Teaching the Science of Agriculture

Agriculture is an applied science that was the basis for science education in early American schools. True (1929) indicated that school gardens provided a laboratory to teach plant growth, botany and related science. Teaching this approach to build on students’ previous experiences, connecting new subject matter with a familiar context. The agricultural curriculum timed period depended on crops and other agricultural enterprises for both a primary food supply and as their income. The connection between science and agriculture was clear. And so was the reliance of classroom and school laboratory instruction to real and practical aspects of daily living and to the needs of society. There were few distinctions between agricultural science and science education. Science education was linked agricultural education to vocational education. That is, clearly separated science education from vocational education. In essence, before the Smith-Hughes Act students were studying the science of agriculture as an integrated approach to learning.

Today, there is a movement in the agricultural education profession that teaches the science of agriculture to promote agriculture as a profession. This shift has similarities to earlier philosophies and raises interesting questions. What does teaching the science of agriculture mean? What has this led to? What concepts, theories, and events support the idea? Is teaching the science of agriculture dependent in agricultural education? Program evolution that leads to progress rarely happens by chance, rather by careful consideration of circumstances and by addressing the relevant questions. Only then can significant energies be directed to accomplish realistic goals. Teaching the science of agriculture should be carefully considered by teachers before launching a program.

Defining the Science of Agriculture

The National Research Council (1988) suggested improvements in agricultural education by applying concepts from physical, chemical, and biological sciences to teach agriculture. With this model agriculture is a context for studying the sciences and a source of real-life examples. Less emphasis is given to the “how” of agriculture and more the “why”, exploring and understanding the scientific principles that enable the industry of agriculture to flourish. These tenants effectively describe what is becoming known as the science of agriculture. Some agricultural programs are establishing separate courses on the science of agriculture, often referred to as agsciences. In some cases science credit is being given for these programs.

Driving Forces

The strongest impetus for teaching the science of agriculture within the profession seems to come from the 1988 Council report. The recommendations called for an updated curriculum, more specific content, and relating the content to the increasingly scientific and technical nature of agriculture. The principles of a more scientific agricultural education have proven successful in several programs across the country, such as in Chicago and Philadelphia. These programs offer a wider range of courses to students in agriculture.

External forces of agricultural education also support teaching the science of agriculture. Carl Perkins legislation provides funds for new initiatives in vocational education that integrate academic and vocational education and create an articulation curriculum from high school to college. Carl Perkins grants are leading to agsciences-type programs in agricultural education. For example, a statewide program is being developed in New York State. Perkins legislation is currently the most significant source of federal funds for vocational programs, including agriculture programs.

Concurrently, the federal government and many state educational agencies have established goals that are compatible with Perkins legislation. For example, a statewide program is being developed in New York State, leading to agricultural education programs. Interdisciplinary learning and curriculum articulations are also high priorities.

Trends in local agriculture programs also suggest that teaching the science of agriculture is a viable and promising direction for agricultural education. A consistent decline in enrollments indicates a narrowing base of students who are interested in traditional agriculture programs. Most public schools have few students with an agricultural background or interest in producing agriculture careers. Teaching the science of agriculture addresses this problem by appealing to a much wider range of students.

THE AGRICULTURAL EDUCATION MAGAZINE

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By Dean Saphin

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Clearly, current trends, forces and factors support teaching the science of agriculture. However, it is unlikely that such efforts will be successful if the current educational environment without a strong, compelling conceptual base.

Conceptual Bases
Four conceptual bases for teaching the science of agriculture show there is a rationale for this approach. These include comprehensiveness, integration and connectivity, experiential learning, and a disciplinary emphasis.

Comprehensiveness. A diverse curriculum with options that appeal to different student learning styles and interests creates a positive learning environment, one based on the democratic principle of choice. Support for a comprehensive school curriculum is traceable to the progressive movement in the 1920s when educators advocated social efficiency and empowerment of individuals to choose, rather than being subjected to imposed authority through a required curriculum. More recently there have been trends for separate vocational centers, tracking, and increased graduation requirements (Tannor and Tannor, 1980). These developments could limit comprehensiveness, if they lead to restricting course options that meet students' educational needs and interests. Teaching the science of agriculture provides another option to learn science and agriculture concurrently, breaking down the barriers between academic and practical studies. Eilot (1982) stressed that free electives allow individuals to discover and develop areas of interest. With the proper design, teachers' agriscience may also count as a unit of science in some states, contributing even more to the comprehensiveness.

Integration and connectivity. Integrating biology, chemistry, and physics sciences, along with social sciences, to address agriculturally related problems or issues helps students find meaning and relevance to a sometimes fragmented school curriculum. Agriculture provides a contextually rich learning environment. Problem solving, experiments, and modeling used in teaching agriculture can show that the science of agriculture requires students to integrate what they have learned from across the school curriculum. For example, lessons on population modeling include concepts from the sciences (e.g., insects, mechanical and biological control, genomics, etc.), social science (e.g., policy issues, government economics), agricultural and human health (i.e., a safe food supply), and environmental studies (i.e., environmental risk management and pollution). The principles of integration and connectivity go back to the late 1800s when the “Quincy System” advocated teaching reading, spelling and writing simultaneously. This was in response to a discovery by Parker, superintendent of schools, and the school board in Quincy, Massachusetts, that students were being taught memorized answers to pass state tests but could not connect subject matter to solve problems. They had no understanding of the thinking process. Similarly, today's educators are challenged by what Parker described in the late 1800s as a disconnected morass of facts and statistics in the school curriculum (Tannor and Tannor, 1990). The science of agriculture can provide a connecting fabric to link subject matter across the curriculum.

Experiential learning. Learning from real-life experiences in a rich cultural context reduces narrowed focus and fragmentation of agriscience. Incorporating science into existing agriculture classes or adopting new agriscience courses is gaining momentum as a major reform of curricular education programs in the secondary schools. If you are an advocate of agriscience reform, you will enjoy reading the articles in this issue describing successful programs which are helping to teach the science of agriculture. Consider what's available today for teaching agriscience, that wasn't developed or being used in agriculture programs five years ago. You are likely to conclude that things are looking good.

To make good things better often requires taking a second look at what's occurring, in this case, with teaching the science of agriculture. Today, that second look must be beyond the confines of new agriscience curricula and focused on student learning in courses where we are teaching the science of agriculture. In many states, agriscience courses are fulfilling high school graduation requirements for science. In Illinois, a year-long Science Application in Agriculture curriculum now satisfies one unit of university admission requirements in science. Are we doing, as many claim, a better job of helping students become scientifically literate by teaching science through agriculture? Are students being adequately prepared for college-level science through agriscience programs? Going directly to the bottom line, are students learning the science concepts and principles that we claim to be teaching in these new agriscience programs? For the most part, the answers to these questions are unknown and can be considered scientific research. We do not have data on what changes have occurred in the curricula, but measuring the impact on student achievement in science needs more investigation.

Fortunately, we do not have to wait for research studies to document our success or failure before taking action which will enhance student learning of science through agricultural applications. Hopefully, we need the advice of science educators, who have a pretty good idea of how students best learn science, even if the lesson was learned the hard way.

How we teach new agriscience curricula is as important as what we teach. For guidance, we should base our teaching on principles which will help our success. Five such principles for effective science teaching are described in a recent publiction of the American Association for the Advancement of Science entitled, UPDAME PROJECT 2061: Education for a Changing Society. The background on PROJECT 2061 read the article by Trexler and Barrett in the January 1992 issue of The Magazine. Their articles provide ideas on how teachers might assist the PROJECT 2061 reform movement and its pertinence to agricultural education.

The following principles for reform of science teaching have special significance for agriscience instruction, too. Applying these principles to the teaching of agriscience can provide new ag-sciences teaching materials that will help ensure that students are learning the science of agriculture that we teach. As a teacher of agriscience, do you model the teaching practices listed with each principle?

Principles of Teaching
Teaching should be consistent with the nature of scientific inquiry.

Teaching should be student-centered.

Teaching should be applied.

Teaching should be relevant.

Teaching should be stimulating.

Teaching should be comprehensive.

Teaching should be integrated.

Teaching should be connected.

Teaching should be experiential.

By Jeff Moss
Dr. Moss is visiting assistant professor of teaching and learning at the University of Illinois.
Bridging the Gap Between Agricultural
and Science Education

By Linda Whitty

It is possible that teachers can spend years teaching in the same school and have little or no idea of what their colleagues are doing in other classrooms! An agriculture teacher was asked about what is going on in the science department. He suggested that biology is taught only by following a textbook. A science teacher was asked about what is going on in the agriculture department. He suggested that agriculture is taught only by following the agricultural science textbook. It is difficult for teachers to understand the curriculum and teaching methods of other teachers. This can lead to isolation and difficulty in planning and implementing effective instruction.

The AgriScience Program

The AgriScience Institute and Outreach Program is testing a model to integrate agricultural and science education in a variety of geographical, ethnical, and rural settings across the United States. The program model focuses on integrating agricultural and science education in two stages. The first stage involves forming collaborative science and agriculture teams to develop and test agriculture science laboratories designed to address specific scientific principles related to real-life agricultural problems. The second phase of the AgriScience Program consists of Outreach Workshops. The workshops, begun in 1992 and continued during the summers of 1992 and 1993, are designed for agriculture and science teachers from the same high school.

An Inquiry Approach to Learning

One objective of the Program is to remove the barriers and confinements of teaching agriculture or science and to expose teachers to the idea of working together as facilitators, discovering knowledge of agriscience along with their students. The teachers, as well as the students, should become involved in the learning process. All of the experiments are designed to challenge students by providing a creative environment to explore a variety of agriscience experiments.

The laboratory experiments highlighted during the Outreach Workshops use Wisconsin Fast Plants and Botany Biology as learning tools to present a wide variety of agriscience concepts. Fast Plants (Brassica rapa) complete their life cycle in 35 days and are an excellent resource for teaching plant science and genetics. Botany Biology uses flower and seed botanies, film canisters, tennis cans, and a variety of other containers to provide an inexpensive, hands-on approach to teaching botany laboratories in the classroom. During the Outreach Workshops, teachers are provided with hands-on examples that illustrate ways to introduce their students to a variety of biotechnological principles through agricultural applications. The workshops employ an inquiry approach to learning where instead of students being provided with answers, they learn to ask questions, form hypotheses, and set up experiments in order to discover answers for themselves.

Agriculture students comfortable with hands-on activities conceived with this problem-solving approach to learning. Science students become excited by testing their own hypotheses and seeking the practical, real-world relationship of science principles and agriscience problems. Working in concert with science teachers, agriculture teachers strengthen their knowledge of science and increase the level of agriscience taught in their classrooms.

The AgriScience Institute

Last summer, 10 agriculture and science teachers came to the University of Wisconsin, Madison campus to attend a two-week AgriScience Institute. Teacher teams, working with university researchers, developed laboratories that challenge students to become actively involved in the agriscience research process. All the laboratory experiments have relevance to problems in the agricultural production industry, ranging from improving plant growth to testing water pollutants by using plant indicators.

During the institute, some valuable things began to unfold. Most of the team members did not know each other before the institute. The Institute provided a forum where teachers from diverse backgrounds came together to share ideas, educational agendas, and other concerns. Teachers discovered similarities in curriculum and gained an understanding of what is taught in other states. Teachers learned how many hands-on science agriculture teachers were incorporating into their instruction and discovered the rich resource of materials and facilities agriculture teachers utilized. Agriculture teachers, in turn, discovered the value of scientific laboratories and the nature that science teachers offer through their programs. All of the teachers left the Institute with a new attitude of openness and sharing.

The Success of Cooperation

During the fall of 1991, the teacher teams returned at their classrooms to field test the instructional materials they had developed in Wisconsin. The testing process further encouraged the development of a working relationship between the agriculture and science teachers. Several teams experienced great success from their new partnership. One science teacher, who taught college-bound students, started teaching agricultural science courses and became more involved in science education. The agriculture students (who considered themselves not academically successful) were excited and enthusiastic to have the science teacher (who taught the high-level science students) teaching their classes. In exchange, the agriculture teacher started teaching agriscience units in the science class. The agriculture students were surprised to learn how much science was involved with agriculture. They discovered that agriculture was an interesting and challenging aspect of agriscience. The result was exhilarating. The whole school started to view the agriculture department as a viable, challenging academic program. The agriculture students were inspired by the agriculture laboratories and their self-esteem and academic success increased.

Another science teacher, working with the agriculture teacher from her school, asked her advanced science students to set up the AGRICULTURAL EDUCATION MAGAZINE

October, 1992

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SIXTH GRADE BIOLOGY STUDENT STUDYING THE RESULTS OF HER BOTANY BOTANICAL ROOT CULTURE EXPERIMENT. OCTOBER, 1992
Teaching the Science of Agriculture: Animal Science

With the current emphasis on increasing science literacy in all schools, and the move to include more science-related curriculum in agricultural education, new educators need to offer new and creative ideas to students to stimulate and develop meaningful science relationships. Here is a method I use to involve the high school science department with my agriculture classes and increase student awareness in animal science.

BY RICHARD HOOK
Mr. Hook is an agriculture teacher at Gordon High School, Gordon, Nebraska.

There is a role for all of the profession to play in teaching the science of agriculture. As agriculture teachers, it’s important to model the teaching practices associated with sound principles for teaching science. Many agriculture education programs can support this effort by planning inservice programs that will help teachers to master effective methods of teaching science. And, teacher educators must critically examine preservice programs to ensure that new teachers are adequately prepared for teaching agriculture. I challenge you to take a second look at the outcomes of teaching the science of agriculture. Are you confident that student achievement in science and agriculture is all that it should be? Let’s look and see.

References
AgriScience Education
An Industry Perspective

THEME ARTICLE

The advent of a global society and the new era of biotechnology has given rise to new challenges for our science and agricultural education systems. For years industry used modern technology to increase production and in doing so encouraged growth. However, with the new challenges facing industry the emphasis has shifted to education. Reformulation or restructuring of the educational systems is necessary to supply industry with properly trained workers for the future. At the same time companies are directing their efforts to retrain and update current workers for the continual changes that will occur.

In order to make science more relevant and representative of the workplace, the efforts of scientists and researchers are being used to bring the educational community together.

The industrial sector has recognized the importance of change in science education to make the sciences more visible and exciting for students. Recruitment in the industry has been an arduous and difficult task. With the lack of interest in the sciences the pool of qualified workers has decreased significantly. Thus, the difficulty of filling work positions is compounded, and available jobs go unfilled each year. Without a stronger emphasis on the sciences, this trend will continue and hold back the development of needed technological advances. To accomplish and expedite this monumental task all levels of education, government, and industry must work together. They must all move beyond their traditional roles and cooperate in generating new ideas, more relevant curricula, and innovative ideas for student projects. These changes are also reflected by the students in the classrooms who are able to use their hands-on experiences in a laboratory setting. Thus, science is now becoming relevant in the classrooms.

This program has been presented in many states throughout the United States to teacher groups of all levels. The positive results show that an increase in teacher experiences will result in an increase in student participation. We have learned through experience that companies and must work together in education activities at all levels. These joint ventures provide more expertise and a wider range of industrial areas. American Cyanamid Company is presently working with local companies and school district administrators on an Education Interface Committee. Our purpose is to link research and development with local school districts. A pool of protocols designed by industrial scientists is being assembled for teachers to use in their classrooms. Also, if scientists in the industry/education partnership based on a three tier structure: elementary schools (grades K-3), middle schools (grades 4-8), and high schools (grades 9-12). This will assist school districts and enable agriculture and science teachers at all levels to develop curricula for continuity in the science programs.

The positive results show that an increase in teacher experiences will result in an increase in agriscience literacy. We have learned through experience that companies and must work together in education activities at all levels.

A master list is comprised with all available programs, services, and resources supplied to all of the school districts for their usage. Thus, a school can utilize one or more companies individually or jointly to enhance its program needs. These programs and services are also made available to civic groups and community organizations.

This type of partnership will enable companies to have greater input, more follow-up, and accountability for program support and success. Corporations involved in this particular program include: Union Carbide, American Cyanamid, AT&T, Union-Poulec, VWR Scientific, Mobil R&D, Plasma Physics Laboratory, PMC, Cytogen Corporation, Bristol-Myers Squibb, General Electric, Astro Space Division, and Hydrocarbon Research. This type of program prevails in many parts of the United States and is supported by many corporations in their respective locations.

Additional companies which sponsor and support these programs include: Dupont, Hoechst Celanese, Union Carbide, Ciba-Geigy, Eastman Kodak, John Deere, Pioneer, as well as some companies in Japan and Europe. Due to the diversity of size and scope of companies, their level of participation in education/industry partnerships and programs will vary. In many areas a company adopts a school and gives them full support in science and math education.

Additional areas involving education which are gaining in corporate support include the following: summer employment for students and teachers, cooperative student employment during the school year, scholarships programs for students and teachers, educational programs for community groups, science awards programs, assistance for curriculum development, use of professional staff, use of plant facilities, workshops, presentations, and demonstrations.

Also, gaining support is the job-shadowing and hands-on experience in industrial laboratories where a student or teacher works or shadow a scientist for a day or more in the laboratory. In this way, they are able to develop a better understanding of needed skills and of current technology required for the job market. This coincides with volunteer mentoring programs where the scientist works with a student on a science project or a specific area of science.

Agriculture and science fairs are ideal for students to interact with scientists involved with their project choice. These events are increasing for all grade levels and enable the students to explore and to be creative and innovative in their projects. They are challenged to think, their curiosity is aroused, and they become more inquisitive in seeking answers. The use of "what if..." helps them reach solutions, and just as in the laboratory setting, caution must be used when setting up a science fair to minimize competition and increase interaction between students. The team concept will enable students to work together to solve problems. It allows the students to 'own' the industry, if available, and should provide constructive comments to participants on their presentations and continuance. Participation is also instrumental in helping students maintain their interest in science.

A new direction or approach to high school science education at the Biotechnology Center established in a New York high school. This is one of three high schools in the United States that allows students to perform at an advanced level in DNA experiments. A few examples of student participation include: becoming familiar with the techniques that are used in making human insulin, interferon, and human growth hormone. The students perform recombinant DNA, splitting together different pieces of DNA. This center is also used for training teachers in technology.
Integrating Science and Agriculture

By TOM DORMOY
Dr. Dormoy is associate professor and extension education at New Mexico State University.

THEME ARTICLE

Additional agriscience study at the secondary level during the 1990-91 school year focused on (1) agriculture teacher training and credentialing in science, (2) agriculture teachers receiving science graduation credit, and (3) agriscience laboratory facilities in agriculture programs, and 4) resource sharing between agriculture teachers and science departments. The goal was to remove misconceptions about teaching science in agriculture and about agriculture and science teacher partnerships. A mail questionnaire was answered by a random sample of about 240 agriculture teachers from 47 states. This summary can help agriculture teachers, science teachers, school administrators and boards of education understand and implement what others are doing in agriscience nationwide.

Science Training, Science Credentialing, and Science Credit

Many agriculture teachers are trained in science-related teaching methods. During preservice, 44% of the agriculture teachers in the study were trained in science-related teaching methods. Of these, 20% took four or more of these courses. The number of agriculture teachers who have taken preservice courses or workshops on science-related teaching methods was much larger, (nearly two-thirds). In fact, more than 25% of the teachers had taken four or more science-related courses or workshops on science-related teaching methods.

Common worries among agriculture teachers are 1) being credentialed in science and 2) teaching agriculture courses receiving science credit, bringing agriculture programs closer to being absolved by science departments. Are these worries justified? Almost half (47%) of the agriculture teachers in this study were credentialed in science. Although science credit is not a requirement for a strong agriscience program, 82 teachers from 33 of the 47 states received science credit for one or more agriculture courses in 1990-91. Only 27 teachers taught non-agriculture courses. Seventeen of these teachers also received science credit for agriculture courses.

The study found that agriculture teachers credentialed in science were more likely to teach both agriculture courses for science credit and non-agriculture courses than those not credentialed in science. Also, more agriculture teachers who were not credentialed in science taught agriculture courses receiving science credit but non-science courses (24) than science courses, and agriculture courses for science credit. (2). Finally, teachers who taught agriculture courses for science credit, more likely to teach science courses than those not receiving science credit. However, many teachers taught agriculture courses for science credit but no science courses (65) than taught both agricultural science and non-agricultural science courses (17).

Twenty-three teachers taught non-agricultural science courses in 1989-90, and 27 taught non-agriculture courses in 1990-91. For the 241 teachers, this is less than a two percent growth rate in teaching non-agriculture and agriculture courses. There were only eight teaching non-agricultural science courses and no agriculture courses receiving science credit in 1989-90, and only ten in 1990-91. This is less than one percent growth rate.

Concern about agriculture teachers becoming science teachers is largely unsupported in this study. School administrators are more likely to use the science expertise of agriculture teachers to benefit agriculture programs, whether or not they are credentialed in science or receiving science credit. The image-enhancing and recruiting benefits of science courses and science credit far outweigh the risk of being absorbed by a science department.

Agriculture Courses Receiving Science Credit

Approximately 100 different titles were reported for 166 agriculture courses receiving science credit. Close to two-thirds of the courses probably had an agricultural production emphasis. As one might expect, courses in forestry, horticulture and agriculture also received science credit. Some courses in agriculture are agricultural, biology, and agricultural science, and environmental science, and resource management received science credit. These patterns should expand visions for agriculture offerings in both life and physical science areas. From a program marketing standpoint, more descriptive and science-oriented titles like “Animal and Plant Science” or “Agricultural Science” are recommended.

Agriscience Laboratory Facilities

To easily understand how agriculture programs have changed, one need only look at current agriculture facilities. Table 1 shows the scope and frequency of agriscience laboratory facilities.

Table 1: Agriscience Laboratory Facilities (data from 235 agriculture teachers)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Freq.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag Mechanics Laboratory</td>
<td>194</td>
<td>86</td>
</tr>
<tr>
<td>Land Laboratory</td>
<td>108</td>
<td>48</td>
</tr>
<tr>
<td>Greenhouse</td>
<td>107</td>
<td>48</td>
</tr>
<tr>
<td>Computer Laboratory</td>
<td>79</td>
<td>35</td>
</tr>
<tr>
<td>Tissue Culture Laboratory</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Aquaculture Tanks</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Meats Laboratory</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Weather Station</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Animal Housing/Laboratory</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Floral Laboratory</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Forestry Laboratory</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Herbarium</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hydroponics Laboratory</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Shade House</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Soil Moisture Probe Station</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Turf Plots</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Resource Sharing with Science Departments

Strong partnerships between agriculture and science departments hinge on sharing human, informational and physical resources. Resource sharing can extend the use of scarce resources while improving agricultural literacy, science literacy, and recruiting. The study found many agriculture teachers and science departments already sharing. While nearly the same number of science departments (71%) shared resources as agriculture teachers (67%) in 1989-90, agriculture teachers shared more resources overall. Even more impressive, more than 80% of agriculture teachers expected to borrow resources from science departments in future years. Agriculture program resources used by more than 20% of the science departments were 1) plant science equipment and supplies, 2) agricultural mechanics equipment and supplies, 3) agriculture advising students to take science courses, 4) audio-visual materials, and 5) government science department resources used by more than 20% of the agriculture teachers were 1) microscopes, 2) informal program advice from science teachers, 3) glassware and plastic ware, and 4) science audio-visual materials.

Although many agriculture teachers and science departments in the study shared resources, their sharing averaged only one or twice a year for each of five resource categories of 1) instructional services (e.g., team teaching), 2) equipment and supplies, 3) curriculum and instructional materials, 4) program support services (e.g., student or program advising), and 5) facilities. To build strong partnerships between agriculture and science programs, partners should think about increasing their contacts.

Agriculture teachers who felt they needed resources from the science department for their instructional program found their new partnership with the science department rewarding. felt science belonged in their agriculture curriculum, felt the science department wants to work with them, and were more likely to share resources. How can agriculture teachers develop these positive feelings?

Only frequent professional contacts will help agriculture and science teachers learn what resources are available from each science instructional programs. Frequent contacts will help develop trust — a prerequisite for sharing. Agriculture teachers can help science and agriculture teachers join science faculty participation in the agriculture program. For example, a science teacher could serve on the agriculture advisory committee. An agriculture teacher could attend science department meetings.

Agriculture has a scientific base, and science can be taught effectively with applied models and problems from agriculture. Agriculture and science faculty need to work together to integrate agriculture and science into science. They can participate in intercollege efforts, like the Agriscience Institute and Outreach Program, that build agricultural and science teacher partnerships while building competence in science and agriculture. These programs will help agriculture and science teachers discover the value and place science and agriculture have in their instructional programs. These programs can expand human, informational, and physical resources without sapping meager instructional budgets. They can build a friendly climate of cooperation, mutual respect, and mutual reward.

Summary

Sound too good to be true? Interest in this study is based on the strong partnership we had with our high school science department when I was teaching agriculture. By having a dynamic agriscience and agriscience instructional program with strong laboratory, FFA, and ASEP components we're building a strong agriscience program. Our agriculture students were rewarded with life science credit for Introduction to Agriculture: Plant Science, and Animal Science courses; and physical science credit for Agricultural Physical Science (soils, agricultural chemicals, and integrated pest management) courses. Each course was science therein and science department instructors. For each course science competencies were cross-referenced with agriculture competencies and presented to our district's science curriculum committee. Members of the committee knew us well and knew what we were doing in our instructional program. Finally, to teach science in our agriculture courses, we used many science department resources. When asked, we also got involved in the science department's instructional program. These strategies can work for others, too.
THEME ARTICLE

Improving Scientific Literacy Through an Agriscience Curriculum

BY CARY TRENDLE and NONI MILLER

Mr. Trendle is coordinator of ABC in Science and MS. Miller is Director of General Education, Sanilac Intermediate School District, Mt. Pleasant, MI.

By all accounts America has no more urgent priority than the reform of education in science ... (AAS, 1989, p. 3)

Scientific literacy is vital to a nation's cultural well being and to its economic competitiveness. Historically, workers with better skills meant greater production. While early farmers sowed seeds with draft horses producing only adequate harvests, progressive producers acquired new knowledge and skills leading to greater yields. Today, American workers' scientific skills are crucial for our economic survival.

In the late 1960s the International Assessment of Educational Progress (IAEP) began collecting worldwide data on students' scientific knowledge and skills. Over the last 30 years, IAEP notes that American students' proficiency has remained low. When compared among contemporaries from six developed countries, American teenagers score the lowest in scientific understanding. In 1988, 37% of Korean 13 year olds could apply intermediate scientific principles as compared to only 26% of American students (UISB, MEAP, 1991).

Sanilac County

Sanilac County is a rural, agriculturally based community with 39,928 residents living within its 1,000 square mile border. It is the largest of the State of Michigan's 83 counties, producing crops such as milk, cereal grains, and sugar beets. Education is delivered through seven local school districts that range in size from 516 to 2,210 students. These districts are assisted by the Sanilac Intermediate School District (SISD) — serving as a link between federal and state agencies and educational programs and services.

The county mirrors both the State and Nation's student performance in scientific literacy. Few students enroll in agriculture and science courses, and from school to school, classes proceed as if scientific literacy can be attained by memorizing lists and facts. Students see science as textbook-driven, with little personal relevance, rather than as a web of interconnected ideas helping them to solve problems and bring understanding to their world.

Strategic Planning for Agricultural and Scientific Literacy

To strengthen both agricultural and scientific literacy, a committee of educators, community members, and industry leaders formed in the winter of 1991. They reviewed current agricultural and science educational research and authored a strategic plan recommending that teachers (1) connect science concepts to students' lives, (2) teach through the acquisition of new knowledge, and (3) adopt emerging teaching practices. Concomitantly, they believed agriculture must be understood by all students. Clearly, a need existed for innovative programming to immerse agricultural concepts into the science curriculum, inservice teachers, and create "hands-on" activities. Hence, the Agriculturally Based Curriculum in Science (ABC in Science) program was born with its overarching goal to improve scientific literacy among Sanilac County's 5,900+ K-8 students.

To attain this goal a supplemental funding source was needed. In the spring of 1991, the SISD submitted a proposal to the W. K. Kellogg Foundation and received funding in February 1992.

Design and Delivery of an Innovative K-8 Agriscience Program

Curriculum design and inservice education opportunities need to evolve together (NRC, 1988, p. 15).

ABC in Science's philosophy and program draws upon the National Academy of Sciences' 1988 report, Understanding Agriculture: New Directions for Education (NRC, 1989). The American Association for the Advancement of Science (AAAS) study Science for All Americans: Project 2061, and the National Strategic Plan for Agricultural Education.

Curriculum

Teaching science through agriculture would incorporate more agriculture into curriculum, while more effectively teaching science (NRC, 1988, p. 11). Three major sources were consulted when designing the fully integrated agriscience curriculum: Michigan's Department of Education Michigan Essential Goals and Objectives for Science Education (K-12) (1991), Technology Education for Michigan (1990), and the 1991 Agricultural Education advisory committee's Report on Agricultural Education. To foster ownership of the curriculum, agriti-thematic science units were created by key classroom teachers. Units were then field tested, modified, professionally published, and disseminated. Hands-on activities from Michigan Farm Bureau's Ag in the Classroom program are also included. Via the agritrathermic science curriculum, kindergarten through fifth grade students develop an awareness of scientific concepts and principles, while their comprehensive exploration occurs in the middle school.

Inservice

Improvements in science education are not accomplished by merely adopting curriculum. Rather, to improve programs teachers must be empowered through new knowledge and skills. Well planned support by both school administration and local community is critical for the process of change. Through carefully designed workshops, supportive teacher networks are nurtured. To ensure success, a systematic, three-year inservice plan for K-8 teachers was developed. In addition to locally developed workshops, teachers will participate in Michigan State University's Summer Institute for Educators. The Institute explores creative ways for teaching K-12 students science, mathematics, economics, language arts, social studies, and other academic subjects. It is also designed to encourage teachers to examine concepts and materials drawn from the food and fiber industry, natural resources, economics, and life sciences.

Hands-on Learning

ABC in Science helps teachers to carefully construct activities allowing students to make sense of what they learn and to create knowledge and understanding for themselves. Students are actively engaged in learning through agricultural themes. They "... dissect, measure, count, graph and compute, plant and cultivate, and systematically observe the social behaviors of humans and other animals" (AAAS, 1989, p. 147).

The program's architects, realizing both the value and time needed to create hands-on lessons, sought to provide students with experimental activities and more effectively utilize teacher planning time. To achieve this, they visited progressive scientific programs, observed practices, and then modified delivery systems for their own use.

Delivery System

The ABC in Science program's teachers and aide support the county's students and teachers. They travel to each school in a van identified by the brightly colored project logo. There, the project's staff assists classroom teachers and delivers kits containing agriti-thematic science.
curriculum (workbooks) and manipulatives (hands-on supplies) needed for instruction. In contrast to many itinerant programs, students do not enter the classroom and walk out scientifically and agriculturally literate. Rather, the van’s purposes are to a) transport support staff to classrooms, thus reducing the student-to-teacher ratio; b) serve as an economical and reliable means to move curriculum materials between schools, eliminating the necessity to fully equip each classroom; and c) serve as a motivational image for early elementary students, as well as an icon for agriculture education.

**Newsletter**

In an agriculturally based community, the citizenry must be scientifically literate to understand environmental and scientific issues. Economic competitiveness requires such knowledge. Publishing quarterly, the newsletter ABC in Science reaches out to community members, increasing agricultural and scientific literacy.

**Conclusion**

Clearly, in a world where rapidly changing scientific and technological advances drive production, America’s cultural and economic future depends upon the scientific literacy of its people. For American agriculture’s future economic competitiveness, we must lead the world in scientific research and apply these innovations to the food and fiber system. As developing countries increase their agricultural exports, they compete against the U.S. with cheaper, more plentiful workforces, less restrictive environmental regulations, and oftentimes unfair trade practices. For the strengthening of America’s competitive edge, science education must connect to real world applications, thereby bringing relevance to learners.

Our country’s future depends on scientific literacy, but current delivery of science education and its related technology falls short. Too few students are excited about learning science; science education must undergo a revolution. Realizing the need to improve science education and the need for agricultural education to increase its audience, Summit Intermediate School District, its seven constituent school districts, and the W. K. Kellogg Foundation developed a partnership to integrate agriculture into the county’s science curriculum — fostering both agricultural and scientific literacy. This curriculum integration does not require major reform; it relies upon innovation. Emphasis is placed upon conceptual understanding and real world applications. Agriculture is the theme weaving together curriculum contents and disciplines (Fogarty, 1991).

(Continued on Page 23)

**THEME ARTICLE**

**Industry’s Role in Developing a Science-Based Agriculture**

Our product is a highly motivated, well-trained young American who is self-confident, self-reliant and self-respecting. Through FFA we are providing a cadre of bright and capable young people with good moral values and common sense. From them let our future leaders be chosen. Tom Hennessy 1990 Chairman, National FFA Foundation Chairman, TSC Stores Nashville, Tennessee

Industry and individuals have long invested in agricultural education and FFA. These sponsors, nearly 3,000 in all, are really partners with agricultural education.

As agriculture has changed, so too have the interests and needs of agriculture students. As a partner with agricultural education, business and industry has provided and continues to provide input to assist in the direction of agricultural education.

**Initiatives in Agricultural Science**

New initiatives in agricultural science are being developed cooperatively between the National Council for Agricultural Education and the National FFA Foundation. These industry sponsored initiatives are mainly in the form of instructional materials packages for agriculture instructors. Programs are funded through the National FFA Foundation and are operated by the Council. Rather than add staff, the Council contracts with an agricultural education professional to direct the project.

These instructional materials initiatives are a result of interest generated by teachers, students, and/or industry. The manager of the project coordinates with industry executives and professionals in agricultural education. Additionally, industry and educational representatives review materials, contribute ideas, provide graphics, and suggest class demonstrations and student laboratory exercises appropriate to understanding the subject matter.

**Agriscience Institute and Outreach Program for Science and Agriculture Teachers**

The Agriscience Institute involves collaboration between teachers and scientists to develop instructional materials and student activities for science and agriculture teachers. The Institute provides instructors with an opportunity to enhance their skills and learn more about science, especially as it applies to agriculture.

The Agriscience Institute is a three-year program sponsored by the W. K. Kellogg Foundation. Agriculture and science teachers, preferably from the same high school, team up to develop "hands-on" instructional materials using WISCONSIN FAST PLANTS® and "BOTTLI BIOLOGY" for use in their classrooms. Training will eventually expand to reach 4,800 to 6,000 agriculture and science instructors nationwide. This instructional program is endorsed by the National Vocational Agriculture Teachers Association (NVATA), National Association of Biology Teachers, and business/industry.

**Food Science and Safety Programs**

The media (newspapers, magazines, television, etc.) are constantly referring to "problems" in our food supply. Some of these reports are factual or unbiased. Unfortunately, a number of such reports indicate a lack of understanding about the United States food supply, food safety, and health issues. The general public has a lack of understanding of agriculture and the food industry.

The Food Science and Safety Instructional Materials program is designed to educate young people about the food supply and food safety. The program will provide teachers with materials on food safety. The project will include a number of "hands-on" experiments and activities for students to conduct.

Not only agriculture students will benefit from this program. Students in home economics will also receive training in all aspects of food safety. By targeting both agriculture and home economics instructors, not only are future employees of food production and processing reached, but also future consumers of U.S. food products.

As Gary Costly, President, U.S. Food Products Division of Kellogg Company, Battle Creek, Michigan, states, "I believe that programs such as these are a worthwhile investment. FFA has developed a hard-hitting, action-oriented learning program in Food Safety."
CLASSROOM TECHNIQUES
Making the Most of the Time in Your Classroom

By GARY S. STRATUMANN
Dr. Stratumann is assistant professor and assistant head of the Department of Agricultural Systems and Technology at Utah State University.

The school bell rings signaling the beginning of another period in your classroom. The majority of your students have entered the classroom and probably have taken their seats for another session under your instructional command. Some schools have designed instruction to occur in distinct 50 minute periods over the typical 18-week semester system. Others offer instruction over 60, 70, or even 75 minute periods in a trimester basis. Still others will have teachers working with students in specific courses on alternate days, referred to as A/B day scheduling. Regardless of the scheduling plan or length of the term, an important issue concerning the quality of your instructional program relates to the amount of time your students are on task.

The concept of time-on-task in education is not new. In 1974, Benjamin Bloom defined this concept as the time students are actively engaged in learning activities. The National Commission on Excellence in Education, in their preeminent report A Nation at Risk: The Imperative for Educational Reform, questioned the use of time in the classroom and challenged all educators to optimize the use of time for the enhancement of instruction.

Several alternatives to increasing the time for learning have been suggested. For example, to increase the amount of time students are actively engaged in learning, why not lengthen the school day or the school year? Many school systems struggling with limited resources cannot afford this solution. Perhaps it would be best to increase the number of academic credits for graduation. Yet, this could act upon a current situation of stagnating national dropout rate of 29%, while resulting in a less than adequately trained workforce. A final alternative advocates the increase in all levels of instruction in academic courses, how can the use of homework help us in agricultural education when specialized equipment, facilities, and materials make the teaching and learning process an imitation of current agricultural science, technology, and management practices?

The most suitable alternative to increasing the amount of time students are actively engaged in learning is to maximize available class time. Keep your students on task while under your mentorship.

How are students currently using their time in your classroom? Research by Halasz and Bohn indicated that vocational students in secondary schools were on task 71% of the time. The balance of the time, 29%, were students not on task. Of the majority of time students were found on task, almost 53% of the time was spent practicing specific skills. Another 30% of the time-on-task was in exploration of theory or practice of the time spent off task, the majority of students were waiting for equipment, materials, or teacher assistance.

How you use the time for instruction in your classroom will reflect your understanding of the role of time-on-task in your agriculture program and your personal teaching style. Through my years in agricultural education as a teacher, a state-level supervisor of teachers, and now a teacher educator, I have seen teachers that get down to business at the sound of the bell. Then again, there were teachers who weren’t even sure they heard a bell! My observations have allowed me to identify several techniques you may find useful in maximizing your student’s time-on-task.

1. Demonstrate to your students that time is an important resource. Students need to see and feel the value of time in working toward the completion of the instructional unit.
2. Wasted time cannot be recaptured for future use. Plan and organize class activities in advance and stick to your schedule.
3. Remember, you also serve as a role model for the world of work. Your time must emulate your expectations for your students.

2. Clearly define student and class goals. Students need to understand their responsibilities in succeeding in your class. Very early in the term of instruction you must establish course goals. By allowing your students to assist in the development of these goals they will become more aware of the use of time in the teaching and learning process.

3. Use a wider range of teaching methods. Stimulate students and therefore keep them on task, vary your teaching approach. With proper planning and content can come alive with the use of a resource person, case study, or experimentation. Additionally,
AQUACULTURE: What the Fish Have Taught Me

BY MICHAEL WALSH

It has now been just over two years since my first introduction to the field of aquaculture. It all started in a teacher in-service workshop. Our agriculture department and FFA chapter had been solely responsible for the financial, managerial, design, and day-to-day running of the Tilapia operation. We are currently preparing to harvest at the first of our 700 fish—a day that at times I thought would never get here. Over the past two years we have seen many ups and downs, successes and failures, but there was always a positive element to the biggest catastrophes. Since our project began I have tried to reinforce two attitudes towards the project. First, we have adopted a portion of the FFA motto "Learning to do, doing to learn." It was terribly important that the students and myself gain the technical and the no-so-technical information needed to successfully raise a group of fish from the fingerling stage through to harvest. Most of what we tried to implement was new to the students and to myself. It was like the blind leading the blind at times. The good thing was that we were learning from the experience—learning why it worked or why it didn't and how to modify the plans to make it work. A lot of what we tried to implement just plain did not work. Things would need to be done over and over again, each time with a degree of modification. Secondly, we learned from our mistakes. Whoever said that you learn from one's mistakes was right. It's nice to have success, but when there are no failures to bring you back down to earth, success is somewhat shallow. Fortunately, we have experienced our share of failures.

Don't Believe Everything You Read

As we were starting our aquaculture venture, the students and I were reading everything we could get our hands on that was related to aquaculture, and more specifically, Tilapia. In northern Illinois there isn't a great deal of press or even publications on Tilapia. Even the local university library didn't have much on the subject. And what they did have was very old, published in the 1950s and 1960s, or it was written in a foreign language, or it was describing a power Tilapia culture halfway around the world. We were looking for applications that could be applied to indoor intensive aquaculture in Illinois, where winter temperatures are known to drop well below zero. After months of research I still have not really found the references I need. The maintenance staff at our high school keeps telling us to write our own book on Tilapia culture, now that we have made a full production cycle. At first, everything that was written said that one should expect to raise Tilapia from the one and one-half inch fingerling stage to the one-and-one-half pound harvest weight in six months. Not. Later I read that a more realistic time frame was nine months. Not. Of course, I can see the possibility of having the most OPTIMUM conditions of water temperature, oxygen, nitrites, feeding amounts and frequency, water quality, and every other variable, and raising the fish in a time frame of six to nine months. In our own situation it has taken a full 10 months for us to harvest 100 of the 700 fish in the tank. The fish are at all different sizes and weights. The next group will probably not be harvested until sometime during the twelfth month. After a full year of production time and money invested in these fish, we still will not have had a complete harvest; there will still be fish left from the originally purchased start-up group. But we are learning.

Have an Emergency Backup Generator

Since we started, everyone was telling us we had better have some kind of backup generator in case there is a power failure. Although I was never opposed to the idea, I felt the cost of a gas-powered generator was more than we were initially willing to spend. We approached it from the standpoint that we would wait and see. Maybe there was a more cost-effective way to handle the emergency situations. Once our operation was established we invested in a pure oxygen injection system. The main concern during a power failure was the lack of oxygen, not necessarily the fact that you need electricity. The fish were losing their appetite, and there was a tremendous increase in the number of fish eating and having difficulty breathing. We decided to invest in a pure oxygen injection system. The main concern during a power failure was the lack of oxygen, not necessarily the fact that you need electricity. The fish were losing their appetite, and there was a tremendous increase in the number of fish eating and having difficulty breathing.
Using Technology to Teach Agriculture

By VAN SHEHACKER and BOB MCLAYR

Dr. Shehacker is associate professor of instruction at Montana State University, and Mr. McBryar is an agriculture teacher at Chinook, MT.

Technological advances in every aspect of our lives demand education in the use of technology and its applications. The space age has created an entirely new need for food plants to be grown in new soil environments or different atmospheric conditions. Precision Positioning Systems will allow farmers to farm the soil rather than fields. Thus comes the new educational challenge — how to teach agriculture, science, research, and environmental concerns.

Can chemistry, biology, electronics, computer communications and hands-on activities all be included in one educational activity? Probably not, unless you are using the latest technology in your instructional approach.

Several Montana agriculture programs are using a technology developed to teach chemistry in the laboratory at Montana State University. The technology enhances the instructional approach when teaching certain science principles. Integration of academic subjects is easily achieved and cooperation between the chemistry teacher and the agriculture teacher is enhanced.

The agriculture teacher and students at Chinook, Montana are demonstrating how technology can be used to teach science, research, and environmental concerns. By use of a microcomputer Sci-LabWorks Interface students can perform research activities, test their hypotheses, and see the results in a matter of minutes. For example, students can measure the effects of fertilizer on soil acidity in one lab period. The effects of soil color on soil temperature can be monitored over a period of time with a computer and a data logger at an interval rate of several hours. The computer will graph and print the results for interpretation. Thus, the effects of fertilizer on plant production practices on soil temperature can be observed in the laboratory.

The Sci-LabWorks Interface is an accurate and specific range of collecting data on pH, temperature, light, soil moisture, and light sensitivity. The software developed with the Interface allows the computer to display the data on its own spreadsheet, chart, or direct readings on the screen. The experiments completed with the Interface must be custom programmed before activities can actually be completed. Programming? Yes, the software uses a pull down menu, which makes programming as simple as using a menu system on your computer. Programmers put the student in total control of what is to be done. It gives students the opportunity to manipulate and experiment with ideas and objects, as the software program can be modified in less than a minute. This flexibility leads to experimentation, originality and creativity. Thus, the teacher acts as a resource and fellow learner, rather than a fountain of knowledge. Consequently, students become self-directed learners, and the learning process is interesting.

Temperatures can be measured at intervals of milliseconds, seconds, or minutes; pH can be measured in hundreds of a whole number. Electric conductivity can be measured in millivolts, volts, etc. Timers can be set to activate switches or take readings from various sensors within a variety of time frames.

Research activities that students can conduct include measuring the pH of plant nutrient content of a steer on a hay ration or pasture as compared to a steer on a heavier ration grain, measuring temperature drop of soil or water as wind blows across the surface, measuring groundwater contaminants, turbidity of water, pH of new and used antifreeze, and use of the Interface to activate electrical and hydraulic systems.

Learning is discovery-based, fact finding, exciting, and it becomes meaningful to the student. Students using the system have become highly motivated to learn about scientific principles that can be discovered by using the Interface. Students are exploring science concepts and asking more questions because of the interactive nature of the system. Students are in control of their learning. Instant feedback in the form of graphics helps students recognize relationships that would otherwise not be recognized. Also, students do not have to spend time memorizing. Thus, students need time available for studying the results. Instant feedback eliminates the need to wait for significant changes to occur as soil temperature changes can be noticed. For example, blowing on the electronic thermometer immediately shows the temperature change. There is no waiting like would be experienced when conducting an experiment with a regular thermometer, and the results can be graphed on the screen as the temperature changes.

Agriculture students at Chinook High School are learning and testing science principles that apply to agriculture. They are learning research methods and techniques that will open the door to new technologies and understanding. Communication between man and machine is learned. The role of electronics in agriculture is better understood. In addition, students who later enroll at Montana State University or other universities will discover that chemistry laboratory classes are much easier and more interesting. Academic integration occurs and the chemistry teacher, student, and agriculture teacher from a working partnership — a partnership that leads to new discoveries and understanding.

Using Technology (Continued from Page 22)

Using Sci-LabWorks will discover that chemistry laboratory classes are much easier and more interesting. Academic integration occurs and the chemistry teacher, student, and agriculture teacher from a working partnership — a partnership that leads to new discoveries and understanding.

Making the Most (Continued from Page 19)

encourage your students to work independently when they are in a problem set or with your approval, cooperatively with other students.

4. Assign meaningful tasks. Nothing will take a student off task quicker than busywork or the monotonous. When students can see value and purpose in their learning activities, they will stay on task longer. Assess your current use of assignments, practice exercises, or lab work and progress the students to meaningful activity.

5. Decrease opportunities for interruptions from outside your classroom or lab. An interruption for scheduled announcements, visitors (or drivers), and students leaving early for an assortment of reasons can take your class off task very quickly. Establish classroom procedures for handling these interruptions to keep your students on task. Work with your building administrator to review the use of these procedures and to ask for their compliance.

Time-on-task is an important issue for all teachers. To maximize the quality of instruction in your agriculture classroom, you must maximize the amount of time your students are actually engaged in meaningful learning. To borrow from an Eastern proverb, "Finding time is difficult. If you want time, make it".

Improving Scientific ... (Continued from Page 16)

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STORIES IN PICTURES

(Photos courtesy of Jeff Moss, University of Illinois)

Agriculture teacher John Rentfrow at Shelbyville High School demonstrates proper procedures for conducting a chromatography experiment from the Biological Science Applications In Agriculture (BSAA) Curriculum used in Illinois.

Teachers attending an Outreach workshop of the Agriscience Institute held in LaSalle-Peru, Illinois, are getting “hands-on” practice in making bottle constructions for conducting experiments.

Enhancing collaboration between science and agriculture teachers is a major goal of the Agriscience Institute. Richard Seidel (agriculture teacher) and Julie Healy (science teacher) from Altamont High School are planting Fast Plants seed at an Institute Outreach Workshop in Vandalia, Illinois.

Student experimentation in cooperative learning groups is an excellent method for teaching agriscience. These students at Shelbyville High School are investigating the types of pigments found in plant leaves.