WCER Highlights

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After-school programs and children's adjustment

A warm and positive climate in child care programs is positively associated with boys' adjustment in first grade.

In her study of after-school care programs, UW–Madison Education Professor Deborah Vandell found a relationship between the experiences of children, especially boys, in school-age child care (SACC) programs, and their performance in first grade. After-school experiences were found to relate to girls' behaviors as well, but associations were less apparent for girls than boys.

The WCER study, funded by the National Institute of Child Health and Human Development, evaluated 38 SACC programs operated in schools, day care centers, and community centers. Eighteen programs were for-profit licensed centers, 16 were non-profit licensed centers, and 4 were community centers. A total of 150 children and their families participated in the study.

Vandell's work, with collaborators Kim Pierce and Jill Hamm, focused on three aspects of children's experiences in the after-school programs:

- the emotional climate established by staff,
- the program's organizational features, and
- the quality of children's interactions with peers.

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From the Director

Rethinking science education

JEFF MILLER

Increasingly the Wisconsin Center for Education Research has expanded its portfolios of work to include cutting-edge studies of the learning, teaching, and assessment of science at the K–12 and higher education levels. This issue of *WCER Highlights* introduces some of this work, which reflects an emerging concern—a concern that science education at all levels needs to go beyond helping students to acquire knowledge *about* science to helping students understand science in ways that allow them to *apply* their knowledge in school and beyond.

What does it mean for students to really understand science? WCER collaborating researcher Angelo Collins distinguishes between knowledge and understanding and she argues that to understand, students need to be engaged in a process of inquiry. WCER researcher David Penner, meanwhile, studies middle-school students as they learn about science as a process of emergent systems. He has found that students come to understand through simulation activities that even simple rules can have unpredictable effects.

A long and continuing theme for WCER research is investigation of equity in education. Professor Mary H. Metz discusses the differing levels of resources available to high schools and their teachers. These differences —veiled inequalities—affect the quality of students' high school experience as well as the teachers' professional lives.

Every year WCER's long-running study of after-school care programs, directed by researcher Deborah Vandell, produces more knowledge about their effects on children's later years. This program of research recently found associations between boys' negative peer interactions in after-school programs and their displaying poor social skills at school.

For more information on these and other research findings, visit the WCER web site at *http://www.wcer.wisc.edu*.

Andy Porter

UW–Madison Education Professor Thomas A. Romberg was recently elected to the National Academy of Education. Membership in the Academy is limited to 125 persons whose accomplishments in the field of education are judged outstanding. Other WCER Academy members are Elizabeth Fennema and Andrew C. Porter.

Emotional climate

The study found that a warm and positive climate in the child care center was positively associated with boys' adjustment in first grade, whereas a negative and hostile climate was negatively associated with boys' adjustment. When after-school staff were more positive in behavior and words, first-grade teachers reported boys to have fewer emotional and behavioral problems than when after-school staff were observed to be less positive. When after-school staff were observed to be more negative, the first-grade boys were more likely to receive poorer grades in reading and math.

A note of caution: This study was correlational, meaning that it doesn't claim to find cause-effect relationships. It's not possible to determine whether children's after-school experiences affected their school adjustment or whether children's adjustment contributed to their experiences after school. Vandell says it may be the case that children who had more emotional and behavior problems elicited fewer positive emotional responses from their after-school caregivers, and children with poorer academic skills elicited more negativity from after-school staff.

Interactions with peers

As the researchers hypothesized, boys' negative peer interactions in after-school programs were associated with their displaying poor social skills at school. More frequent negative interactions with peers in the programs also were associated with heightened internalizing problems for boys and more externalizing behaviors for both boys and girls at school. (Internalizing problems include withdrawal, somatic complaints, and anxiety or depression. Externalizing problems include delinquency and aggression.) These associations are further evidence of the difficulty in making causal attributions from correlational designs, Vandell notes. "Our research does not ascertain whether children's problematic functioning simply was evidenced in negative peer interactions in the after-school and school contexts, or whether the negative interactions with peers after school contributed to children's emotional and behavioral problems."

It has been suggested that after-school programs provide a context in which children can develop and refine their social skills. Consequently, the researchers expected that children's positive or neutral interactions with peers in SACC programs would be positively related to social skills displayed at school. The study did not find such an association, however; only negative interactions seemed to matter. The study combined

continued on page 5

Understanding begins with full inquiry

It's not enough for students to have knowledge about science. They must understand science. And there's a big difference, according to Angelo Collins.

Collins is associate professor of science education at Peabody College of Vanderbilt University and codirector of WCER's National Center for Improving Student Learning and Achievement in Mathematics and Science (NCISLA), funded by the Office of Educational Research and Improvement, U.S. Department of Education.

Collins works from the central assumption that understanding science requires relating different aspects of science knowledge to one another and to knowledge of other nonscientific topics. Genuine student understanding of mathematics and science goes far beyond knowledge. For example, science classes often require students to memorize that "magnets attract and repel each other and other types of materials." This isolated fact evolves into understanding when a student *uses* the fact to predict which objects a magnet might attract or repel.

Engage students in inquiry

One aspect of understanding science is understanding the process of inquiry. Collins distinguishes between simple inquiry and full inquiry. Students engaged in simple inquiry engage in processes like observing, comparing, contrasting, and hypothesizing. Students engaged in full inquiry use these skills in the context of (1) well-structured science subject matter knowledge and (2) the ability to *reason* and to *apply* science understanding to a variety of problems. Full inquiry requires asking questions about nature, conducting investigations using appropriate tools and techniques, constructing and analyzing explanations, and communicating arguments.

Collins points out that the National Research Council's *National Science Education Standards* begin with inquiry. "Inquiry is the foundation of the other content standards," Collins says. The *Standards* require students to complete one full inquiry each year, in which a student or group of students begins with a question of interest and importance to them and to science. They investigate an answer to the problem through laboratory, field, library, and other forms of scientific investigation. Then they persuade others through reasoned arguments based on evidence that a defensible relation exists between the question, the investigation, and the proposed answer.

"It's no longer sufficient for students to be able to describe, compare, contrast, measure, draw inferences, or hypothesize, although mastery of these discrete process skills is necessary," Collins says. "Nor is it sufficient to memorize scientific terms, although knowledge of science concepts defined by those terms is necessary. The NRC's *Standards* call for student inquiry into questions about nature as a way to develop deep understanding of science subject matter and to apply the understanding to new topics."

Accordingly, the NRC's *Teaching Standards* call for teachers to plan and implement inquiry-based science programs. In such programs, teachers focus and support inquiry as they interact with students, encouraging and modeling skills of inquiry them-

continued on page 8

Collins distinguishes between knowledge and understanding.

JEFF MILLER

Full inquiry involves students in laboratory, field, and other kinds of investigation.

Students learn science as an emerging system

Penner uses a tile-and-grid game to get students to think about science in a new way.

Since Isaac Newton, people's views of science have been dominated by the conception of nature as mechanical—a clockwork universe. In this view, the world is ruled by direct cause-and-effect relationships. The world seems to obey simple, fixed mathematical principles that support predictability. But this traditional view has come under increasing scrutiny. In disciplines from biology to meteorology, scientists have come to view the world less as strictly mechanistic and more as the *emerging* result of *interactions* within complex systems.

For example, a boulder in a stream bed can create a wall of water upstream of the rock—a phenomenon known as a standing wave. The laws of physics govern the formation and existence of standing waves, but these laws are unable to predict the nature of any given standing wave. Rather, each standing wave is the emergent result of interactions among several things—water molecules, the shape of the rock, and the width and depth of the stream.

Emergent models have become an increasingly important means for understanding the world around us. Middle-school children began learning how to reason about emergent phenomena in a recent study by UW–Madison education professor and WCER researcher David Penner. With funding from the National Academy of Education / Spencer Foundation, he studied students as they played a game called *Life*, developed by mathematician J. H. Conway.

In this game pairs of students explored the relationship between a set of simple rules and the patterns they generated. The students began the process believing that the world is predictable and stable. But through their investigation of *Life*, the students came to see that even simple rules can have unpredictable effects. Further, they found that simple changes in initial conditions can have considerable effect on the form and number of patterns generated.

Modeling organism growth

In their work with the *Life* game, the middle-school students were asked to try to explain how a set of simple rules governed the development of patterns on a grid (see illustrations). Penner observed the students making sense of the relationship between simple rules and emergent complexity.

Each grid represents a self-contained universe in which one-celled "organisms" live or die according to a small set of rules. Each cell can assume two possible states: black (alive) or white (dead). Including the diagonals, each cell has eight neighboring cells.

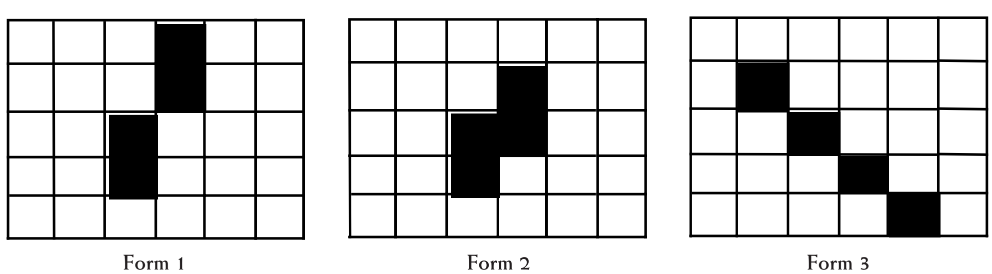
In the game, students place black counters on the grid while applying these rules:

1. Every counter with either two or three neighboring counters survives for the next generation.
2. Every counter with four or more neighbors dies from overpopulation. Every counter with one or fewer neighbors dies from isolation.
3. Each empty cell with exactly three adjacent counters is a birth cell. A counter is placed on the empty cell in the next generation.

As the students discovered, very simple modifications had dramatic effects on the patterns produced. Consequently, focusing on the macro-level allowed the students to point out large-scale similarities and differences in the patterns.

Penner's research interest was, "How do students view the relationship between deterministic rules and emergent patterns?" Specifically he followed three questions:

1. How do students make sense of the patterns that develop? What types of regularities do they notice? How do they explain them?
2. Do students believe that there is any way to predict future states from a given start state?



Students apply a few simple rules to watch a virtual "organism" develop on grids.

3. What effects do small changes in the initial state have on future pattern development?

Students began the *Life* investigations with little understanding of how local interactions lead to global patterns, but they were able to use their experience with *Life* forms to initially think about the relationship between cellular arrangement and the number of possible generations. They found that the number of possible birth cells in an initial arrangement does not predict the number of generations. The students found that even simple situations rapidly become complex.

What did the students learn about emergence? At a minimum, they became aware of the need to distinguish between local and global levels of analysis. They also began to see that there was no principled means by which an outcome could be predicted, even though the environment is completely determined by the three rules.

The degree to which the students came to consider the *Life* environment as having some similarity to the natural world is less clear, Penner says. Future research needs to address how such activities as *Life* can lead to explorations of real-world emergence.

"Students understand only what they can create," Penner says. "Their constructions can range from computer simulations to play activities in which students model organism behavior." By involving students in constructing complex systems, Penner says, we provide them with opportunities to understand how interactions among objects obeying simple rules can lead to very complex patterns. And students can reflect on their growing knowledge.

Young students often believe that "doing science" simply means uncovering previously hidden facts. But with appropriate experiences, many students come to view science as the construction of explanations.

For more information, contact Penner at *depenner@facstaff.wisc.edu* or visit his web site at *http://www.soemadison.wisc.edu/edpsych/facstaff/penner.htm*

After-school

continued from page 2

positive and neutral interactions into a single coding category, creating a certain lack of specificity that may have contributed to these findings. "Peer interactions with a clearly positive tone may reinforce social skills, whereas neutral interactions may not have this beneficial effect," Vandell conjectured. In future research, greater effort should be made to distinguish between these different types of interaction, Vandell says.

Program curricula

Vandell's study rated SACC program curricula in terms of flexibility and activities. Programs rating low in flexibility did not allow children much choice in activities or their playmates. The researchers found that more flexible programs were associated with social benefits. Boys who were enrolled in more flexible programs displayed better social skills with their first-grade classmates than did boys in less flexible programs. Vandell suspects that this association occurred because more flexible programs provide more opportunities for negotiation, sharing, and play that help to improve boys' social skills with their peers in other settings.

Programs rating low in available activities offered only a limited number of activities that focused on only one or two areas of development. The study found that, when their after-school programs offered fewer activity options, boys obtained better grades in reading and math and displayed fewer internalizing problems and externalizing behaviors in the first-grade classroom. The researchers suggest that perhaps the after-school programs offering a limited array of activities on a given day more closely resemble the boys' school classrooms in terms of both the type and number of activities, thereby facilitating a cross-contextual transfer of skills. When boys are first adjusting to the expectations of the first-grade classroom, such consistency may be useful.

With the exception of interactions with peers, which were similarly related to both girls' and boys' performance at school, associations between program experiences and school adjustment in this study were evident for boys but not girls. Future research should consider gender differences in relation to after-school program experiences, Vandell suggests. As Vandell's study continues to observe these same children through elementary school, the researchers will determine whether greater amounts of program experience of varying quality are associated with children's development over time. The researchers also will examine more closely the possibility of child effects on program quality.

For more information contact Kim Pierce at *kmpierce@facstaff.wisc.edu*, (608) 262–9394 or visit Vandell's web site at*http://www.soemadison.wisc.edu/edpsych/facstaff/vandell.htm*.

Vandell's study found that flexible programs were associated with social benefits.

Community social class affects teachers' perspectives and practices

Schools in suburban and urban enclaves provide different educations for the students of these communities. Suburbs themselves stand in a ranked hierarchy. Most middle-class parents and many working-class parents are very aware of these differences as they choose housing that brings with it a determination of the schools their children will attend. These environments provide very different contexts for their teachers, as well.

These differences between schools are informal and unofficial, however. Formally, American schools are supposed to be similar, in order to provide equal opportunity to all children. In many formal ways, they are indeed very similar, says UW–Madison Education Professor Mary Metz. Most professionals involved in education think of public schools, especially high schools, as expressions of a single form of education intended to offer a sound education and a fair chance for success in life to all children.

Hidden elements—veiled inequalities—are critical for teachers' and students' work together.

There are, increasingly, a few exceptions to this unified vision, as wide attention is given to the distressing circumstances that hinder education in schools in poverty areas, especially those in central cities, and as movements grow for some freedom for variations in schooling practices through charter schools for those families who want distinctive patterns of education.

Metz calls this vision of unified American educational practice and the similar patterns in actual schools that it fosters "Real School." Ideas about what constitutes a Real School both reflect and generate a surprising amount of actual standardization in the practices of American schools, Metz says. At the high school level, school architecture, time schedule, curricular scope and sequence, class size, duties for the teaching staff, and methods of instruction vary only within narrow parameters. Our sense of a single American High School is grounded in these similarities.

If American high schools are so similar, why do middle class parents stretch their budgets to buy houses in suburbs where the schools are "better?" What reality are they—and the real estate market—responding to? The differences among high schools are as genuine as the similarities, says Metz, but they have received little formal study.

Differences left her 'reeling'

In work initially funded by the U.S. Department of Education's Office of Educational Research and Improvement, and follow-up research funded by the Spencer Foundation, Metz analyzed the differences in teachers' work in high schools across communities differing in social class. She says that the differences in the daily work of these schools left her "reeling." Her visits left her with the impressions that everything was different—the feel of the halls, the students' behavior, the teachers' concerns and, most strikingly, the rhythm and content of classes—even when they had the same title and used the same textbook. It was only on reflecting on the similarity among high schools assumed by her colleagues that she noted how much was also the same.

Metz argues that all schools have to meet many goals in addition to formal academic education. Generally, the higher the social class of a community the fewer resources were needed for nonacademic supporting goals. More of whatever resources were available could be marshaled to support teachers in their core academic work. Further, even though students' academic needs are greater where social class is lower and families have less education of their own to support and supplement the academic work of the school with their children, in general the lower the social class of a community the fewer its schools' resources in staff and materials.

Perhaps the most visible and important difference in resources was that the schools that were high in social class provided teachers two preparation periods each day in addition to a lunch period. Teachers at the other schools had other duties in periods beyond their five classes and one lunch period.

The lower the social class of the community, the more difficult it was to maintain the daily schedule as a reality. Students were less likely to arrive at class on time and more likely to be moving about the halls during classes. They were more likely to be absent from individual classes or from school; these absences greatly hindered academic continuity. Confrontations among students or between students and nonstudents inside the school or in the area immediately surrounding the school were much more common.

In the city schools, the faculty were more diverse. Few community parents had any college education and many had not completed high school. There was more distance and conflict between the values and world view the teachers promoted and that which students learned in the community. Teachers were thus less able to attach students to the school as a social setting and therefore to its academic goals. Relationships between teachers and students—on the whole and with exceptions—were more ambivalent and complex.

Finally, adults in these communities segregated by economic resources and social class can claim quite different levels of worldly success. Both students and teachers enter a high school with different expectations for the learning of the students. This is especially true by the time students reach high school. These differences in students' achievement entering high school and the differing expectations that teachers, parents, and students hold for their future accomplishments powerfully affect both teachers' and students' motivation to pour resources into academic effort.

In city schools there was more distance between teachers' and students' values.

Actual education in real schools

Regularities in high schools' structural and technical arrangements that are visible from the outside can mask a great deal of what happens in schools. The observable regularities are significant influences on life inside high schools, but they provide a seriously incomplete list of the elements that affect teachers' and students' work together in a school.

But the hidden elements —those veiled inequalities—are critical for teachers' and students' work together and for students' learning. Parents, who look at their children's schooling both holistically and microscopically, seem to be more aware of them than are professionals. Perhaps professionals, as they concentrate on the formal academic goals and the technical and bureaucratic structures constructed to facilitate them, overlook the daily interactions that form the stuff of education as teachers and students experience it together.

It is painful and politically delicate to look too closely at the separation among schools created by housing and school district lines in metropolitan areas. To look too closely, to admit that this separation has profound educational consequences, is to admit that we are not offering equality of opportunity to the nation's children. But painful as it may be, it is important for policymakers to look more closely at the stuff of everyday life inside these differently situated schools and to begin to trace more systematically its connections to differences in community circumstances and to the process of academic education.

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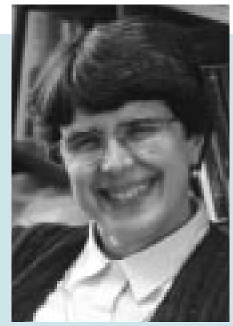
[Information in this article appeared in slightly different form in a paper delivered at the 1998 annual meeting of the American Educational Research Association. The related research was supported by the National Center on Effective Secondary Schools at WCER through a grant from the Office of Educational Research and Improvement, U.S. Department of Education and the Spencer Foundation.]



Metz found that the differences among high schools are as genuine as the similarities.

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Understanding science

continued from page 3

selves, and structuring classroom time so that students can engage in extended inquiries. Because inquiry includes communicating ideas and arguments in science, the *Teaching Standards* encourage science teachers to build learning communities that promote student collaboration and provide opportunities for students to *talk about* science.

Asking and answering questions

The *Standards* change the nature of familiar teaching activities such as planning, guiding and facilitating learning, to assessing teaching and the students' learning, and maintaining safe physical and social learning environments that provide students with opportunities to learn. How? The *Standards* call for curriculum and instruction that include activities designed to allow students to ask questions, seek answers, and communicate what they are learning, Collins explains. They capture students' interests and match their abilities. Teachers support this student inquiry by helping students shape questions while they develop arguments from evidence.

"Students often believe that science is a difficult subject in which only selected students may participate," Collins says. "And parents often affirm the belief that science is difficult. But science is really a process of asking and answering questions about everyday phenomena, questions driven by human curiosity." And, she says, teachers too often believe science is a rhetoric of conclusions they dare not attempt until all the terms are mastered, rather than imagining science as an adventure that engages them and their students.

Collins would like to see a continued shift of focus in science education from teachers covering content to students achieving understanding. For example, rather than teaching about animals, teachers and curriculum developers need to articulate what all students should understand about animals. In the former approach the focus is on a topic—animals—whereas the latter approach emphasizes children and their understanding.

"In my vision of science education," Collins says, "all students achieve understanding through inquiry, and they're able to apply this understanding."

For more information contact Collins at *angelo.collins@vanderbilt.edu* or visit the NCISLA web site at *http://www.wcer.wisc.edu/ncisla/*

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