government announced an intent to provide a common curriculum for all learners. This involved eliminating the time allocations in terms of being defined by subjects and the designation of programs such as basic, general, and advanced in grade 9. In response to the challenge to eliminate streaming (tracking) difficulties in grade 9 and in an effort to increase meaning and relevance, many schools focused on integrating the curriculum. They did this in a wide variety of ways limited only by the imaginations of the curriculum developers and the support of their schools and districts. At the same time, many schools that did not receive funding for transition years projects were inspired to explore innovative ways to answer some of their educational dilemmas.

Given the freedom to innovate, many schools came up with creative solutions. The results of these explorations during the transition years initiative are guiding the educational policy currently being developed at grades 1 to 9. The major thrust of this policy is to educate the citizens of the 21st century. The emphasis is on clear expectations (knowledge, skill, and values) for students to attain by the end of their primary, junior, and transition years. These expectations reflect an integrated, holistic approach to curriculum. This policy is expected to be extended until graduation.

Integration was a conscious effort to connect curriculum areas that had not previously been connected. I was astonished by the vast differences in interpretation of what integration might be and how it might work. These differences become clear in the following list of some Ontario explorations.
that range from grades 6 to 12 and involve gifted, learning disabled, and mixed ability groupings:

- Subdisciplines such as auto mechanics, graphics, welding, electricity, and woodworking were integrated into a broad-based technology approach at the provincial level.
- Integrated curriculum was written at central office for the early childhood years.
- A theme or issue was being infused into existing curriculums. For example, the International Joint Commission of the Great Lakes worked on infusing environmental issues into existing science and social studies courses.
- One teacher working on an existing course of study adapted it in a way that connects to other subjects.
- A group of teachers from one school developed curriculum together, but each teaches independently in a separate classroom.
- Another group of teachers developed, team taught, and evaluated curriculum together.
- Use of "curriculum merges" or "curriculum links" integrated various subject areas. This has been done in a variety of ways. In one high school, grade 9 classes met during the first period of the day. At other schools, teachers who see subject connections chose to work together.
- Some newly built schools have had the luxury of a principal who began with a new vision and new staffs to match that vision. In these instances, the schools have been able to move more quickly than others toward integration across the curriculum. There are several examples of this phenomenon, ranging from K-8 schools to a school that initially included only grades 9 and 10 but eventually moved to include 11 and 12.
- One high school has organized all curriculums around the environment. Another high school is organizing around technology as an integrating focus.

Gathering the data for this exploration involved various strategies. On some occasions, I interviewed several key players on an integration team. At other times, I was involved in inserviceing with a district. I also attended planning meetings and presentations on curriculum integration whenever possible. I led a provincial curriculum team that developed a K-12 transdisciplinary curriculum based on story as the organizing principle (Drake et al. 1992). During this experience I kept a journal that I shared with my colleagues; this facilitated a mutual understanding of the process.

During this exploration I interacted with many people who were involved in integrated projects from several different districts. I am deeply grateful to those who so generously gave their time to share their experiences with me. I have chosen to name only a handful of these people in this account; however, the experiences of the many others are reflected in the stories that are offered.
I found that the process does get easier. One Ontario district, deeply involved in integrating at a systemwide level, reports that new teams beginning the journey are "light years ahead" of the groups that originally embarked into the uncharted territory. These newer groups have the advantage of reading materials such as Jacobs' (1989) *Interdisciplinary Curriculum: Design and Implementation*, Tchudi's (1991) *Travels Across The Curriculum: Models for Interdisciplinary Learning*, and the *Educational Leadership* (October 1991) issue on integration. They are also able to talk to those who are currently implementing their integration ideas. Collectively they are beginning to identify the process that leads to success.

Nevertheless, the process outlined here may sound pessimistic. The descriptions are not intended to be frightening, but realistic. In asking several of the people represented on these pages if I should soften the experience, the response was uniform. For them, *undergoing the process was the most important aspect of developing integrated curriculum*; they believed it is essential to know that there is indeed a struggle ahead. It is just as important to know that the journey is worth taking and that the process gets easier once you have been through it.

This interpretation is not offered as a "truth," for much of the process is still taking place in uncharted territory. It is offered in the hopes that it may increase understanding for others who are undertaking ventures like ours.

**The Journey Metaphor**

When I began the project with my own curriculum team, I offered the metaphor of a journey as a guide for the process ahead. This journey was based on my interpretation of the "Journey of the Hero" developed for an earlier integrated studies project (Miller et al. 1990); later, I applied this metaphor to organizational change (Drake 1990) and to individuals involved in significant new learning (Drake 1991). Since this venture involved both experiencing organizational change and significant new learnings, the model seemed to fit.

This journey metaphor worked well for us, a team of six strangers who were well aware of the obstacles ahead. We could have spent all the allotted time dwelling on our perception that there was not a school system in Ontario that offered a realistic structure in which to teach such a curriculum. (In two years this has shifted dramatically.) The metaphor allowed my team to move past the impossibility of the project into navigating new territory with a positive risk-taking attitude.

Listening to others, I was struck at how often I heard the metaphor of "journey." For one district the process was a journey of continually extending their boundaries and learning more. For a high school it was a "voyage of discovery" that primarily involved process rather than product. Karen Erskine, a principal of a K-8 school, comforted her integrated team during times of stress with the metaphor of a ship sailing through choppy waters to get to a safe shore. Fullan and Miles (1992) also use the metaphor of journey
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for educational change, acknowledging that it is a process of moving through largely uncharted territory.

The "Journey of The Hero" is the basis for most of our stories throughout time and across cultures. According to noted mythologist Joseph Campbell (1988), this quest can be interpreted metaphorically as a blueprint for successful transition. The hero is called to adventure; he or she leaves the kingdom in search of this adventure. Ahead are the demons to be confronted, the dragons to slay. Often the hero is aided by a magic helper such as a magic sword. Finally, the hero slays the dragon, receives a reward, and returns to the kingdom where he or she must share the lessons of the journey.

For educators, the journey could be interpreted as five stages in developing integrated curriculum (Figure 1.1). The heroes as curriculum writers hear a call to adventure and enter the world of integrated curriculum. They leave behind traditional methods of curriculum development and experience endings accompanied by loss. This is followed by a struggle as they encounter anxiety, conflict, and the excitement of stepping into the unknown. Finally they reach the reward and personal satisfaction of truly understanding how to integrate curriculum. The last stage is service where the heroes, feeling fulfilled, share what they have learned with other interested educators.

Chapter 2. The Call to Adventure

Educators are being called to adventure. The catalyst may be either their critics or a sense that there are more relevant ways of educating students. Integration offers an exciting challenge. There are several things to consider at this stage concerning the phenomenon of resistance and the exigencies of planning.

Resistance

A natural human reaction to impending change is resistance. More than one team leader reported that a typical beginning has been to say, "It can't be done." Fullan and Miles (1992) caution that we shouldn't even use the word resistance. This initial reaction would be better understood as coming to personal meaning. Rather than bemoaning resistance, we need to support people through this first reaction.

Teachers will offer some solid reasons for resistance such as:

- "This is just a fad; ignore it long enough and it will go away."
- "I'm not interested in change for change's sake."
- "I'm not fixing what already works."
- "I am already integrating in my subject area."

As we move into a world in which knowledge is proliferating at a fantastic rate, it is hard to conceive of integration as a fad. We simply can't keep
adding to the curriculum. As I heard over and over "we need to add by subtracting."

Most teachers are already doing a good job. I found that educators resisted the need to integrate when they felt that a personal attack was being made on their current teaching. Claire Ross, principal of Holy Family Education Center, offers a helpful perspective: "It's not that we haven't been doing a good job—we have, but the world is changing and we must change with it."

True, many teachers are currently integrating in their own areas. Yet, from a global perspective a more inclusive view of integration may be more appropriate.

Planning

Setting out on the journey, it is best to plan for the knowns with a collaborative vision of the destination. The vision is often very hazy and "when you get there, it's never how you thought it would be." However, to borrow K-8 principal Karen Erskine's metaphor, "without some description of the safe haven the ship is sailing toward, it will no doubt be destined to forever cruise the choppy waters or return to the familiar shores it left behind."

Some aspects that need to be explored are philosophical: What is worth knowing? What is the image of the learner? How do students learn? and What values are important? With a vision in place, it is possible to address some of the more obvious questions. The following is a synthesis of answers recommended by a variety of groups.

Who Should Be Involved?

Many teams start with numbers as large as 13; this may include all teachers in one school or include others such as central office consultants. This is clearly an attempt to involve everyone, but most conclude it is too many; they tend to break into smaller groups anyway. My team worked well with six individuals from different subject areas; others report good success with four people. One experienced team leader found an even number seemed to work better than an odd number. Given group dynamics, it seems that any number over seven is too many for constructive work to emerge.

Initial efforts in a district often include representatives from different schools writing together; the expectation is that each representative will act as a messenger and take the process back to others in their own school. In practice, this hasn't worked as well as expected; the writers also need to be able to implement collaboratively. This creates a greater sense of ownership and a greater understanding of the process itself. As teams work together they get good at the process and curriculum planning becomes infinitely easier.

Only those who volunteer should be involved. Usually there are a few enthusiastic participants, some who are there "in case something good might
happen," and those who are "brick walls." Reflecting on sometimes painful experiences, many team leaders recommended letting the "brick walls" go. It may seem like this person's subject area is necessary and there will be an important gap in the curriculum design. However, a brick wall, regardless of subject area, can sabotage the whole project. Accept the limitations and begin with people who are willing to innovate and take risks.

According to the experiences of many, the members of an ideal writing team:

- Are volunteers
- Will implement the product
- Love teaching and students
- Are willing to learn
- Are risk-takers
- Demonstrate interpersonal skills
- Perceive the teacher as a facilitator
- Are generalists who "love" a specialized area or
- Are specialists interested in a generalized approach
- Are innovative and creative
- Have taught several subjects
- Are technologically literate

What Form Should Integration Take?

Integration can occur in many different forms and combinations. Perceptions of top-down mandates of how to integrate have often been met with almost reflex-like resistance. Allowing groups to come to their own sense of meaning of "what," guided by a collaborative vision is important. Others, seeing the energy and enthusiasm of those actively involved, are often inspired to join. "Show them that their jobs will be easier" or "better" has convinced many who are hesitant to make a true commitment.

How Much Time Do We Need and Where Should We Work?

The amount of time people spent planning varied from five days, to a month, to a year. Planning seemed to work best when teachers were allowed blocks of time. One or two full days of orientation sets integration in a positive and supportive context. Orientation sessions in which outside "experts" offered a vision of integrated curriculum and some practical strategies were helpful. Subsequent sessions seemed to be most effective when teams were allocated half a day.

Planning time seemed to be most successful when it occurred outside of a school setting. This was particularly true for the initial sessions. My team, funded by the Ontario Curriculum Superintendents' Cooperative, had the luxury of meeting at a hotel in a central location. Other projects have met at a district retreat setting; one team did its best writing over two weeks in the summer at one member's house. Talking over food and drink in the relaxed forum of an outside setting increased feelings of collegiality.
How Do We Do It?

In the final analysis, integration takes "jumping in and doing it." The jumping in can take many forms. Some teams spend a year in preparation. Others are less cautious. One participant commented: "Everyone else has dipped their toes in the water. We jumped in head first. That's how my father taught me to swim."

Successful teams evolved "comfort zones of integration." One integration team consisting of Peter Marshall, Sally Friedenberg, Raquel Ahearn, and Jerry DuQuetteville collaborated for two years through grades 6 and 7. They described this comfort zone as a "balance between working together and respecting that each member will interpret things differently in the classroom . . . and that's okay." The process seems best as an ongoing process of both planning and implementation. Together, through collaboration and personal experience, the team members come to develop this "comfort zone," however, not without having to navigate the path of the journey ahead.

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Criteria for reflecting on the quality of the unit one is planning to teach:

Higher-Order Thinking: Do students use higher-order thinking as they work with ideas and concepts in the classroom?

Depth of Knowledge: Do students explore complex relationships and important concepts in the subject matter?

Connectedness to the World: Does the class have value or meaning in life beyond the classroom?

Substantive Conversion: Does the process of teaching build on student ideas, revealing connections between ideas, processes, and facts in a coherent process of exploration?

Social Support of Achievement: Does the class encourage high expectations, respect, and inclusion of all students?

Author unknown.
Levels of Consideration for an Integrated Curriculum
Where are you? Where do you hope to be? Who will be with you?

Distribution
Requirements

Curriculum
Integrated

Curriculum Integration

Random
Classes

Linked
Periods

Block
Schedule

Class Schedule

Departmental
Organization

Cross Disciplinary
Teams

House/Family
Systems

Faculty Organization

Weekly Staff
Meetings

Some Common
Prep-Time

Common Planning
Time with House
When taking the first steps toward developing an integrated curriculum it can be a challenge to visualize not only what the curriculum might look like for students, but also what the planning process might look like for teachers. The story of Evelyn Madison and Diane Rainey takes us step-by-step through the planning stages to illustrate how teachers can take a curriculum idea and shape it into a rich learning experience.

Choices about what to teach are some of the most important decisions that educators make. While national and state standards and district curriculum frameworks can give general guidance, teachers make the final decisions for day-to-day instruction. The following hypothetical story presents one way teachers might work together to develop curriculum.

Evelyn Madison, a life science teacher at Elmore Middle School, and Diane Rainey, a mathematics teacher, had often worked together, sharing ideas and trying to be sure their instruction was complementary. They benefited from their school's commitment to professional time for teachers—one afternoon a week was set aside for planning, meetings, and conversations that helped the faculty explore ways to improve their teaching.

The two teachers had often collaborated on student activities that usually lasted a week or two and focused on an issue in science with extensions in mathematics. If they extended this effort over time, perhaps a six-week unit, they thought they would be able to introduce and pursue themes. They wanted to design a unit that enabled students to explore ideas, pose problems, and work toward their own solutions.

**Integrating Design Technology**

Their discussion interested Will Hooks, Elmore's technology education teacher. Hooks was not the computer teacher, although he included computers in much of his instruction. He taught about systems-theory design, development, and influence. He was particularly interested in the connections between classroom instruction and the world of work.

Listening to Madison and Rainey discuss their ideas, Hooks realized that students involved in this work could build their understanding of systems development. He suggested combining the efforts of the three classes—mathematics, life science, and technology—in a way that would emphasize the connections among disciplines. The school's scheduling would
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accommodate a shared group of students--the school called it a student "family"--who would attend all three classes.

The teachers' thoughts coalesced into the idea of designing and building a model hydroponics farm. Madison had seen a similar project at the previous year's state science teachers' conference and liked the way it demanded understanding of both mathematics and science.

The three teachers searched an online database offered by the Eisenhower National Clearinghouse and found a helpful notebook, the Technology Science Mathematics Connection Activities Binder (available from Glencoe/McGraw Hill). With its purchase, the teachers had detailed instructions for six long-term projects, including a hydroponics farm that integrated science, mathematics, and technology.

Building on the Curriculum Framework

The teachers knew that they needed to ground their plans in the district's curriculum framework, and that some topics outlined for each discipline fit quite nicely. An understanding of biological and physical properties were key components for producing the farm's products. In mathematics, concepts of determining volume, interpreting ratios, and analyzing data were essential to the model's development and the interpretation of its results. Hooks knew that basic design elements--understanding environmental requirements, analyzing materials and equipment, sketching and refining designs--were fundamental to developing the model.

Remembering the Big Ideas

With such a complex undertaking, the big ideas in each lesson can be overlooked, so the teaching team set regular meetings and continually reminded themselves of the areas they wanted to cover. For Madison, these included understanding pH balance, exploring plant structures, and determining the role of nutrients in plant growth. Rainey's class would concentrate on determining volumes of various containers, interpreting ratios, drawing conclusions, and making predictions from data. Hook's focus would be on the basics of systems design, the role of materials and equipment, and responding to the model's environmental needs including light and temperature controls.

In their first meetings, the team established their learning goals, based on curriculum requirements. Their choices for specific learning activities emerged from their students' interests and the requirements of the model. While goals were set in these first meetings, the three came back to them many times over the semester, not only to see if the goals were being met but also to revise them.

Early in their planning, the teachers outlined ways they might assess students' understanding. While the students' completion of the model would be tangible proof of some forms of mastery, the specific goals of content understanding also needed to be addressed along the way.
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The teachers agreed that each class period would provide time for the students to keep journals that would include a short log of that day's activity and learning. Rainey asked her students to include their calculations for determining container volumes and ratio interpretations in these journals. She read the journals weekly.

Madison scheduled discussion times throughout the unit for teams to respond to specific questions, such as "What do we mean by pH level?" and "What happens if a plant receives a nutrient solution with a pH level that is too acidic? Too basic?" Following each of these discussions, students wrote short essays to respond to questions that stretched their understanding.

Every two weeks, Hooks asked each student team to prepare a summary of their learning, responding to questions, such as "What changes did you make to your original design, and why?" and "How would you describe the hydroponics farm model in terms of these four characteristics: input, process, output, and feedback?"

Through these assessment approaches, the team hoped to keep track of student progress and understanding.

Linking with the Community

At the beginning of the unit, the teachers had set the goal of establishing links with the world outside their school. They believed that students needed to understand how the experience of designing, building, and observing their model could be useful beyond the immediate classroom experience.

One afternoon Hooks invited several guests to the class, including a local farmer, an instructor from a nearby agricultural college, and a friend who was a systems engineer. Before the visit, the guests had talked with the three teachers about the project and what the students should accomplish.

The teachers posed several specific requests to the guests, asking them to comment on changes they had seen in their work in the past 10 years, the effect of the use of technology in their work, and how science and mathematics affected what they did. The students were also ready with questions of their own.

To get a look at the world outside their town, students spent some time on the Internet and found an international study of fast-growing plants in space called the Collaborative Ukrainian Experiment http://fastplants.cals.wisc.edu/cue/cue.html. This study was collecting data similar to the information the students would be gathering from their model.

Keeping the Focus

As the project progressed, the teachers tried to maintain a classroom atmosphere that encouraged inquiry and exploration. Bringing in community guests and surfing the Internet further broadened the students' horizons and
INTEGRATING CURRICULUM: How to Integrate

increased their queries beyond the unit's original plan. They posed new questions, such as

- Does growing in space affect plants in a different way from growing on the surface of the earth?
- What is the economic impact of farming on our town?
- Is there a computer game that simulates plant growth and environmental impact?

The students' explorations were suggesting so many avenues to pursue that the teachers began to fear that the learning would become scattered. If less is more is a guiding principle for in-depth understanding, the breadth of content must be limited to allow continued, thoughtful exploration of specific content.

Steven Levy in his book *Starting from Scratch* (1996) describes his method of classroom curriculum development. He concentrates on finding the genius of the topic--determining the essence of what makes the content unique and letting that essence steer the development of the lesson. This helps him decide which questions will lead the students to a closer understanding of the topic and which will lead them away. So, while communicating electronically with the Collaborative Ukrainian Experiment about growing plants in space might be fascinating, the teaching team or students must determine first if it contributes to their learning goals and, if it does, how to guide the exploration so it is productive.

**Looking Back**

By the conclusion of the project, the three teachers and their students had faced many practical and theoretical issues. The strengths of their work became apparent as they reflected on their experience. The benefits of their teamwork and sharing across disciplines were paramount. They were also convinced that student learning was enhanced through practical experience.

The teachers liked the notion that, while they had designed a firm structure for student work, much of the learning was directed by student inquiry and exploration that emerged naturally. Their effort in setting up and working through a logical sequence of activities had resulted in a rewarding experience for the students.

The teachers decided to use some of the summer after their first year to learn about embedded assessment and developing rubrics for measuring student work. They were already convinced that these assessment techniques might be more useful than traditional methods had been. They were looking forward to improving and extending their collaboration in the coming year.
INTEGRATING CURRICULUM: How to Integrate

Criteria for Promising Practice
Adapted from New Visions for Public Schools,
Center for School Success
http://www.newvisions.org/schoolsuccess/

Integrating curriculum involves much more than just developing curriculum in new ways. It requires deliberate planning of whole-school practice that aligns with the design, mission, and culture of the school. The following assessment rubric is one way a staff can begin to look at the “whole picture” of curriculum integration and envision a future for integrated curriculum that meets their needs, while fulfilling “Promising Practice” requirements. The New Visions web site also offers several excellent examples of integrated units.

A school's instructional model should aspire to meet the following criteria in order to be considered a "Promising Practice":

<table>
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<tr>
<th>“Promising Practice” Criteria</th>
<th>Existing</th>
<th>Emerging</th>
<th>Non-existent</th>
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<tbody>
<tr>
<td>Curriculum integration is consistent with the school's mission. There are clear and specific goals for the integrative curriculum and they are described in the school's official plan (e.g., Comprehensive Education Plan).</td>
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<td>Action Plan:</td>
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<td>A broad-based concept, theme, or essential question that goes across two or more discipline areas is the driving force of the curriculum. The curriculum engages students in the &quot;big ideas&quot; of a discipline or disciplines, encompasses critical skills, and fosters habits of mind that will produce lifelong learners.</td>
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<td>Action Plan:</td>
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**INTEGRATING CURRICULUM: How to Integrate**

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<tbody>
<tr>
<td>The curriculum has carefully conceived design features: a scope and sequence, a cognitive taxonomy to encourage thinking skills, behavioral indicators of attitudinal change, and a solid evaluation scheme.</td>
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<td>Action Plan:</td>
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- Staff are sufficiently supported to implement curriculum through common scheduling of prep time, professional development, and control over resources. Three to four weekly meetings of at least 30 minutes each is recommended.

| | | |
| | | |
| Action Plan: | | |

- Student scheduling is consistent with goals for integrating curriculum (e.g., there is block programming, or teachers teach the same set of students).

| | | |
| | | |
| Action Plan: | | |
**INTEGRATING CURRICULUM: How to Integrate**

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<tr>
<td>The curriculum is aligned to the standards in each of the disciplines involved. There is a process in place for teachers to examine the standards within their discipline and share them with their peers in other disciplines. Together they determine the overlap of knowledge, skills, and habits of mind that cross-cut their disciplines.</td>
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<td>Action Plan:</td>
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<td>Sufficient time has been provided to pilot, evaluate, and modify curriculum units.</td>
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<td>Action Plan:</td>
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<td>Teachers have sufficient autonomy to design, shape, and modify the curriculum according to their students' needs.</td>
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<td>Action Plan:</td>
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<td>There are sufficiently rich resources to support the curriculum.</td>
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<td>Action Plan:</td>
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### INTEGRATING CURRICULUM: How to Integrate

#### “Promising Practice” Criteria

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<tbody>
<tr>
<td>Students are engaged in the curriculum. Students have input into identifying topics, developing questions of study, planning the inquiry, assigning tasks, selecting and gathering resources and information, and developing the assessments.</td>
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<tr>
<td>Parents are informed and understand the curriculum. They know what their children will be expected to know and do, and how they will be assessed.</td>
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<td>Action Plan:</td>
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<tr>
<td>A variety of assessments (formal and informal) are incorporated into the curriculum to determine what students know and can do.</td>
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<td>Action Plan:</td>
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This lesson from Colleen Niemi is an example of an engaging, interdisciplinary unit where one teacher was able to combine the study of math and science in a real-world context.

High school students learn how mathematics helps us understand the natural world

To help create a more positive attitude toward studying mathematics among high school juniors and seniors and to address their questions about its relevance, I developed lessons connecting mathematics and nature. The ideas came from a course in the Educators' Science and Mathematics Institute Series (ESMIS) at Michigan Technological University. The lesson described here is based on the capture/recapture technique, which naturalists use in estimating the number of a certain species in a given geographic area.

The lesson is successful with students because they are actively engaged in the collection of data outdoors rather than using textbook-generated samples of data. Students also develop their cooperative learning skills as they collect, analyze, and present their data.

The mathematical topics covered include ratios and proportions, percents, measurement, calculation of perimeter, circumference, area and volume, and random sampling. Throughout the activity, the students refine and demonstrate their knowledge of these mathematical concepts, as well as acquire new information and skills.

Capturing Candy

In Michigan, this activity must be implemented early in the fall because it is dependent on the presence of soldier beetles and goldenrod plants. Because using the capture/recapture method with the beetles is quite challenging, we begin with a brief activity in which individually wrapped caramel candies are used to represent the beetles.

Before class, I outline an area in an overgrown field and scatter caramels throughout the area. The goal for the students is to estimate the total number of caramels I distributed even though they cannot find all of the candies.

To begin, half of the students are designated naturalists. They have two minutes to search for and "capture" caramels. When they run out of time, they record the total number of captured caramels, mark each caramel with an X, and redistribute the marked caramels in the designated area.
The remaining students then become naturalists for two minutes. This time, some of the caramels they find will be marked and some will be unmarked. The students record the number of each. When that task is complete, the students search for the remaining caramels, knowing that all the candy will be eaten as we discuss our data.

For a large class, this activity could be expanded to several trials. Another option would be to have several different search sites.

Once we are back in the classroom, the students estimate the total number of caramels originally distributed using the following ratio:

\[
\frac{\text{Number of marked caramels collected in 2}^{\text{nd}} \text{ search}}{\text{Total number collected in 2}^{\text{nd}} \text{ search}} = \frac{\text{Number marked in 1}^{\text{st}} \text{ search}}{\text{Total number initially distributed}}
\]

Inputting the numbers from their searches and solving the proportion gives an estimate of the total number of caramels. This number is then compared to the actual value that I first distributed. The discrepancy between the two numbers gives students some idea of the difficulties faced by naturalists when they are searching for animals rather than candy. It also prepares them for the next activity.

**Capturing Beetles**

In their first experience with real collection of data from nature, students use the capture/recapture activity to determine the size of the population of soldier beetles on the property surrounding the school. The insect to be collected will depend on the species found near your school. I selected soldier beetles because goldenrod is abundant on the school property, and the beetles are attracted to the pollen of the goldenrod.

Before our actual data collection, the students determine the area of the school property (in square meters), and select several different sites to search. Each site must have the same area, measured in square meters. Students are assigned to groups and each group is responsible for a site. Data are collected for four days before making a prediction.

While marking caramels is easy, marking soldier beetles is a little trickier. We have tried using different colors of fingernail polish. Each group of students goes out on day one with a bottle of red fingernail polish. When they find a soldier beetle, they mark its back with a tiny dot of fingernail polish. It is important not to get any polish on the wings, which would harm the beetles. The total number of beetles marked on day one is recorded.

For the next two days, the students go to their designated sites with different colors of fingernail polish. They record the number of marked and unmarked beetles they find and mark the unmarked ones with the color of the day.
On the fourth day, students go out again to gather data, but do not mark any beetles. They calculate the predicted population size each day using the same formula they used with the caramels, and make observations about how the size changes, if in fact it does. See Figures 1 and 2 for examples of the individual data sheet/class data sheet and prediction calculation sheet we used.

The activity concludes with discussion about the use of this type of sampling and population determination. This activity is even more meaningful if you can arrange to have a naturalist or a representative of the Department of Natural Resources visit the class to discuss how scientists use the capture/recapture method.

My students benefited from the cross-curriculum approach of this lesson and enjoyed learning about a method used in forestry and wildlife management and how it relates to mathematics.

**Resource:**


**Figure 1. Data Collection Sheet for Capturing/Recapturing Beetles**

![Data Collection Sheet](image)

This same form is used for recording small group data and for recording combined data for the entire class.
This simple proportion gives an estimate of the number of a particular species in a designated area. The percentage of the number of marked beetles found on the second day gives us an idea of what percent of the total population we marked the previous day.

Because this was our first experience with the capture/recapture method, we took data for four days and made comparisons of estimated population sizes. We used the data again when we were studying probability and statistics.
Engaging students while covering important content is a challenge faced by all teachers. In some cases, combining subject matter provides more avenues to “hook” students, and to differentiate for multiple learning styles by offering more than one way to reach an outcome. The Dream House project crossed multiple disciplines, combined multi-layered daily activities with long-term goals, and used various assessment methods.

This project was a collaborative effort of Mimi Tiderman and Susan Williams, sixth grade teachers at Roosevelt Middle School in Port Angeles, Washington. This project took four weeks and was accomplished as part of the math curriculum, though it integrated elements of geography and language arts.

The unit began with students reading a description of Bilbo’s house in J.R.R. Tolkien’s *The Hobbit*. As a class, they discussed the ways that it was perfectly suited to its environment and its inhabitant.

Next, students were introduced to the idea of dreaming up their own house. They had no limits, including cost. But, they did have to address some specific criteria, such as:

- Where will the house be located? Including the hemisphere, continent, country, state or province (if applicable) and city (in or near).
- Why did you choose to build the house there?
- How have you designed your house to be unique to you and/or its setting?

Students began the project with a pre-design activity. They looked at floor plans from architectural magazines to get ideas and began measuring everything from doorways to bathtubs. In hindsight, the teachers would like to have invited an architect to share actual blueprints with the class.

For the first draft of the project, students had to list all of the rooms they wanted to include and determine the initial layout and shape of the house. Some began with the outside frame and other began by fitting together individual rooms, like a puzzle. As students tried to answer questions about room dimensions, such as square footage, they realized that they lacked some necessary math skills. The classroom atmosphere became one of students saying, “I need to know how to do X” and teachers saying, “Let’s figure it out!” The lessons stuck much better embedded in a real world context.

Mini-lessons arose to teach the difference between linear measurement and area, how to find the perimeter, how to represent architectural characteristics.
in the floor plan. Related lessons included issues of privacy and access as students had to determine whether a room would be accessed through a hallway or private entrance, for example.

The students’ favorite part of the project was shopping for home furnishings. They were charged with completely furnishing three rooms in the house, within a budget of $3,000 to $20,000 for each room. “Furnish” also included flooring, such as hard wood or carpet. Student shopped in catalogs and honed their Internet skills by shopping online. They learned to manipulate photos, comparison shop, figure tax, and balance a budget.

The final product of the Dream House project consisted of an information sheet, which demonstrated students’ knowledge of math concepts, an essay answering the original location and design questions, and drawings/blueprints of the façade and floor plans. The final assessment included a student self-assessment; they were very hard on themselves, especially after seeing other students’ projects.

Some project extensions created options for extra credit.

Students could:

- Build a scale model of their house
- Create a landscaping plan for their house
- Use a computer program (CAD) to input their house dimensions and see if it looked like they thought it would

Students often ask, “Why do I need to know this?” With this project, students participated in deciding what they needed to learn and could make the connection between their work and the world around them.
PRE-DREAM HOUSE DESIGN ACTIVITY!

You will attempt to complete as much of this assignment as possible. At any time you believe that you need more information or need to learn how to do something before you can complete requirements, list them on “I NEED TO KNOW!!” chart below.

Draw floor plans for a bungalow (small house). The following is required:
- **Rooms**
  - 2 Bedrooms
  - 1 Bathroom
  - Kitchen
  - Living room

- A key
  - Show the scale
  - Symbols for windows
  - Symbols for doors

- Show the dimensions and square footage of each room

- Choose the floor covering of your choice for each room
  - Figure the cost of the carpet, etc. that you choose

- Figure the total cost of the house based on total square footage ($89/sq. ft.)

**I NEED TO KNOW:**

1.

2.

3.

4.
DREAM HOUSE PROJECT!

This project will consist of several components, each worked on in class and after explanation. There is no need to work ahead, but you can think ahead!

- Make a **FLOOR PLAN OF YOUR HOUSE** using graph paper. It will consist of 6-20 rooms. Include doors, windows, hallways, fireplaces, etc. using the methods shown in class.

- Include the **SQUARE FOOTAGE** of each room with **DIMENSIONS** written clearly on your drawing.

- **FURNISH 3 ROOMS OF YOUR HOUSE.** To complete this part of the assignment you must have all the following in each room:
  
  A. A page for each room with a catalog or digital picture of the items to be purchased for the room.
  
  B. Create a spreadsheet of expenditures, spending no less than $3,000 and no more than $20,000 per room.

- **DRAW A SIMPLE VIEW** of the front of your house.

- **PURCHASE FLOOR COVERING FOR 3 ROOMS** in your house. Figure the cost for each room using the floor covering form (in packet). Be careful that you are figuring square footage, not square yardage.

- **SUBMIT A HOUSE INFORMATION SUMMARY** with your final project (form in packet).

- **WRITE A HOUSE ENVIRONMENT ESSAY** describing how, where, and why you build your house.

- **STAY UNDER THE TOTAL BUDGET OF $1,500,000** (not including rooms furnished) using the cost of $89.75 per square foot.
**DREAM HOUSE INFORMATION SHEET**

1. **HOUSE ENVIRONMENT**

   Attach an essay in final form explaining:
   - Where you will build your dream house
   - Why you chose to build it there
   - How you have designed your house to be unique to you and/or its setting

   Supply the following information here before you begin your essay:
   - Hemisphere
   - Continent
   - Country
   - State or Province (if applicable)
   - City (in or near)

2. **TOTAL NUMBER OF ROOMS:**

3. **ROOMS AND SIZE** (example: Bedroom #1 is 15 ft. x 18 ft. = 270 sq.ft.)

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<thead>
<tr>
<th>Room</th>
<th>Dimensions</th>
<th>Square Footage</th>
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4. **TOTAL SQUARE FEET:**

5. **TOTAL COST OF CONSTRUCTION:**

6. **TOTAL COST OF FURNISHINGS:**

7. **TOTAL MONEY SPENT:**
The Boat Project
Gena Merliss, Dan Noel, Mit Wanzer, Ann Colligan,
Tanya Bouzy and Derek Brown
Francis W. Parker Charter Essential School
http://www.parker.org/

The Boat Project came about because of the dedication and collaboration between six teachers in the Mathematics, Science, and Technology team at Parker Charter Essential School in Devins, Massachusetts. The Boat Project was a seven-week unit involving 150 students in grades 7 and 8.

The Boat Project was designed to cover the content areas of density, measurement, mechanics, and fluid dynamics, but the teaching team found that communication, career exploration, community connections, and language arts were threaded throughout the project.

Teacher Gena Merliss said the integrated curriculum influenced students’ learning because, “kids could see math and science as one, and they were jumping back and forth between the two without even realizing it. The math became the evidence for their scientific reasoning.”

In terms of the collaboration between staff to build the curriculum, Dan Noel stressed the “ability to have an openness to let your team-members decide what is important to cover in their subject-area, and then working that into the plan.” Having common planning time was crucial for Gena and Dan, as well.

What emerged from all of the collaboration was a unit with solid content and high student engagement with a problem-based frame that students loved. The school hosted a family boat night where the fire department came and brought their rescue boat, and students found local boat owners and interviewed them informally. Then they put their knowledge to the test (after much trial and error on a smaller scale) and built their boats for the big race, which had many challenges, surprises, and rewards.

The three Challenges of the Week (COW’s) that follow demonstrate the seamless blend of math, science, and technology present in this project, but, more than anything else, it is clear just how much fun this project was for students and teachers alike.
Ahoy maties! Your challenge for this term is to design a boat that can carry you. And unless you want to get wet, it better be a good, sound boat! Each student will design a boat and create a small cardboard model of it. On October 20, we will test the boats to see which one carries the most weight. The winner of the contest will receive an exciting prize! Then the class will get to build that boat. The final test will be when we put it in the water with someone inside.

The Learning Goals
In order to advance in academic standing at Parker Charter School, students must demonstrate proficiency in 5 competencies: Math, Science, Humanities, Technology, and Personal Development. The benchmarks needed to reach the competency in science include skills and habits of mind. In the science competency, we address these benchmarks in this term:

Design Process
Propose a design to a given problem or challenge
Implement a solution that conforms to design constraints
Communicate the problem, process, rational and solution

Data and Results
Take scientific measurements
Observe
Construct table of data using Excel
Summarize results concisely

Materials and Methods
Conduct experiments
Communicate experimental procedure
Identify variables
Define variables operationally
Design investigations with appropriate methods of recording and interpreting data

Content
Physical science-fluid mechanics: density, pressure, buoyancy, Archimedes principle, water displacement

Accurately use scientific and technological vocabulary, symbols and models

Demonstrate an understanding of scientific concepts in writing and orally

Identify the relevance of scientific concepts and their connection to real life

Teambuilding
Build a boat with other students
Challenge of the Week #12
Float Your Boat!
Boat: Due March 14th, 2003
Write-up: Due March 17th, 2003

Design Challenge:

Build a boat that can carry the most cargo in your class . . . without sinking!

Be sure to include:

- Fantasy drawing
- Final drawing on graph paper
- Your boat
- Explanation of how concepts of fluid mechanics influenced your design
- Summary and analysis of results

Assessment rubric for COW #12, based on the Parker School Criteria for Excellence and Habits of Learning

1. You understand the problem.
   - you restate the problem in your own words
   - you make connections to class activities

2. You solve the problem.
   - you use graphs, tables, drawings, and modeling
   - you use mathematical and scientific language
   - your work is correct and you have supported it with evidence

3. The work shows effective effort.
   - your approach is efficient or sophisticated
   - your work is well organized and detailed
   - you have completed all parts

4. You go beyond the requirements (exceeding the standards).
   - you formulate a conjecture or a question and follow through with an investigation

Exceeds = all of i-4
Meets = all of i-3
Approaches = some of i-3
Just Beginning = little or none of i-3
You may not live near the Titanic or even the Mayflower, but you can choose any local boat that is significant because of its appearance, strength, speed, or historical or social impact. Once you have chosen your "local wonder" you should visit it, research it and present your findings orally to the class.

Your final presentation should include:

1. Name and description of boat (identify the type of boat, when it was built, describe and explain its parts).
2. Why is this local wonder important, interesting, or significant? What is/was it used for?
3. Approximate size (dimensions, displacement, etc.)
4. Approximate date boat was built.
5. What the boat is made out of? How was it constructed?
6. Multiview drawing of your boat.
7. Interesting facts about your local wonder.

Sample questions to research:

- What are the parts of the boat?
- Why was it built?
- Why did the builders choose the materials they did?
- How much weight can it hold?
- How long did the construction take?
- What is the boat used for?
- Who has owned the boat?

[Assessment Rubric not available]
You are an employee of Quality Boat Systems (QBS), a company that designs boat hulls for carrying people and cars. Like many other boat design companies, QBS has been able to develop cost-effective, high performance hulls by building and testing scale models. Your customers want boats that will speed up their ferry service to and from the cape cod mainland to Martha’s Vineyard. Your team’s challenge is to research how to increase the speed through water by redesigning the boat hull. For COW 14, each student will hand in his/her own written work, but will design the boat in pairs.

Design Challenge:

- Make a Quick-Build according to plans and collect baseline performance data
- Understand how fluid dynamics affects hull speed
- Redesign the model hull to improve its performance
- Test the new design, Collect quantitative data, and calculate percent improvement in performance
- Document your process, design improvement and tests using the steps of the Engineering Design Process
- Explain your rationale for your final boat design, connecting it to what you have learned during this unit

Assessment rubric for COW #14, based on the steps of the Engineering Design Process

1. You identify the need or problem
2. You research the need or problem
   - you examine the current design
   - you explore other options: class, books, magazines, internet
3. You develop possible solutions
   - you brainstorm possible solutions
   - you draw on mathematics and science
   - you present the possible solutions in two and/or three dimensions
4. You select the best possible solution
   - you determine which solution best meets the original requirements
INTEGRATING CURRICULUM: What it Looks Like

5. You construct a prototype

6. You test and evaluate your solution
   - you evaluate whether your solution works
   - you make sure that it meets the design constraints

7. You communicate the solution
   - you state how your solution meets the needs of the initial problem
   - you discuss the pros and cons of your design

8. You attempt to redesign
   - you propose further improvements or ask questions

Exceeds = all of 1-8 and it is connected to what you learned in this unit
Meets = all of 1-8
Approaches = some of 1-8
Just Beginning = little of 1-8
The Ultra 5000 Project
James Mitchell, Patty Blome, and Eileen Ege
The O’Farrell Community School
San Diego, California
http://ofarrell.sandi.net/index.html

The Ultra 5000 Project, formed by an interdisciplinary team at the O’Farrell Community School, combines community involvement, problem-based learning, and career exploration in an exciting, ambitious format with high rewards for students.

The O’Farrell Community School is a pioneer charter school in the San Diego school district. The school serves 1,500 middle school students in six “families” of 250 students each, with a high level of autonomy granted to each family. The families share a common administrative office and CEO, but have control over staffing, scheduling, discipline, assessment and curriculum decisions. Each family has a core of subject-specific and special education teachers, family support teachers, ESL teachers, and instructional aids. Most students remain with the same educational family the entire time they attend O’Farrell.

The Ultra 5000 project was a joint effort by the Horizon Explorers teachers (Family 6), to combine the study of science and the humanities. Enlisting the aid of a forensic scientist, Family 6 created a unit complete with a crime lab, a press center, and a courthouse. The team strived to make the project a simulation of the criminal and judicial system, and the students were asked to select a role in the process to solve a problem/crime. The crime was the theft of a new telescope, the Ultra 5000, during a party at the school. Students selected roles from the following choices:

- Jurors
- Defense Attorneys
- Prosecution Attorneys
- Paralegals
- Bailiff
- Suspects
- Witnesses
- Custodians
- Handwriting Specialists
- Forensic Scientists
- Reporters

Each day the students were given a case update and a task (see sample daily assignment) pertaining to their role. Moving between the crime lab, witness room, attorney room, courthouse, and library, the students would complete their task by working cooperatively and doing research surrounding their role and objective. The project would culminate when the trial ended and the jury reached a verdict.

The Horizon Explorers teachers found that the students were highly motivated by the project, and couldn’t wait to find out what the next layer of the case would be. The teachers also found that having the expertise of a forensic scientist raised the standard of the work and gave the students a
high-stakes audience. Students also contacted community members who held jobs in the roles they were playing for the project.

Through the Ultra 5000 project, students engaged in:

Science - data collection, scientific inquiry, investigative analysis and interpretation;

Social Studies - studying societal institutions, power, authority, and governance, governmental mechanisms, and social justice;

Language Arts - writing for different audiences, purposes, and career applications, reading to learn new information and for career applications, and communicating to a range of audiences for effective delivery.
Sample Project Description:

WHAT HAPPENED?

On Thursday at 6:00 pm there was a party at O’Farrell Community School in room 213 to celebrate the arrival of a new telescope — the Ultra 5000. People from the community, in addition to the school staff, were invited to attend the celebration.

The telescope is a state of the art model that has the power to see the surface of Pluto with perfect clarity. The marvelous part of it is that it weights a mere 15 pounds, which makes it very light and portable. Needless to say, it is extremely expensive.

Sometime during the evening, the Ultra 5000 telescope was stolen. The night custodian, Joe Clean, called the police to report the missing property and possible burglary at 9:57 pm.

There is a guest sign-in sheet, which names most of the guests who were in attendance that night, in addition to their arrival times. A few of the attendees are Sadie Truth, Justin Time, Seth Mefree, and Hope N. Fортhebest.

All of the attendees of the party are suspects. Furthermore, the custodian has not been cleared from being a suspect. The task of solving this crime now rests in the hands of detectives and forensic scientists. They are assigned to collect and examine the physical evidence left in room 213, as well as to sort through the information provided by the suspects and witnesses in their interviews. It is up to them to try to piece together all of the evidence to find out who stole the Ultra 5000 telescope and put the suspect on trial in a court of law.
Sample Project Assignment:

REPORTER

What you need to turn in on April 20th to get an ACCOMPLISHED grade for the Trial of “Who Stole the Ultra 5000?”

You will submit one complete project portfolio containing the following (in order):

- Log of all interviews conducted
- Subject/Date/Time/Location sheets
- Sampling of interviews (at least two)
- Sampling of articles written (derived from interviews) (at least two)
- Sampling of articles written about forensic science (derived from research)
- Journal/collection of daily reflections on Forensic Science

NOTE! Your journal must include reflections on the following questions:
1. What are you learning about the role you have been assigned?
2. How is forensic science affecting your character’s life? Or what have you learned about forensic science?
3. Explain one new hypothesis that you or your team has developed.
Sample Project Assignment:

**PARALEGAL**

**What you need to turn in on April 20th to get an ACCOMPLISHED grade for the Trial of “Who Stole the Ultra 5000?”**

You will submit one complete project portfolio containing the following:

- **Journal/collection of news articles with reflection**
  The pool of reporters will be writing daily news articles and you will need to read them, and reflect on your character’s portrayal, whether or not the information presented is accurate, etc.

- **Journal/collection of daily reflections on forensic science**

  NOTE! Your journal must include reflections on the following questions:
  1. What are you learning about the role you have been assigned?
  2. How is forensic science affecting your character’s life? or What have you learned about forensic science?
  3. Explain one new hypothesis that you or your team has developed.

- In addition to the reflections, create a daily task list for the following day.

- Create a “Joe defense attorney or prosecutor” poster.
Sample Project Assignment:

**HANDWRITING ANALYST**

What you need to turn in on April 20th to get an ACCOMPLISHED grade for the Trial of “Who Stole the Ultra 5000?”

You will submit one complete project portfolio containing the following:

- **Journal/collection of news articles with reflection**
  The pool of reporters will be writing daily news articles and you will need to read them, and reflect on your character’s portrayal, whether or not the information presented is accurate, etc.

- **Journal/collection of daily reflections on forensic science**

  NOTE! Your journal must include reflections on the following questions:
  1. What are you learning about the role you have been assigned?
  2. How is forensic science affecting your character’s life? or What have you learned about forensic science?
  3. Explain one new hypothesis that you or your team has developed.

- **Research paper on the life of a handwriting analyst or a criminologist.**

- **“Joe handwriting analyst or criminologist” poster.**
Sample Daily Assignment for Reporters and Attorneys:

REPORTERS!

The prosecution has just announced a defendant. The defendant will be tried on Wednesday and Thursday of this week.

Your job is to get the scoop! You may question people who were suspects, or witnesses, as well as the attorneys and forensic science team.

You should have a story published on the web at http://165.24.16.243/ by the end of the school day.

ATTORNEYS!

On Friday, the prosecution announced who the defendant will be; now it is time to prepare for trial! The trial is on Wednesday and Thursday of this week.

Today, you have to decide how you are going to defend or prosecute the defendant. In order to do this you need a plan. After developing your plan, you may want to decide who you want to call as a witness in the trial. Practice with them so they know what to expect when on the stand. Also, think about who the other side is going to call for their witness, and how you are going to counter them on the stand.

If you want to call expert witnesses you will need to decide who you are going to call, and for what reason. The expert witnesses are in room 213. Call them and interview them before making a final selection.
The following books were recommended by school practitioners. The reviews are drawn from book jackets, publishers, and websites.

**Designing & Implementing an Integrated Curriculum: A Student-Centered Approach**
Edward T. Clark, Jr. (1997)
Holistic Education Press
http://www.great-ideas.org/clark.htm

Ed Clark, more adeptly than anyone else, has translated the revolutionary insights of systems theory and ecological science into a specific educational agenda for the twenty-first century. In this new and compelling book, he makes it clear that "integrated curriculum" is more than the mere combination of subject areas, and more than another passing educational fad: By examining hidden assumptions about human potential, learning and intelligence, the nature of the universe, and the effectiveness of organizations, Clark demonstrates that the established educational structure is not equipped to cope with the major changes taking place in the world today. He calls for systemic restructuring.

An integrated curriculum begins with important, open-ended questions about student’s places in society, history, their community, and the ecosystem. Integrated teaching is attuned to natural processes of learning, such as constructing meaning and understanding context, relationships, and concepts within a genuine community of learning. Clark explains how, in the technological worldview, isolated facts came to assume undeserved importance; in a systemic, ecological perspective, the purpose of education is not to pile up facts but to cultivate inquiry, meaningful understanding, and direct personal engagement. Surveying the political and economic scene at this time, Clark concludes that such goals are vital to the survival of democratic citizenship. Systemic, ecological thinking is increasingly relevant today because of the complexity and speed of social, cultural, and technological change. Clark quotes Margaret Mead: "Now young people face futures for which their parents culture cannot prepare them." Clark’s integrated curriculum enables students to address their world with imagination, creativity, and purpose, rather than making them passive consumers of textbook and media-packaged information. This is a visionary book, yet firmly grounded in the author’s extensive and successful work with school staffs attempting genuine restructuring.

*Designing and Implementing an Integrated Curriculum* is a powerful curriculum development tool for teachers, schools, and school districts. By using the philosophy, strategies, and models presented in this book, individual teachers, teacher teams, or administrators can design a curriculum
that is integrated, interesting, substantive, provocative, and genuinely
relevant to the concerns and needs of students.
Drawing from the hundreds of workshops that he has conducted over the last
twenty years, Clark examines the assumptions that support traditional
educational designs and proposes a new perspective that is integrated,
ecological, and learner-centered. He then develops the principles of a truly
integrated curriculum framed by a set of universally relevant concepts and
organized around "questions worth arguing about." He concludes with
dozens of real-world examples that illustrate the implementation of the
integrated curriculum in a Chicago-area school.

Dr. Ed Clark is an educational consultant specializing in integrated
curriculum design and site-based educational change. He has been involved
in teacher education for thirty years -- as Director of Teacher Education at
Webster University, as Professor of Environmental Education at George
Williams College, and as an independent educational consultant for the last
fifteen years. A native of Virginia, he and his wife Margaret live in the far
western suburbs of Chicago.

Making Sense of Integrated Science: A Guide for High Schools
Biological Sciences Curriculum Study (2000)
http://www.bscs.org/cp_ids.html

The interconnectedness of natural science disciplines has become
increasingly obvious of late. The "high ground" perspective of observing
Earth from space allows us to see that the individual "-ologies" are really part
of a unified whole: integrated science.

Across the country, we at Biological Sciences Curriculum Study (BSCS)
have heard a consistent message from teachers, schools, and districts that are
thinking about ways to improve science education for their students. In
general, we have found the following:

- Teachers seek a coherent alternative to the discipline-based
  sequence.
- States are establishing standards across the disciplines and teachers
  see a multidisciplinary science program as a way to meet those
  standards.
- Science programs that integrate across disciplines engage a greater
  diversity of learners.
- Science that integrates across the disciplines reflects the unity of the
  natural world.

How can high school teachers best use this concept to enhance their students'
understanding of their natural world? How might schools go about
implementing such a program? Check out our new guide: "Making Sense of
Integrated Science: A Guide for High Schools," which is the result of a study
funded by the National Science Foundation, and can be downloaded in its entirety from our website.

The key features of BSCS Science Inquiry Approach include:

- Rigorous, standards-based content
- Lessons that are activity-based
- Opportunities for structured and open inquiry in relevant contexts
- A constructivist, student-centered approach
- The BSCS 5-E Instructional Model [see website for information]
- A collaborative learning environment
- A comprehensive assessment package
- The use of student science notebooks

Concept-Based Curriculum and Instruction
Teaching Beyond the Facts
H Lynn Erickson, Gonzaga University (2002)
Corwin Press
http://www.corwinpress.com/

"It is the clearest approach I have seen for helping teachers distinguish the difference between concepts and facts. I will recommend it everywhere."
- Heidi Hayes Jacobs, Curriculum Designers, Inc.

"A lucid and helpful volume, very much what people need to move beyond simplistic teaching."
- Grant P. Wiggins, Learning by Design, Inc.

This book is the ideal companion to Erickson’s landmark Stirring the Head, Heart, and Soul, Second Edition. Here, the author explores concept-based learning on a more in-depth level across disciplines and grade levels. Teachers can use the specific strategies to create a seamless learning program that teaches students the skills they really need to think conceptually and to solve problems in today’s complex, changing world.

Learn how to:

- Take learning beyond the facts
- Facilitate deep understanding and knowledge
- Develop conceptual systems in the brain to process new information
- Meet higher academic standards related to content knowledge, process abilities, quality performance, and school-to-work transitions
- Align your curriculum with state and national standards and establish appropriate performance assessments
This excellent resource for K-12 teachers, teacher educators, curriculum designers, and staff developers contains numerous charts and figures that enable readers to put the book to immediate use.

Making Integrated Curriculum Work:
Teachers, Students, and the Quest for Coherent Curriculum
Elizabeth P. Pate, Elaine R. Homestead, and Karen L. McGinnis
Forward by James A. Beane (1997)
Teachers College Press
http://store.tcpress.com/cgi/sc/productsearch.cgi?storeid=tcpress

"Almost every teacher has been confronted by students asking, 'Why do we have to learn this? Rarely, though, do we hear of teachers raising similar questions: 'Why do I have to teach this?' 'What is this for?' 'When will they ever use this?'… This book could stand alone as an example of the kind of reflective teacher research that is presently breathing fresh air into the generally abstract and aloof world of educational inquiry… [or] as a sourcebook on teaching methods… for those who are willing to try some progressive teaching but are not sure how to get started."

– From the Foreword by James A. Beane

Full of real stories and practical suggestions, this book searches for a curriculum that is at once inclusive, democratic, and empowering for teachers, students, and parents. Based on their one-year curricular experiment called the "McHome Team," the authors—two classroom teachers and a university professor—describe their efforts to guide a middle-school class to co-create their own curriculum. Exploring their successes and challenges, the authors examine the implications their approach has for the study of integrated curricula and democratic schooling. Rather than relying on outside sources for curriculum decisions and justifications, the authors suggest that teachers turn to their students and to their own professional judgment to create possibilities for curriculum and teaching.

Introductory chapters are followed by individual chapters on each of the eight essential components of coherent curriculum:

- Goals
- Democratic Classrooms
- Traditional and Alternative Assessments
- Content Integration
- Pedagogy
- Communication
- Scheduling and Organizational Structures
Multicultural Mathematics: Interdisciplinary, Cooperative Learning Activities
J. Weston Walch, Publisher (1993)
http://www.enc.org/resources/records/full/0,1240,003787,00.shtm

Packed full of complex, constructivist activities, this activity book demonstrates how cultures across the globe and through the span of time use(d) math structures to explain, invent, and create their societies. This book would work very well at the ninth grade level with heterogeneous groups working at different paces, but needing to grasp similar concepts.

This reproducible blackline master book of 55 multicultural activities for mathematics is designed as a supplement and enrichment for the mathematics curriculum of the middle and secondary grades. The authors propose to expose students to the mathematics practices of other peoples of the world; to show students how mathematics is applied in science, social studies, art, and sports; and to develop the critical thinking skills of students.

Each activity includes cultural, historical, or other background information as appropriate; an explanation of the pertinent mathematical concept; problems to be solved with examples; an optional THINK ABOUT THIS section to encourage further exploration of the mathematical concept and its relevance to real world situations. Activities frequently are set in the context of real life situations. One chapter is devoted to activities that emphasize developing skills for estimation, approximation, mental arithmetic, and judging whether results are reasonable.

A brief teachers' guide prefaces the book. It includes suggestions for how to use the activities, a concepts and a skills chart relating the activities to the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for grades 5 to 8, and reproducible grids. The book also includes a bibliography for multicultural and global mathematics.
INTEGRATING CURRICULUM: What it Looks Like

Introduction
- Content of activities
- How to use this book
- Concepts and skills chart
- Sequence of activities
- Reproducible grids

Chapter 1: Numbers Old & New
Reproducible activities
- Names for numbers
- All kinds of numerals
- Chinese stick numerals
- Calculating: Roman, Egyptian, and Maya style
- The amazing Maya calendar
- Ancient Egyptian multiplication by doubling
- Counting on the Russian abacus
- Counting on the Japanese abacus
- Fractions in Ancient Egypt, part 1
- Fractions in Ancient Egypt, part 2, Eye of Horus fractions
- Fractions in Ancient Egypt, part 3, unit fractions
- Is zero anything?
- Casting out nines
- More about numbers, Goldbach’s conjecture
- Pythagorean triples

Chapter 2: Using Numbers in Real Life
Reproducible activities
- Rounding numbers
- Big numbers and approximation
- Mental arithmetic, part 1, money in West Africa
- Mental arithmetic, part 2, more cowrie shells
- Mental arithmetic, part 3, African genius
- Benjamin Banneker’s Almanack
- Change in population of four cities
- Growth of the population of the United States
- Spending our money: the federal budget

Chapter 3: Geometry & Measurement
Reproducible activities
- The largest garden plot
- The shape of a house
- The wonderful pyramids of Egypt
- The golden ratio

Chapter 4: Probability, Statistics, and Graphs
Reproducible activities
- What are the outcomes?, part 1, toss a coin or two
- What are the outcomes?, part 2, toss a cowrie shell
- What are the outcomes?, part 3, toss more coins and shells
- What do you eat?
- To smoke or not to smoke, part 1, Why die young?
- To smoke or not to smoke, part 2, Who pays?
- Infant mortality: why do babies die?
- Population of California
- Population of New York state
- Big money
- Where does the money go?

Chapter 5: Fun With Math
Reproducible activities
- The first magic square
- Magic squares: find the mistake
- Four by four magic squares
- More four by four magic squares
- Secret codes with numbers
- Map coloring
- Networks, part 1, Chokwe
- Networks, part 2, Bakuba
- Networks, part 3, more Bakuba
- Three in a row games: Tapatan
- Three in a row games: Picaria

Bibliography for multicultural and global mathematics

Answer key
This book, written by undergraduate or pre-service teacher educators, offers a collection of essays that discuss how students' learning in mathematics and science can be improved through both conventional formal writing and regular informal writing. The forward traces the development of educational philosophy in the twentieth century and places the writing to learn process in an historical context. It also explains the seminal nature of John Dewey's work proposing language and writing as starting points that can be used to enhance the teaching of science and mathematics. The essays emphasize the importance of using writing for advancing, not just testing, student understanding in math and science, and present ideas and strategies designed to give students an understanding of and experience with the writing to learn process. This writing process also aims to enrich students' conceptual understanding, to develop thinking, and to integrate information. A sample article, Writing and Mathematics Theory and Practice, contains a review of recent publications that describe efforts to use writing in the teaching of mathematics and considers the impact of writing activities on the mathematics classroom. Each chapter ends with references. (Author/JRS)

Contents:
Preface
Foreword:
- The ordinary experience of writing, by Leon Botstein
- Writing and the ecology of learning, by Paul Connolly
- Writing and mathematics: theory and practice, by Barbara Rose

Part 1: Defining problems, seeing possibilities
- Using writing to assist learning in college mathematics classes, by Marcia Birken
- Writing to learn science and mathematics, by Sheila Tobias
- Reflections on the uses of informal writing, by Alan Marwine

Part 2: Writing as problem solving
- Writing is problem solving, by Russel W. Kenyon
- Locally original mathematics through writing, by William P. Berlinghoff
- Writing and the teacher of mathematics, by David L. White and Katie Dunn

Part 3: Classroom applications: what works and how
- Writing micro themes to learn human biology, by Kathryn H. Martin
- The synergy between writing and mathematics, by David Layzer
- Exploring mathematics in writing, by Sandra Keith
- Writing to learn: an experiment in remedial algebra, by Richard J. Lesnak
INTEGRATING CURRICULUM

- Writing as a vehicle to learn mathematics: a case study, by Arthur B. Powell and Jose A. Lopez
- Writing in science education classes for elementary school teachers, by Mary Bahns

Part 4: Programmatic policies and practices
- The advanced writing requirement at Saint Mary's College, by Joanne Erdman Snow
- Qualitative thinking and writing in the hard sciences, by William J. Mullin
- What's an assignment like you doing in a course like this?: writing to learn mathematics, by George D. Gopen and David A. Smith

Part 5: The context of learning
- On preserving the union of numbers and words: the story of an experiment, by Erika Duncan
- They think, therefore we are, by Anneli Lax
- Writing and reading for growth in mathematical reasoning, by Hassler Whitney
- The dignity quotient, by Dale Worsley

Part 6: Responses
- Is mathematics a language? by Vera John-Steiner
- A mathematician's perspective, by Reuben Hersh
- About the editors and contributors
- Index
INTEGRATING CURRICULUM

NOTES: