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# THE UNSCHOOLED MIND

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CHAPTER

# 11

# Education for Understanding During the Early Years

Imagine an educational environment in which youngsters at the age of seven or eight, in addition to—or perhaps instead of—attending a formal school, have the opportunity to enroll in a children's museum, a science museum, or some kind of discovery center or exploratorium. As part of this educational scene, adults are present who actually practice the disciplines or crafts represented by the various exhibitions. Computer programmers are working in the technology center, zookeepers and zoologists are tending the animals, workers from a bicycle factory assemble bicycles in front of the children's eyes, and a Japanese mother prepares a meal and carries out a tea ceremony in the Japanese house. Even the designers and the mounters of the exhibitions ply their trade directly in front of the observing students.

During the course of their schooling, youngsters enter into separate apprenticeships with a number of these adults. Each apprentice group consists of students of different ages and varying degrees of expertise in the domain or discipline. As part of the apprenticeship, the child is drawn into the use of various literacies—numerical and computer



languages when enrolled with the computer programmer, the Japanese language in interacting with the Japanese family, the reading of manuals with the bicycle workers, the preparation of wall labels with the designers of the exhibition. The student's apprenticeships deliberately encompass a range of pursuits, including artistic activities, activities requiring exercise and dexterity, and activities of a more scholarly bent. In the aggregate, these activities incorporate the basic literacies required in the culture—reading and writing in the dominant language or languages, mathematical and computational operations, and skill in the notations drawn on in the various vocational or avocational pursuits.

Most of the learning and most of the assessment are done cooperatively; that is, students work together on projects that typically require a team of people having different degrees of and complementary kinds of skills. Thus, the team assembling the bicycle might consist of half a dozen youngsters, whose tasks range from locating and fitting together parts to inspecting the newly assembled systems to revising a manual or preparing advertising copy. The assessment of learning also assumes a variety of forms, ranging from the student's monitoring her own learning by keeping a journal to the "test of the street"—does the bicycle actually operate satisfactorily, and does it find any buyers? Because the older people on the team, or "coaches," are skilled professionals who see themselves as training future members of their trade, the reasons for activities are clear, the standards are high, and satisfaction flows from a job well done. And because the students are enrolled from the first in a meaningful and challenging activity, they come to feel a genuine stake in the outcome of their (and their peers') efforts.

## EDUCATIONAL ENVIRONMENTS FOR YOUNG CHILDREN

A reader's first thought on the possibility of youngsters' attending such an intensive museum program rather than or in addition to the public school may be disbelief. The connotations of the two types of institution could scarcely be more different. "Museum" means an occasional, casual, entertaining, enjoyable outing; as Frank Oppenheimer, founder of San Francisco's Exploratorium, was fond of commenting, "No one flunks museum." "School," in contrast, connotes a serious, regular, formal, deliberately decontextualized institution.

Would we not be consigning students to ruination if we enrolled them in museums instead of schools?

I believe we would be doing precisely the opposite. Attendance in most schools today does risk ruining the children. Whatever significance schooling might once have held for the majority of youngsters in our society, it no longer holds significance for many of them. Most students (and, for that matter, many parents and teachers) cannot provide compelling reasons for attending school. The reasons cannot be discerned within the school experience, nor is there faith that what is acquired in school will actually be utilized in the future. Try to justify the quadratic equation or the Napoleonic wars to an inner-city high school student—or his parents! The real world appears elsewhere: in the media, in the marketplace, and all too frequently in the demimonde of drugs, violence, and crime. Much if not most of what happens in schools happens because that is the way it was done in earlier generations, not because we have a convincing rationale for maintaining it today. The often-heard statement that school is basically custodial rather than educational harbors more than a grain of truth.

Certainly there are exemplary schools, and just as certainly there are poorly designed and poorly run museums. Yet as institutions, schools have become increasingly anachronistic, while museums have retained the potential to engage students, to teach them, to stimulate their understanding, and, most important, to help them assume responsibility for their own future learning.

Such a dramatic reversal of institutional significance has come about for two complementary sets of reasons. On the one hand, youngsters live in a time of unparalleled excitement, where even the less privileged are exposed daily to attractive media and technologies, ranging from video games to space exploration, from high-speed transportation to direct and immediate means of communication. In many cases, these media can be used to create compelling products. Activities that might once have engaged youngsters—reading in classrooms or hearing teachers lecture about remote subjects—seem hopelessly tepid and unmotivating to most of them. On the other hand, science museums and children's museums have become the loci for exhibitions, activities, and role models drawn precisely from those domains that do engage youngsters; their customary wares represent the kinds of vocations, skills, and aspirations that legitimately animate and motivate students.

In previous chapters I have documented some of the difficulties



exhibited by youngsters in coming to understand the topics of school. It is of course possible that, even if one cannot flunk museum, one might fail to appreciate the meanings and implications of exhibitions encountered there. Indeed, I suspect such non- or miscomprehension often happens on "one-shot" visits to museums. An active and sustained participation in an apprenticeship, however, offers a far greater opportunity for understanding. In such long-term relationships, novices have the opportunity to witness on a daily basis the *reasons* for various skills, procedures, concepts, and symbolic and notational systems. They observe competent adults moving readily and naturally from one external or internal way of representing knowledge to another. They experience firsthand the consequences of a misguided or misconceived analysis, even as they gain pleasure when a well-thought-out procedure works properly. They undergo a transition from a situation in which much of what they do is based on adult models to one in which they are trying out their own approaches, perhaps with some support or criticism from the master. They can discuss alternatives with more accomplished peers, just as they can provide assistance to peers who have recently joined the team. All these options, it seems to me, guide the student toward that state of enablement—exhibiting the capacity to use skills and concepts in an appropriate way—that is the hallmark of an emerging understanding.

If we are to configure an education for understanding, suited for the students of today and for the world of tomorrow, we need to take the lessons of the museum and the relationship of the apprenticeship extremely seriously. Not, perhaps, to convert each school into a museum, nor each teacher into a master, but rather to think of the ways in which the strengths of a museum atmosphere, of apprenticeship learning, and of engaging projects can pervade all educational environments from home to school to workplace. The evocativeness and open-endedness of the children's museum needs to be wedded to the structure, rigor, and discipline of an apprenticeship. The basic features I have just listed may assume a central place in educational environments that span the gamut of ages from preschool through retirement and the full range of disciplines.

In this chapter and the next, I review some promising educational ideas. I begin with instances drawn from early education, from education in the preschool and the primary years. At this age, what is most crucial is the opportunity to work intensively with the materials that nourish the various human intelligences and combinations of intelligences. I stress the impact of encompassing milieus, in which the messages of learning and work are manifest and inviting. Meaningful mastery of the basic literacies is most likely to emerge under these conditions. In the concluding sections of this chapter, I turn to education for children in the middle years. This is a time for intensive involvement in apprenticeships with knowledgeable adults and for the opportunity to heighten basic skills in the context of meaningful and rewarding projects.

In the next chapter, I consider some instances of education of older students, for whom disciplinary mastery is the goal. In these cases, it is vital that students have the opportunity to confront directly the disjunctions among the various ways of knowing and to integrate these into the fullest possible understanding. In the case of misconceptions, I recommend a kind of experience that I term a "Christopherian encounter"; where algorithms are applied rigidly, I suggest explorations of the relevant semantic world; with respect to stereotypes, I urge the adoption of multiple perspectives on a task or project.

As far as I can tell, it is not possible for students to skip the various regimens described here. Students of any age who are novices need a period of exploration and a phase of apprenticeship before they can enter more formal learning environments that deal with disjunctions among ways of knowing. The length of these periods can probably be shortened with older students, but the extent to which they can be truncated is not yet known.

Although I describe contrasting regimens for students of different ages and degrees of expertise, I wish to stress that each of these milieus can be adapted for the range of students. Richly stocked environments, skilled "masters," and lessons that mediate among different modes of representation all have their place *across* the educational firmament. Indeed, even though my descriptions of various projects highlight different facets, a number of themes characterize the range of projects described here and should pervade an education for understanding from start to finish. Among these overarching themes are the recognition that children have different intellectual strengths and learn in different ways; that teachers must serve as role models of the most important skills and attitudes and must in a sense embody the practices that are sought; and that meaningful projects taking place over time and involving various forms of individual and group activity are the most promising vehicles for learning. Perhaps most centrally, all these educational programs feature an explicit concern with assessment. Such assessment should



take place, insofar as possible, in the context of normal daily activities of learning; over the course of a youngster's education, assessment in context by others and by oneself should become a regular, increasingly automatic part of the educational experience. The chances that these curricular, pedagogical, and assessment themes will pervade an educational setting is a direct function of the extent to which the genius of the children's museum and the power of the apprenticeship is wedded to the authority and regularity of the school.

I believe that the various experiments and pilot projects described in these concluding chapters can have a beneficial effect on education and that study of these models can be very useful. It is important to stress, however, that it is the incorporation of the ideas, analyses, and understandings on which these projects are based and not the adoption of one or more of their methods that is crucial. Too often, invocation of the label or adoption of the surface practices of an educational innovation is mistakenly taken as evidence that the educational innovation itself has actually taken hold and is achieving its desired effects. A school will not work better simply because it styles itself after a children's museum or institutes reciprocal teaching or mandates the keeping of process-folios. Children will not attain understanding just because they watch masters who exemplify understanding in their own practices. If, however, the reasons underlying such innovations are accepted and teachers and administrators are searching for ways of implementing such innovations, the examples here can prove suggestive.

## THE EXAMPLE OF PROJECT SPECTRUM

In our own work with young children, we have devised an educational approach that at its best blends the strengths of the school and the children's museum. The prototype is Project Spectrum, a form of early childhood education spanning the period from preschool through the early primary grades. Spectrum began as a collaborative assessment effort, carried out in conjunction with my longtime colleagues David Feldman of Tufts University and Mara Krechevsky of Harvard Project Zero. At its inception in 1984, our principal goal was to ascertain whether preschoolers already exhibit distinctive profiles of intelligences; we confirmed that even students as young as four years old present quite distinctive sets and configurations of intelligences. In the course of this research, however, we found ourselves developing a more general approach to early education.

In a Spectrum classroom, children are surrounded each day by rich and engaging materials that evoke the use of a range of intelligences. We do not attempt to stimulate intelligences directly using materials that are labeled "spatial" or "logical-mathematical." Rather, we employ materials that embody valued societal roles or "end-states" drawing on relevant combinations of intelligences. So, for example, there is a naturalist's corner, where various biological specimens are brought in for students to examine and to compare with other materials; this area draws on sensory capacities as well as logical analytic power. There is a storytelling area, where students create imaginative tales using an evocative set of props and where they have the opportunity to design their own "storyboards"; this area evokes linguistic, dramatic, and imaginative facility. There is a building corner, where students can construct a model of their classroom and manipulate small-scale photographs of the students and teachers in the room; this area draws on spatial, bodily, and personal intelligences. Numerous other intelligences, and combinations of intelligences, are tapped in the remaining dozen areas and activities in a Spectrum classroom.

It is highly desirable for children to observe competent adults or older peers at work—or at play—in these areas. Provided with the opportunity for such observation, youngsters readily come to appreciate the reasons for the materials as well as the nature of the skills that equip a master to interact with them in a meaningful way. It is not always feasible to provide such an apprentice-master setting, however, and so "learning centers" have been constructed in which children can develop some facility from regular interactions with these materials even by themselves or with only other novice-level peers. In this sense, our "entry-level" environment is a self-sustaining one that harbors potential for cognitive and personal growth.

Over the course of a year or more spent in this nourishing environment, children have ample opportunity to explore the various learning areas, each featuring its respective materials and its unique set of elicited skills and intelligences. Reflecting the resourcefulness and curiosity of the mind of the five-year-old, most children readily explore the majority of these areas, and children who do not cast their nets widely are encouraged to try out alternative materials or approaches. For the most part the teacher can readily observe a child's interests and talents over the course of the year, and no special



assessments are needed. For each domain or craft, however, we have also devised specific games or activities that allow a more precise determination of the child's "intelligences" in that area.

At the end of the year, the information gathered about each child is summarized by the research team in a brief essay called a Spectrum Report. This document describes the child's personal profile of strengths and weaknesses and offers specific recommendations about what might be done at home, in school, or in the wider community to build on strengths as well as to bolster areas of relative weakness. Such informal recommendations are important. In my view, psychologists have traditionally been far too concerned with norming or ranking; comparable efforts throughout the school years should help individual students and their families make informed decisions about their future course, based upon a survey of their capacities and options.

Over the last several years, Spectrum has evolved from a means of assessing strengths to a rounded educational environment. In collaboration with classroom teachers, we have developed curricular materials in the form of theme-related kits that draw on the range of intelligences as they may figure in the development of a broad theme such as "Night and Day" or "About Me." With younger children, these curricula are used primarily in an exploratory mode. With older children, they are tied more closely to the traditional goals of school, promoting preliteracy or literacy attitudes, approaches, and skills. Thus children encounter the basics of reading, writing, and calculating in the context of themes and materials in which they have demonstrated interest and an emerging expertise. As they gain proficiency in a board game, for example, children can be introduced to numerical tally systems, and as they create adventures at the storyboard, they can begin to write them down as well as recite or dramatize them.

The adaptability of Spectrum has proved to be one of its most exciting features. Teachers and researchers from several regions of the country have used Spectrum as a point of departure for a variety of educational ends. The Spectrum approach has been adapted with children ranging in age from four to eight, for purposes of diagnosis, classification, or teaching. It has been used with average students, gifted students, handicapped students, and students at risk for school failure, in programs designed for research, for compensatory purposes, and for enrichment. Just recently it has been made the center of a mentoring program, in which young children have the opportunity to work with adults from their neighborhood who exemplify different combinations of intelligences in their jobs. One of my delights as a researcher-turned-implementer has been to sit in on discussions among people who have never met each other but who have adapted Spectrum to their varied needs. It seems clear from such conversations that the Spectrum school-museum blend is appropriate for young children of very different interests, backgrounds, and ages.

In our own work we have made explicit the ties to the children's museum. Working with the Boston Children's Museum, we have transformed our theme-based kits so that they can be used at home and in the museum as well as at school. The home and school furnish regular stimulation, while the museum provides the opportunity to encounter a related display in an awe-inspiring setting, such as the moon and the stars viewed in a planetarium. It is our hope that encountering a similar cluster of themes, materials, and skills in disparate settings will help children to make this cluster their own; we speak of a "resonance" among these milieus that ultimately leads to the child's internalization of important understandings.

Naturally this kind of cross-fertilization works best when children have the opportunity to visit the museum regularly. Thus we are excited by the installation directly in the Washington, D.C. Capital Children's Museum of a Spectrum-inspired Model Early Learning Preschool Classroom—an ambitious melding of school and museum. But even when visits are less frequent, a well-prepared class of students can profit from the opportunity to interact with skilled professionals at a children's museum, particularly if they then have the opportunity to revisit related experiences and lessons on a more leisurely basis at home or at school.

Spectrum has shown particular power in identifying talents and inclinations that are typically missed in the regular school. Donnie (as I'll call him) was a six-year-old who was highly at risk for school failure. The product of a broken home with more than its share of violence and substance abuse, he was having such difficulty in the tasks of first grade that by the second month, his teacher had reluctantly concluded he would have to be retained.

In Project Spectrum, however, Donnie excelled at the assembly tasks. He had greater success in taking apart and putting together common objects, like a food grinder and a doorknob, than any other student his age. (Indeed, most teachers and researchers fail to match Donnie's skilled and seemingly effortless achievements in these mechanical tasks.) We videotaped Donnie's impressive performance and showed it to his teacher. A thoughtful and dedicated person, she was overwhelmed. She had difficulty believing that this youngster, who experienced such trouble with school-related tasks, could do as well as many adults on this real-world endeavor. She told me afterwards that she could not sleep for three nights; she was distraught by her premature dismissal of Donnie and correspondingly eager to find ways to reach him. I am happy to report that Donnie subsequently improved in his school performances, possibly because he had seen that there were areas in which he could excel and that he possessed abilities that were esteemed by older people.



In addition to identifying unexpected strengths in young students, Spectrum can also locate surprising difficulties. Gregory was an excellent student in first grade, apparently destined for a bright scholastic future. In the terms of this book, he displayed skill in the acquisition of notational and conceptual knowledge. He performed poorly, however, across a number of Spectrum areas. His teacher felt that Gregory was able to perform well only in situations where there is a correct answer and where a person in authority had somehow indicated to him what that answer is (an anticipation of the correct-answer compromise). The Spectrum materials posed problems for Gregory because many of the activities are open-ended and do not harbor any evident correct answers; he was thus frustrated and looked to the teacher or to other students for clues about what he should do. As a result of his participation in Spectrum, Gregory's teacher began to look for ways to encourage him to take risks, to try things out in new ways, to acknowledge that there are not always correct answers, and to appreciate that any response entails certain advantages as well as certain costs.

It is important to stress that Spectrum is an emerging approach to early education rather than a finished program. We do not know how successful it can be as a total approach to early education, nor to what extent it can "trickle up" to the older elementary grades. We do know that it is valued by students, parents, and teachers; that its assessments yield quite varied cognitive profiles even among young children; and that its core materials and concepts can be adapted in any number of ways across several populations.

I have described a general approach to education—an amalgam of features of school and museum—and one particular instance of its use with young children, Project Spectrum. When such education has been implemented successfully, young students gain competence and self-assurance in areas where they have potential. At their youthful level of development, it seems appropriate to speak of understanding, for the children are fusing sensorimotor and symbol-using capacities in ways meaningful to the domains in which they are working, and these incipient forms of understanding relate to meaningful adult roles such as mechanic, storyteller, or architect. These understandings build upon intuitive theories; rather than directly challenging them, they temper those theories in the light of practices that are valued in the society.

Anyone familiar with educational practice will appropriately point out that these features are by no means unique to our Spectrum program. Identical or related practices have been observable in sites of good progressive education for the better part of the century. In the case of preschool education, they can be seen in Montessori classrooms, High-Scope classrooms, and other programs influenced by Piaget and Dewey, as well as in their forerunners, such as the classes inspired by Friedrich Froebel and Johann Pestalozzi. I consider this confluence a happy development, one that increases the likelihood that research-based approaches like Spectrum can assume their place in the education of young children.

At the same time, it is important to point out features that make Spectrum distinctive: a theory grounded analysis of student strengths, a concerted effort to relate these strengths to meaningful adult roles, the creation of curricular materials and learning centers that foster these strengths in a natural way, and the development of assessment procedures that can provide reliable information about, and yield pertinent recommendations for, a student's profile of capacities at a given moment in his development. These features not only produce an early education with a distinctive flavor; they also allow children's intuitive theories to be tested out in a comfortable setting, and they encourage a smooth transition to the introduction of basic skills and literacies during the elementary grades.

## DEVELOPING LITERACIES IN THE EARLY SCHOOL YEARS

Recently, several approaches that grow out of developmental research have also been applied to the education of young children. Rather than seeking to cover the whole educational landscape, I will focus here on a number of specific areas of the curriculum.

While there are still reasons for introducing youngsters to the world



of print through drill and through a focus on phonics, a one-sided stress on this approach makes less sense nowadays. Too many children have little sense of *why* one should read, because they reside in environments where the adults do not read. Notably, a number of programs, typically termed "whole-language" approaches, have proved successful at setting a context for literacy activities while at the same time helping students to acquire the basics that will allow them eventually to read and write on their own.

The fundamental idea of whole-language programs is to immerse children as early as possible in the world of text and to allow them to become meaningful apprentices to competent literate individuals. From the first days of school, students see the elders around them read and write and are drawn into that milieu as expeditiously as possible. They tell stories and have others write them down; they make their own storybooks out of a combination of pictures, invented spelling, and dictated correct spelling; they "read" their stories to others and listen to, comment critically upon, or even "read" the stories written by others; they may type out their own narratives on a computer keyboard. The atmosphere more closely resembles a newspaper or magazine editorial center than an old-fashioned teacher-dominated classroom.

Such a program can work only if teachers embody these approaches and these values in their own lives. It is heartening to report, therefore, that classes filled with student writing and "prewriting" exemplify what is probably the major change in American elementary education over the past quarter century. A whole-language emphasis is far from being a universal practice, but it is being used in many places where it was not seen a decade or two ago.

I believe that this small-scale pedagogical revolution has occurred because teachers themselves have discovered (or rediscovered) not only that they can write but that they actually *like* to write. This spirit is of course infectious, and children are soon drawn into the excitement about letters, words, and meanings. Similar effects are at work in reading. Children read not because they are told—let alone ordered!—to read, but because they see adults around them reading, enjoying their reading, and using that reading productively for their own purposes, ranging from assembling a piece of apparatus to laughing at a tall tale. Fundamental experiences that may in earlier times have been restricted to children reared in highly literate households are now made available to all the youngsters in the school.

Setting an appropriate classroom tone is crucial for other areas of the curriculum as well. Just as American educators have relied too exclusively on phonics while neglecting the *reasons* for reading, there has been a tendency to treat arithmetic as a set of number facts to be memorized. Although this approach may result in somewhat higher scores on tests of basic arithmetical knowledge, it is ultimately self-defeating, because students do not understand the reasons for undertaking these activities that involve numbers.

A fresh approach that echoes "whole language" makes mathematics part of the overall atmosphere of the primary school. Numbers and numerical operations enter the ordinary, meaningful conversation among youngsters and between youngsters and teachers. From the start, children in "whole-math" environments are encouraged to engage in games that involve measuring, counting, and comparing, not merely to rehearse number skills but also to help out in activities that are needed and valued. Kitchen-based experiences like cooking serve as an excellent context, for arithmetical operations constitute a ready and readily understandable part of preparing and then serving a meal to a class. Telling time, going on a trip, buying food and favors for a party, and measuring clothing are but a sampling of the many other activities of consequence that call for the use of numbers. Intriguingly, once children become involved in such apparently pragmatic activities, many of them will go on to acquire—or reacquire—a fascination with the world of numbers and numerical relationships per se.

The same general approach can be used to involve students in the ways of thinking characteristic of science. Unlike the case of verbal and numerical literacy, there has not really been a strong competing vision of science in the early years of school; rather, science has generally been postponed until the years of middle and high school. Such a delay is not necessary, however, and may represent a missed opportunity; as Piaget convincingly demonstrated, scientific habits of mind in many ways fit quite comfortably with the interests and curiosity of young children. The challenge is to mobilize these interests in areas of concern to working scientists, such as the classification of the animal world, the means whereby machines operate, or the paths followed by astronomical bodies.

Perhaps most important for such early science or pre-science training is the serious cultivation of a reflective attitude. Young children very naturally raise questions: "Why do I have a shadow? What makes my shadow long? Why do I sometimes have two shadows?" By the same token, such youngsters are fascinated by the phenomena of





growth in plants and animals; by life, death, and illness; by concepts like time and space; by apparatuses like levers, gears, and computers. The scientifically oriented teacher not only encourages such questioning but also reinforces the inclination to observe, to try out small-scale experiments, to note the results of these experiments, and to relate them back to the question that motivated them initially.

For the most part, early science education need not directly address the students' misconceptions. Such a confrontation can occur later on; in fact, it should await the time when the child has been thoroughly immersed in the phenomena that science addresses and has taken her intuitive theories and concepts as far as they can go.

Sometimes, however, it is appropriate to engage children's intuitive conceptions. For example, most young children believe that a sweater contains heat, which it then transfers to the body of its wearer. With such youngsters one can carry out small-scale experiments in which the temperatures of sweaters and persons are independently measured. One can have children leave a thermometer inside a sweater for several days and monitor its changing temperature; one can place the sweater in a sealed bag, or in the sun, and observe its temperature; one can also wear a sweater (or some other garment) for an hour, or place it upon a pet, and observe its changing temperature. In the course of such readily executed investigations, the earliest theories of matter and theories of heat are first articulated, then brought to bear upon the results of appropriate investigations, and finally modified as warranted by the evidence. To be sure, students are unlikely to abandon early theories simply because they have encountered one discrepant demonstration, but the habits of mind developed through such a critical testing of one's intuitive predictions should serve them well in subsequent science education.

Although I have divided these examples into the familiar categories of reading, writing, arithmetic, and science, there is no reason whatsoever for these divisions to be maintained within the classroom. Often, in the style cultivated by progressive education earlier in the century, it makes sense to feature overarching multifaceted thematic units that occupy a dominant physical space in the classroom as well as the better part of the day. A unit on water, for example, provides opportunities for exploration in virtually every area of the curriculum. Students can write about their own beliefs and feelings about water and enjoy classic and humorous texts on the subject. Activities using water can draw on all kinds of counting, measuring, and comparing activities. Historical and geographical issues arise naturally, as students consider the organization of cities around bodies of water and the many disputes that have arisen over the years about access to sources of energy and transportation routes as well as more recent concerns about waste disposal and long-term droughts. Finally, water naturally raises a host of questions that students can investigate in a scientific manner, ranging from the sources and composition of water to the reasons for its flow, its capacity to carry out work, and such phenomena as showers, puddles, evaporation, and conversion to steam or to ice.

While perhaps fun for students, a unit on water does not in and of itself constitute a pedagogical revolution. One cannot assume that students will connect these various facets of water with one another, nor that a multidisciplinary approach is necessarily more exciting or more effective than a univocal perspective. But such a central subject at least makes it possible for teachers to point up the relationships among various facets of a many-sided topic and for students to begin to relate in their own minds the often disparate shards of knowledge encountered in the course of the school day. Students also invest sufficient time in a subject so that they can begin to examine it from several perspectives. While the purpose of these related activities need not be a direct onslaught upon intuitive theories, misconceptions, and stereotypes about the universe of liquids, the by-product is often a more critical stance toward received opinions about various realms of knowledge.

Well executed, a classroom unit on water does more than adding to the child's basic skills in literacy, numeracy, social studies, and science; it constitutes a powerful example of what it is like to use such skills in the prosecution of meaningful activities, activities that can be informative and enjoyable in the manner of an effective exhibit at a children's museum. Moreover, if the school-based activities are integrated sensitively with the more intuitive forms of knowing, it is possible to minimize the unfortunate disjunction between ways of representation that can so cripple subsequent learning.

## MIDDLE CHILDHOOD: APPRENTICESHIPS AND PROJECTS

Some of the approaches that have proved effective with younger children can also be drawn upon in middle childhood, when students are encountering the broader range of disciplines in a more systematic



way. As before, I begin with examples from our own studies, mentioning other related work as well.

The Key School is an unusual inner-city public elementary school in Indianapolis, Indiana. One of its founding principles is the conviction that each child should have his or her multiple intelligences ("MI") stimulated each day. Thus, every student at the Key School participates on a regular basis in the activities of computing, music, and "bodily-kinesthetics," in addition to theme-centered curricula that embody the standard literacies and subject matter. The school reflects the design and the desires of its faculty; I have been an informal adviser since its initial planning in the middle 1980s.

While an "MI curriculum" is its most overtly innovative aspect, many other facets of the school also suggest an education that strives toward understanding. Three practices are pivotal. First, each student participates each day in an apprenticeship-like "pod," where he works with peers of different ages and a competent teacher to master a craft or discipline of interest. Because the pod includes a range of ages, students have the opportunity to enter into an activity at their own level of expertise and to develop at a comfortable pace. Working alongside a more knowledgeable person, they also have what may be a rare opportunity of seeing an expert engage in productive work. There are a dozen pods, in a variety of areas ranging from architecture to gardening, from cooking to "making money." Because the focus of the pod falls on the acquisition of a real-world skill in an apprenticeship kind of environment, the chances of securing genuine understandings are enhanced.

Complementing the pods are strong ties to the wider community. Once a week, an outside specialist visits the school and demonstrates an occupation or craft to all the students. Often the specialist is a parent, and typically the topic fits into the school theme at that time. (For example, if the current theme is protection of the environment, visitors might talk about sewage disposal, forestry, or the political process of lobbying.) The hope is that students not only will learn about the range of activities that exist in the wider community but in some cases will have the opportunity to follow up a given area, possibly under the guidance of the visiting mentor. One way of achieving this end is through participation in a Center for Exploration at the local Indianapolis Children's Museum; students can enter into an apprenticeship of several months, in which they can engage in such sustained activities as animation, shipbuilding, journalism, or monitoring the weather.

The final, and to my mind most important, avenue for growth at the Key School involves student projects. During any given year, the school features three different themes, introduced at approximately ten-week intervals. The themes can be quite broad (such as "Patterns" or "Connections") or more focussed ("The Renaissance—Then and Now" or "Mexican Heritage"). Curricula focus on these themes; desired literacies and concepts are, whenever possible, introduced as natural adjuncts to an exploration of the theme.

As part of school requirements, each student is asked to carry out a project related to the theme. Thus students execute three new projects each year. These projects are placed on display at the conclusion of the theme period, so that students have an opportunity to examine what everyone else in the school has done (and they are very interested in doing so!). Students present their projects to their classmates, describing the project's genesis, purpose, problems, and future implications; they then answer questions raised by classmates and by the teacher.

Of special importance is the fact that all project presentations are videotaped. Each student thus accumulates a video portfolio in which his succession of projects has been saved. The portfolio may be considered as an evolving cognitive model of the student's development over the course of his life in the Key School. Our research collaboration with the Key School has centered on the uses that might be made of these video portfolios.

In the course of their careers in the American schools of today, most students take hundreds, if not thousands, of tests. They develop skill to a highly calibrated degree in an exercise that will essentially become useless immediately after their last day in school. In contrast, when one examines life outside of school, projects emerge as pervasive. Some projects are assigned to the individual, some are carried out strictly at the individual's initiative, but most projects represent an amalgam of personal and communal needs and ends. Although schools have sponsored projects for many years and the progressive era featured an educational approach called the "project method," such involvement in projects over the years has been virtually invisible in records of a child's progress.

Here our research team has sought to make a contribution. We believe that projects are more likely to be taken seriously by students, teachers, parents, and the wider community if they can be assessed in a reasonable and convenient way. We have therefore sought to construct straightforward ways of evaluating the developmental so-





phistication as well as the idiosyncratic characteristics of student projects.

According to our analysis, every project can be described in terms of several separate dimensions. Some of these dimensions can be thought of in terms of developmental levels; one would expect beginning students to exhibit the performance of a novice and students with more experience to advance toward the level of journeyman or even master. Assuming such a developmental perspective, one can ask of the project: How well is it conceptualized? How well is it presented? How well has it been executed in terms of technical facility, originality, and accuracy? To what extent, and how accurately, is the student able to assess the project on these criteria? It is possible to secure reasonable consensus on such evaluations, and the fact that projects can be so described and evaluated allows them to be considered seriously by the entire community rather than being dismissed as a frill.

A developmental evaluation of projects is valuable, but other dimensions merit consideration as well. We have focused on two other facets. One is the extent to which the project reveals something about the student himself—his own particular strengths, limitations, idiosyncracies, and overall cognitive profile. The other is the extent to which the project involves cooperation with other students, teachers, and outside experts as well as the judicious use of other kinds of resources, such as libraries or computer data bases.

Students are not graded up or down if projects are more individualistic or more cooperative. Rather we describe projects in this way because we feel that these features represent important aspects of any kind of project in which a person will ever participate, aspects that should be noted rather than ignored. In particular, in working with others, students become sensitive to the varying ways in which a project can be conceived and pursued; moreover, in reflecting upon their own particular styles and contributions, students receive a preview of the kinds of project activities in which they are most likely to become involved following completion of school.

The other form our involvement has taken concerns the preparation of projects. Somewhat naively, researchers and teachers originally thought that students could readily create and present projects on their own. In the absence of help, however, most projects either are executed by parents or, if done by children, are pale imitations of projects already carried out before or observed elsewhere. Particularly common are book reports or television-style presentations in front of displays resembling weather maps. If students are to conceptualize, carry out, and present their projects effectively, they need to be guided—"scaffolded" is the term of choice—in the various phases and aspects of this activity.

Far from undermining the challenge of making one's own projects, such support actually makes participation in projects possible and growth in project-execution abilities likely. Just as students benefit from apprenticeships in literacy or in a craft, discipline, or pod, so too they benefit from an apprenticeship in the formulation and execution of projects. Some students are fortunate enough to have had this apprenticeship at home or in some community activity, such as organized sports or music lessons. But for the vast majority who have not had such opportunities, elementary school is the most likely place where they can be apprenticed in a "project" way of life—unless they happen to go to graduate school fifteen years later!

The course of project construction gives rise to opportunities for new understanding. A project provides an opportunity for students to marshal previously mastered concepts and skills in the service of a new goal or enterprise. The knowledge of how to draw on such earlier forms of representation or understanding to meet a new challenge is a vital acquisition. Planning the project, taking stock along the way, rehearsing it, assembling it in at least tentatively final form, answering questions about it, and viewing the tape critically should all help to enhance the student's understanding of the topic of her project, as well as her own contributions to its realization.

These features of the Key School point up some aspects of understanding during the period of middle childhood. To an immersion in a richly furnished environment one now adds a more or less formal apprenticeship; skills are acquired in a domain-appropriate form, and the purposes and uses of these skills remain vivid in the consciousness of the apprentice. At the same time disciplines are encountered not in an isolated form that provides little motivation but rather as part of a continuing involvement in encompassing themes that reverberate throughout the curriculum of the school. The student's emerging knowledge and skills are mobilized in the course of executing a project of her own devising, which has meaning for herself, for her family, and within the wider community. Such skills and projects are assessed as much as possible within the context of daily school activities, the assessment involving not only the teacher but also peers and, increasingly, the student herself. The student comes to view the project from a variety of perspectives, as it speaks to a variety of



audiences and as she observes it evolving, often in unpredictable ways, over the course of time.

I must point out that the picture I have painted is an idealized one. Neither apprenticeships nor projects, in and of themselves, guarantee an education for understanding. Apprenticeships can be occasions for copying or for goofing off; projects can be assembled hurriedly on the last day and can draw heavily on the child's own previous work or the work of a friend or classmate. Some materials must be learned by drill; others are more readily presented by classroom lecture or by textbook reading rather than by hands-on, museum-style activities or by participation in an apprenticeship arrangement. What I call for is not the wholesale abolition of current educational practices but rather the shrewd and judicious introduction of apprenticeships and projects in contexts where their strengths can pay off. When these approaches are pursued over a significant period of time, they should lead to an education that makes sense to the various participants and that leads to more robust and more flexible forms of learning.

Even as the recommended procedures do not constitute a panacea, the Key School and others now being designed along its lines are not utopias. Not all students participate equally in the program, and not all benefit equally from its particular methods. Yet, at its best, this school demonstrates that an education for understanding may be possible even in less favorable settings in America today.

## SCHOOLING FOR UNDERSTANDING IN MIDDLE CHILDHOOD

Surveying the country, one encounters numerous other experimental programs that seek to involve the broad range of students in significant projects and aim for an education suffused with understanding. Among those that have recently attracted attention are the schools designed by Henry Levin for accelerated learning and the schools conceived by Stanley Pogrow that seek to develop higher-order thinking skills; both of these programs stress inquiry, discussion, and reflection.

Some of such programs are focused particularly on the acquisition of literacies. Researchers at the University of California at San Diego have for a number of years sponsored an innovative after-school program in which at-risk students work together at microcomputers to carry out various projects, from mastering systems of logic to editing their own newspaper. Among the special features of this program are its satellite linkages to other children all over the world, from Alaska to the Soviet Union. Investigations carried out in class and stories created for the class newspaper have significance not just for the person sitting in the next aisle but for groups located halfway around the world, and computer linkages are the optimal way for such communication to take place. Because the students at both ends of the terminal are strongly motivated to communicate their ideas to others and to comprehend what the others have created, misunderstandings can be nipped in the bud and understandings can arise in the natural course of events. In "Star School" programs, which are similar, students at different sites communicate by satellite with one another and with scientific experts as well, in a joint effort to collect data relevant to global problems, such as the incidence of acid rain or radon in the environment; here language barriers can be readily transcended.

Face-to-face group processes are a major feature of another approach that seeks to enhance literacy in middle childhood. Called "reciprocal teaching" or "reciprocal learning," this approach features a group of students reading a text together, initially under the guidance of a trained teacher. At first the teacher demonstrates the various stances and approaches that one can assume vis-à-vis a text. She articulates the gist of the text, raises questions that occur to her, clarifies possible misunderstandings, and conveys her impression of what might happen next. As rapidly as possible, the teacher relinquishes her central role as a model and the students themselves start to assume the various stances that she has demonstrated. Still, she remains present, ready to provide help to students at their own particular level of competence and to "scaffold" the group to more proficient levels of literacy.

As reciprocal teaching proceeds, each student in turn assumes the roles initially modeled by the teacher, including reading a portion of the text aloud to their peers. In the course of ensuing exchanges, the student assumes a variety of roles: questioner, summarizer, clarifier, skeptic, arguer, thereby having the opportunity—indeed, the obligation—to approach the text in many different ways and to represent it mentally in diverse forms as well. Students learn to work together and to construct meanings together. These roles serve as monitoring devices, indicating which students are beginning to understand and which ones remain confused. Teachers intervene when the students



encounter pronounced difficulties and when it is time to introduce new challenges. Rather than seeing a text as a single kind of entity, to be read and absorbed in one way, students now approach it as a congeries of meanings, which emerge as a result of the various interactions among and interpretations provided by students. Most happily, students who participate in reciprocal reading gradually become able to internalize the various roles, so that they can use them even when they are approaching a text on their own, without the benefit of modeling teachers or collaborating peers.

Collaborative procedures like reciprocal teaching have also proved beneficial in other domains of literacy. As early as the first grade, Japanese students are posed arithmetical problems of some complexity and allowed up to a week to solve the problems. They are encouraged to work together, to criticize one another's approaches, and to try out different roles vis-à-vis the problem. Teachers deliberately avoid serving as a source of answers, although they may coach, direct, or probe in various ways. Not only do students come to appreciate early on that mathematics is an active process—what James Greeno calls a "conversation"—but they discover the advantages that can be derived from interacting with their peers, each of whom may have a distinctive contribution to make to the problem-solving process.

One of the most ambitious recent attempts to bolster mathematical understanding at the middle school level has been undertaken by teacher-researcher Magdalene Lampert. Working for a year with fifth-graders in an ordinary American public school, Lampert has sought to transform the students' entire approach to mathematics from a subject where students look for rules, right answers, and teacher approval to a discipline where together they learn to raise questions, put forth hypotheses about underlying principles, and explore the whole arena of mathematical meaning. The teacher's role is to alter the social discourse in the class by initiating and supporting interactions that exemplify mathematical argumentation of the sort carried out by mathematicians and others who use mathematics in their everyday lives. In terms used earlier, a transition occurs from the pursuit of the correct-answer compromise to the undertaking of risks for understanding.

In a representative lesson, students are challenged to discern the patterns that may exist among the squares of numbers ranging from 1 to 100. No specific problem is posed, and no specific answers are given. Students are encouraged to think aloud, to describe any pattern they discover, and to define and argue with one another about the meanings of those patterns. Norms evolve about the proper and improper ways of putting forth ideas and arguing about their plausibility. (An acceptable format would be "I want to question so-and-so's hypothesis"; an unacceptable format would be "That's a stupid idea that doesn't make any sense.") Students are encouraged to spell out and defend their ideas; various graphic or gestural representations vivify their conjectures. When the lesson works well, students arrive with little guidance at key ideas about how exponents work. They make distinctions between exponentiation and multiplication and discover new procedures for solving problems and for discerning fresh relationships. Lampert reports that, in one implementation of this particular lesson, fourteen out of eighteen students expressed at least one mathematically substantial notion about exponents.

Many of these innovations can be implemented using materials that have been available for decades; but increasingly, new technologies are being utilized in conveying middle school curricula. John Bransford and his colleagues at Vanderbilt University have used a well-designed videodisk, linked to a personal computer, to introduce students to the basic ideas of algebra. *Jasper* relates the story of Jasper Woodbury, who, using only a specified amount of money, must purchase a boat, fill its fuel tank, and then return home on the boat before dark. In helping Jasper achieve his goal, students arrive in a natural way at posing and then attempting to answer many of the questions and procedures of elementary algebra. Considerations involving fractions and decimals arise naturally as students deal with volume, time, and distance. In addition, information from related disciplines, including geography and science, crops up as students interact with a medium they enjoy and in which they can come to feel expert.

Working in a similar vein, my colleague Joseph Walters at Harvard provides students with a data base of information about each of the Irish immigrants who arrived on a certain ship in Boston Harbor in 1850. Students adopt a family and make decisions for its welfare, in the process not only utilizing a variety of mathematical operations but also gaining more intimate acquaintance with many historical, economic, and social issues that immigrants confronted during the last century. In related activities, students read journals kept by these families and go on to create at their computer a desktop version of *The Pilot*, the Boston newspaper that served the newly emerging Irish community. As in the case of *Jasper*, the *Immigrant* unit is a child-friendly way of covering large portions of the middle-school curriculum and involving students actively in processes that lead to a more rounded understanding.



Although youngsters typically find such technology-based activities engaging and motivating, their use raises a number of questions. First of all, is one simply making use of the latest gimmick in an effort to capture students' attention? An affirmative answer to this question does not necessarily detract from its utility; after all, gaining the interest of students ought to be a high priority for educators. And if these technologies are more consistent with the students' lives outside of school, then it is simply shortsighted to pretend that the situation does not exist. As I noted in Part II, attempts to insulate the school from the potent effects of the mass media and the consumer society are problematic; it is far better to recognize these factors and attempt to marshal them productively than to ignore them.

A second question has to do with costs. In some cases—*Jasper*, for example—the initial investment in technology is expensive. Until the costs come down, such materials cannot be used widely. The *Immigrant* package, however, is designed to be used on the Apple II-E, the most widely stocked personal computer in American classrooms. The problem with *Immigrant*, then, is not its cost but rather whether teachers feel comfortable using it and whether they can provide the proper support.

The most important question, of course, is whether such technological prosthetics actually improve classroom performance and lead to deeper understandings. The results here are still not definitive, because, not surprisingly, some innovations lead to dramatic effects while others have little or no impact on significant forms of understanding. Even with respect to Logo, the most widely used computer language in American schools, the verdict on educational effectiveness is not in.

My own view is that a well-trained and effective teacher is still preferable to the most advanced technology, and that even excellent hardware and software are to little avail in the absence of appropriate curricula, pedagogy, and assessment. Still, other things being equal, the capacity to immerse oneself in a problem using the latest technology and to be able to manipulate data or events electronically can make a significant contribution to student learning. As with the other educational experiments discussed here, it is not the use of a project like Spectrum or a computer program like *Immigrant* in itself that produces understanding. Rather, such educational interventions are viable to the extent that they can heighten exploration, apprentice-like and cooperative relationships, multiple representations of data, and the assumption of different roles.

Clearly, the kind of school that I am recommending—one filled with apprenticeships, projects, and technologies—differs significantly from the schools of yesterday and of today. In many ways, it more closely resembles a children's museum than the one-room schoolhouse of 1850 or the mass-produced comprehensive school of 1950. It is quite likely that students will prefer this more dynamic and engaging educational environment, but unless that environment yields stronger and more robust understandings, it will not have fulfilled its purpose.

In my view, experiments conducted so far suggest that enhanced understandings may indeed emerge under such circumstances. The kinds of environments for which I am calling encourage students to represent knowledge in a number of different ways, to begin to adopt the roles that are ultimately occupied by skilled adult practitioners, and to engage in the kind of self-assessment that allows one ultimately to take responsibility for one's own learning. Involvement in significant projects and regular discourse with one's peers increase the possibility that one's own stereotypes and misconceptions will be challenged and that a more realistic and comprehensive perspective will begin to emerge. Such a process of reflection on one's own assumptions is crucial if students are to benefit from discipline-centered instruction in secondary school and beyond.



# CHAPTER 12

# Education for Understanding During the Adolescent Years

If education has proceeded in satisfactory fashion during the years of elementary school, students should have a solid foundation for the more focused, discipline-based learnings of high school, college, and beyond. During the early years of school, they will have achieved a familiarity with the materials of the physical and social world; their readily absorbing minds should have had ample opportunities to exercise relevant intelligences as these students are immersed in an atmosphere that encourages the emergence of verbal, numerical, and scientific literacy. Projects like Spectrum and institutions like the Key School provide models of how such early education might be carried out.

During the years of middle childhood, according to this desirable scenario, students will have had opportunities to develop more targeted skills—those literacy, numeracy, and scientific skills that will allow them to probe more deeply into the disciplines. Rather than learning these in a rote manner, however, they will have had the opportunity to engage in a number of apprenticeships, where they