WCER Highlights

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More content courses? Maybe not

Preservice science teachers could benefit from knowing more about the role of theory in posing problems and constructing new understanding.

Three essential components of a teacher's life-long professional development are subject matter coursework, preservice teacher education, and in-service teacher education. Yet WCER researcher Peter Hewson and colleagues Ken Zeichner and Robert Tabachnick see only weak relationships between these components in most science education teacher preparation programs. Ideally, these three components should be strongly connected.

The success of science teacher education programs depends on offering prospective teachers a coherent, integrated experience, according to the team's recent research. To understand how one program influenced the ongoing process of learning to teach, the team conducted case studies of several prospective elementary and secondary science teachers. The researchers sought to identify the successes and failures of the program's various components and how well its participants did in achieving its stated outcomes.

Underlying assumptions are powerful

Prospective teachers' understanding of the nature of knowledge is a critical factor in their teaching. Most of the prospective teachers studied began their programs with a "transmissionist" view, believing that true knowledge exists, that it is independent of

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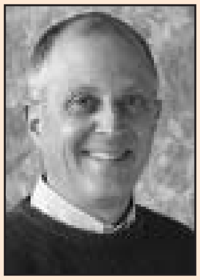
FROM THE DIRECTOR



From elementary grades through doctoral education

Reflecting the breadth of research conducted here at WCER, this issue of *Highlights* examines education practice and policy from the primary grades through doctoral education. The first two articles discuss science education.

Teacher education programs for prospective science teachers can be strengthened with a tighter link between three components: subject matter coursework, preservice teacher education, and inservice teacher education, say researchers Peter Hewson, Robert Tabachnick, and Ken Zeichner.

Parents can also help their children succeed with science school work; many take their children to museums and participate in other related activities. But equally as important is learning how to help children become better at scientific reasoning, according to researchers Mary Gleason Heffron and Leona Schauble.

Doctoral education in the U.S. is said to be the envy of the world, but there's always room for improvement. Christine Golde discusses how there can be a better match between doctoral students' goals, their doctoral training, and their actual careers.

And Marianne Mooney and colleagues discuss how students with and without disabilities would benefit if their teachers had better knowledge of students' postschool outcomes, and had better knowledge of how to use this data. This in turn can help educators better understand what is happening at their schools.

For more news about recent research, see our Web site at *www.wcer.wisc.edu*.

Andy Porter

individuals, and that it can be transmitted or passed on to another person by using good explanations and demonstrations of scientific principles. The transmissionist view contrasts with a "constructivist" view, which sees knowledge as being constructed in student's minds as they draw on their prior knowledge to make sense of new experiences.

All the prospective teachers developed an interest in their students' prior knowledge over the course of their student teaching experience. However, the prospective teachers viewed the affective function of considering students' views as more important than its cognitive function. In other words, they saw the value of eliciting students' ideas in contributing to a supportive, inclusive classroom atmosphere, but downplayed the significance of students' ideas leading to conceptualization of intended curricular outcomes.

Interviews with prospective teachers indicated that their understanding of biology and life science tended to be based on a static, relatively disconnected collection of facts. The major difference between the prospective elementary and secondary teachers was the quantity of information they knew.

It is often said that an effective way of learning a subject is to teach it. Accordingly, Hewson, Tabachnick, and Zeichner had anticipated that classroom practice would give young teachers a deeper and more coherent understanding of content knowledge. Yet the final interviews provided little evidence that this was the case. There was an increase in prospective teachers' confidence in, and familiarity with, their own knowledge. But the change appears to have been largely affective—it made them feel good about their level of knowledge. Teaching did not seem to lead the prospective teachers to a greater coherency in, and a deeper understanding of, their content knowledge.

The research team found that teachers coming into the program knew little about the methods of inquiry used within the discipline of biology. This left prospective teachers without an understanding of the role of theory in biology and the way in which scientists use theory to pose problems and construct new understandings. The conceptual change model of teaching and learning emphasizes the importance of making class time for their students to consider the relative status and value of alternative conceptions. The conceptual change approach uses theory development in science as a metaphor for how individuals construct new conceptions.

Prospective teachers need to understand theory development in science. Without it, they will be ill equipped to help their students evaluate the relative status of scientifically accepted conceptions and other potential competing conceptions the students bring to the classroom.

Amount vs. coherence of knowledge

The content courses taken by the prospective teachers in this study prepared them to do little more than transmissionist teaching. While this might be expected for prospective elementary teachers, it was also the case for secondary candidates. Prospective secondary teachers' conceptual understanding was, by their own accounts, inadequate for teaching at the high school level, and probably also at the elementary and middle school levels. The problem had less to do with what they didn't know than with the lack of coherence of what they did know. Hewson, Tabachnick, and Zeichner believe the lack of coherence results from

Content courses sometimes leave preservice teachers without understanding how students' conceptions can be tested and revised.

college science teaching and assessment strategies that do little to emphasize the integration of course content. For example, the lecture setting seldom encourages students to think about and relate concepts to each other, and multiple-choice tests ask for information in a piecemeal fashion.

More coursework in the major?

It is often suggested that, to improve content knowledge, prospective teachers should take more courses in the academic disciplines, often at the expense of education courses. This study, along with much of the existing data on the preparation of teachers in the arts and sciences, shows instead that an academic major, as currently taught, does not seem to guarantee deeper conceptual understanding than an education major[1].

A key factor for prospective teachers in this study was their lack of understanding of how scientific knowledge is produced, what role theories play within the discipline, how those theories are revised, and especially what problems those theories were developed to solve. Teachers' methods courses in this study gave them some awareness of their students' conceptions, but their content courses left them without an understanding of how those conceptions could be tested and revised like scientific theories. This points to the need for significant changes in the curriculum and instruction of content courses, ideally arising from dialogue between science educators and their colleagues in the arts and sciences.

Recommendations

The research led to the following additional conclusions about how preservice teacher education could be strengthened.

Prospective teachers would benefit from methods courses that offer more comprehensive perspectives on how students learn, and teachers teach, science. Such courses would provide prospective teachers with a richer variety of opportunities to learn how to teach science. In addition, science teaching methods should be revisited after prospective teachers complete their student teaching. This review could help them tie together classroom experiences with their emerging constructivist conceptions about important issues such as the nature of scientific knowledge, science, and learning.

Student teaching experiences likewise need to be reevaluated. Probably the most important role here is that of the cooperating teacher in the student teaching placement. The cooperating teacher is a powerful role model; his or her beliefs and teaching approaches can significantly influence the direction of a prospective teacher's development. "We fault ourselves for not doing more to engage cooperating teachers in the task of reconceptualizing the practices of science teaching and science teacher education," says Hewson.

Time for reflection was also in short supply. Time constraints prevented the prospective teachers from adequately reflecting on their student teaching experiences. There is little reason to believe that they will have more time when they enter their first year of regular classroom teaching. It may be beneficial for prospective teachers to teach fewer sections during their student teaching and use the extra free time to reflect more deeply on their lessons.

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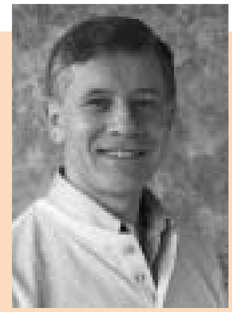
[1] See McDiarmid, G. W. (1994). The arts and science as preparation for teaching. In K. Howey & N. Zimpher (Eds.), *Faculty development for improving teacher preparation* (pp. 99–138). Reston, VA: Association of Teacher Educators.



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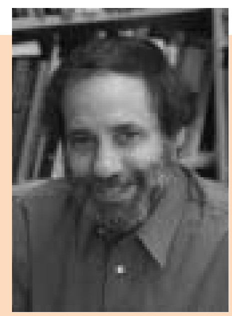

Zeichner

Tabachnick

Parents can help children reason scientifically

Recent science reform standards urge that a prominent place in science instruction should be given to inquiry. Yet, research suggests that elementary school–aged children typically show a variety of biases and errors in generating and interpreting experiments. What role can parents play in reinforcing and expanding on their children's science instruction?

Science projects present opportunities for parents to clarify children's thought.

However, the science content that children are learning may not be familiar to their parents, either, and little is known about parents' effectiveness in helping their children with problems that parents find unfamiliar. In these cases, parents themselves may find it challenging to provide forms of assistance that are sensitive to children's own learning needs.

UW–Madison education student Mary E. Gleason Heffron and professor Leona Schauble posed a scientific reasoning problem to 20 pairs of parents and their preadolescent children and observed them as they spent 45 minutes solving the problem. As the parent-child pairs worked, researchers videotaped their experimentation strategies and their patterns of interaction, and watched for changes in their knowledge about the science content.

The study addressed these questions:

- What evidence-generation and evidence-interpretation strategies did the parent-child pairs use?
- What were the patterns of interaction? Who assumed which roles in the problem-solving process? Who assisted whom, and who controlled the course of problem solution?
- How did problem-solving strategies relate to changes in the theories that the participants developed?

The task assigned to the parent-child pairs (described below) was similar in many ways to those that parents are increasingly likely to encounter as they assist their children with school work, interact with their children at science museums and children's museums, and participate with their children in other informal clubs and activities.

The pairs worked with a model canal filled with water and six small wooden boats. The pairs were asked to determine which features in the boat and canal system affected how long it took for a boat to be towed down the canal by a weight-and-pulley system. Features that could be manipulated included the depth of the canal, boat shape, boat size, and boat weight. The parent-child pairs were to vary the manipulatable features in the system, conduct multiple trials, and determine which features affected the time a boat took to travel the length of the canal.

On the positive side, most of the parent-student pairs were effective at generating informative and interpretable experiments, mainly because of the guidance and assistance the parents provided. On the other hand, parents missed some important opportunities to provide assistance.

It was usually the parents who did the conceptual work of generating and consulting the data records and interpreted the data by stating or writing inferences. In contrast, children usually managed the physical work of setting up and releasing the boats and timing their progress. There was little evidence that over the 45-minute session parents ceded to their children the important roles of data recording and evidence interpretation. They seldom explained the value of these activities to their children and frequently failed even to share their ideas, for example, by stating inferences aloud. As a result, children missed opportunities to perform these conceptual roles that are vital to understanding the relations between theory and evidence. (It should be noted that not all parents are alike, and that these parent-child pairs happened to be recruited in a large children's museum in the Midwest and through education courses at a large Midwestern university. Most of the parents had college degrees or were attending college.)

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Educators need more and better data

Many reform initiatives emphasize educational accountability, in which communities, schools, and educators take a strong interest in examining and improving student outcomes.

Students with and without disabilities deserve to achieve academic, occupational, and social competence and to become productive and independent adults. But educators sometimes need help in using data to understand what is happening at their schools and what should happen next.

WCER's Research Institute on Secondary Education Reform for Students with Disabilities (RISER) is conducting a 5-year research study on practices and policies that improve learning opportunities and postschool outcomes for students with disabilities in significantly restructured high schools. RISER researchers are studying four high schools based on their promotion of, and participation in, "authentic and inclusive teaching and learning" practices, using the conceptual framework of restructured schools developed by Fred Newmann and Gary Wehlage in 1995 at WCER's Center on Organization and Restructuring of Schools. The four schools range in size from 400 to 1,000 students in grades 9–12 or 7–12. They are located in a major urban setting and in smaller communities in the northeast and southwest.

Local educators are sometimes reluctant to use formal data to inform their decision making. Data are often collected for purposes originating outside the school and thus fail to reflect educators' goals for their own communities. Second, some educators don't believe that research and data can help improve teaching and learning. Third, some educators sometimes have limited capacity to use data critically and effectively.

Marianne Mooney and colleagues at RISER surveyed educators' perceptions of the usefulness of collecting information on postschool outcomes for students with and without disabilities. The intent was to answer the question, "In what ways would postschool outcome data on students with and without disabilities prove useful to your instructional practices and schoolwide policy development?"

In a review of each school's documents (i.e., handbooks, district reports, selected follow-up studies, newsletters, etc.), Mooney and colleagues learned that these schools traditionally monitor postschool status and outcomes only through students' entry into college, rather than through systematic and comprehensive graduate follow-up data collection efforts. Educators in these schools rely primarily on personal contacts with graduates for "proof" that the school is successful. Moreover, when schools have collected some postschool data (mostly at the district or state level), they frequently have not used the information for school improvement or change.

Six themes and related points of interest emerged from the data. If substantial, meaningful, school-specific postschool outcome data were readily available to local educators, they would use this information in the following ways:

1. *To inform current instructional practices.* Postschool outcome data could be used to inform current instructional practices generally and also to identify specific classroom practices that need to be adapted, modified, or replaced to better promote student learning.
2. *To encourage curriculum development and change.* Educators said such data could help them to (a) shape and restructure the curriculum by revamping existing units and programs and developing more applicable and realistic lessons; (b) diversify the curriculum by expanding program offerings and alternatives that address weaker performance areas or areas of neglect; and (c) meet students' unmet needs.

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Better data about how students fare after graduation could help educators improve practice and policy.

Improving doctoral education

Golde

The U.S. higher education system is often said to be the envy of the world. And while many doctoral students say they are generally satisfied with the quality of their doctoral preparation, a recent survey shows that doctoral education could be improved in a number of ways.

In many cases, doctoral students receive training that is not what they want and does not prepare them for the jobs they take. Many doctoral students do not clearly understand what doctoral study entails, how the process works, and how to navigate it effectively.

But students and programs need not be at cross-purposes, according to former UW–Madison education professor Chris M. Golde. Changing current practices will involve the collective efforts of students, faculty, and administrators.

In a recent study, Golde and coresearcher Timothy Dore administered a survey to doctoral students in 11 arts and sciences disciplines at 27 universities and one cross-institutional program. (Disciplines included philosophy, history, English, mathematics, art history, sociology, ecology, geology, psychology, molecular biology, and chemistry.) Overall, 4,114 students responded to the survey. Data from the survey show that in today's doctoral programs there is a three-way mismatch between student goals, training, and actual careers. This results in students who are not well prepared to assume the faculty positions that are available and who lack a clear concept of their suitability for work outside of research.

Employment. The number of tenure-track academic positions has been decreasing. That trend has been amply documented and discussed by the media, professional associations, and graduate student activists. No more than half of the doctoral students in the fields studied (which exclude such professional fields as engineering and education) will be hired into full-time tenure-track faculty positions. Of those faculty positions, only a small proportion will be in research universities. Yet this is the career students want. Nationally, nearly half of all faculty are part-time employees, and most faculty hold positions in comprehensive and community colleges.

Research. Students are not well informed about all aspects of research. Although publication is critical in the research process, less than half of the students surveyed reported being prepared by their program to publish, and slightly more are confident of their ability to do so.

Ethics. Survey data also indicate that the ethical dimension of faculty and professional life—how to act responsibly and in the best interests of the profession—is not, as is often assumed, part of graduate training. Although most respondents understand policies and practices regarding appropriate relations with undergraduates, using copyrighted materials, and generating and using research data, only 20 to 30 percent reported being clear about customary practices involving patent policies, proper use of research funds, allocating authorship for papers, and avoiding conflicts of interest.

Teaching. Teaching and, to a lesser extent, governance and service, are the central activities in the lives of most working faculty members. Although doctoral students are reasonably well prepared to conduct research, survey results show that prospective faculty members don't report being as well prepared by their programs to teach or be academic citizens.

Diversity. There are too few faculty of color in all disciplines and too few women in many fields. One solution would be to both encourage more underrepresented students to consider faculty careers and to provide the additional supports and changes to make the profession more attractive.

Preparation for doctoral study. Students reported that they decided to enter a doctoral program without having a good idea of the time, money, clarity of purpose, and perseverance that doctoral education demands. Many seem to have entered the pursuit of the doctorate blindly. Survey responses reveal that students often enroll in a Ph.D. program at the encouragement of a favorite undergraduate professor, without considering a full range of alternatives and without developing a clear understanding of why they are doing so. Many students cautioned against enrolling simply because earning a Ph.D. seems interesting or the next logical step.

A surprising proportion of the students would make changes, were they to start their programs again. Nearly half of respondents report that they would or might select a different university. Additionally, 39% answered yes or maybe to whether they might select a different advisor and 42% said they would or might select a different dissertation topic.

Once enrolled, many students appear to receive little guidance about how to navigate the process. As students progress through their programs, many of the details of the day-to-day processes are unnecessarily ambiguous, hindering students' ability to make the most of their doctoral education. More than half the survey respondents report that they do not know where the funding for their doctoral study or research will come from, how much time they can expect to spend with their advisor, or what criteria will be used to determine when they can graduate.

Unformed expectations

In sum, respondent comments reveal that many students came to graduate school with unformed or unrealistic expectations. They did not know about the constrained academic job market, nor did they have an idea of how to get the most out of the experience. Prospective students must actively seek out the information they need to make a careful decision. Those institutions at which students seek to enroll have a responsibility to provide, as a matter of course, comprehensive information about the program and guidance to prospective students. Similarly, the institutions at which prospective graduate students are undergraduates bear responsibility for helping students make fully informed choices.

It is responsible educational practice to make expectations clear to students; students, in turn, need to ask for clarification when these core aspects of graduate life are unclear. Much of the critique of doctoral education centers around the lack of mutual understanding of how the process works and what roles student and faculty should play in ensuring that students are well educated. Clear communication between students and faculty is essential and can ensure that the fundamental aspects of doctoral education are carried out in an ethical and responsible manner.

For more information, see the full report, "At Cross Purposes: What the experiences of doctoral students reveal about doctoral education," available for viewing and download at *www.phd-survey.org*.

Funding for this study was provided by the Pew Charitable Trusts.

Better data

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3. *To improve student preparation and learning for the "real world."* The preparation of students with disabilities for life after high school was of particular concern. Respondents said outcome data could be used to identify concerns specific to this group of graduates, such as the availability and use of postschool support systems and the further development of student self-advocacy skills. Survey respondents emphasized the need for development of life skills that lead to a quality postgraduate life for students.
4. *To initiate changes in schoolwide policy.* Outcome data could be used to initiate changes in schoolwide practices, including developing admissions policies and strategies; diversifying and broadening course offerings; improving accessibility of school activities; designing more inclusive and student-centered policies; determining staffing needs; and determining special services offerings.
5. *To change faculty and staff expectations and attitudes.* Outcome data could be shared with colleagues and community members to reduce prejudice and lack of understanding about students with disabilities. Data could provide examples of students' productivity and success. Respondents hope to reinforce the belief that all students are educable and capable of attaining high performance standards if they are taught with a variety of timely and personalized teaching strategies. Several respondents suggested that data could help define gaps and inconsistencies between their school mission and student outcomes, ultimately leading to a reexamination of the school's mission and philosophy.
6. *To measure general reform effectiveness.* Educators viewed collecting postschool outcome data as an opportunity to address concerns about inclusive schools and classrooms, and about authentic practices within these schools. Among concerns frequently expressed about the effectiveness of education reforms were: How well are we preparing students with and without disabilities for inclusive postschool environments? Are we able to create equity and heterogeneity in the classroom simultaneously? And, do we lessen the value placed on postsecondary preparation and training by using an inclusion model for all students?

The results of this survey expand our knowledge of how postschool outcome data may be used in restructured inclusive high schools today, says Mooney.

For more information, contact Marianne Mooney, *mmooney@education.wisc.edu*, (608) 263–5456.

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Children's reasoning

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But parents in this study did provide their children with much valuable assistance, particularly during the evidence-generation phase of the trials. Parents helped their children manage the relations between goals and subgoals in the work, reminded their children to make predictions and inferences, and asked them to consider mechanisms that might cause the effects they were observing. They also gently steered children back on course when they proposed experiments that were invalid or uninformative. In fact, most of the parental assistance was concentrated in the evidence-generation phase of the trials; relatively little help was provided with evidence interpretation.

Perhaps because of these patterns of role taking and assistance, the children achieved few apparent gains in their understanding of the boat-canal system, although the parents made measurable progress.

Implications

Parents may be more effective participants in their children's learning when they better understand how children think and learn. Effective parental assistance is likely to be based on understanding children's thinking in the particular domain with the problem at hand. Of course parents do not require knowledge at the level of detail that a cognitive psychologist would value. Yet the highly educated and enthusiastic parents in this study missed some important opportunities to assist, presumably because they did not understand that children display characteristic errors in their interpretation of evidence. Ongoing research should examine ways to help parents better assist their children, including improving parents' understanding of their children's thinking in science.

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