Places where things are right

Analysis of the reasons for the success of a number of outstanding high-school programs in physics suggests a set of conditions for creating successful programs at other schools.

Jack M. Wilson and Tim C. Ingoldsby

While the general state of high-school physics teaching in the United States is cause for concern, there are many areas with outstanding programs. These exemplary programs stand out as hopeful symbols of what might and should be done. Excellence in physics teaching is not confined by region or type of community and can be found in large cities, small towns, or rural farming communities.

Although the variations from program to program are great, there are a number of common ingredients found in all. Enthusiasm, visibility, recruiting, fun, excitement, laboratory experiences, computers, a supportive community, local scientific interactions and an interest in the breadth of the science and mathematics experience appear to make up a recipe for outstanding programs, but the key element is an outstanding teacher or teachers.

Although the previous articles in this special issue have demonstrated that the state of physics teaching is quite poor, they have also indicated actions that could be taken to cause improvement. In the following I will demonstrate that excellence in science education is possible in a variety of formats and geographic areas. The abysmal state of physics education may not be cause for despair, but instead could be the motivation required to implement many of the activities discussed in this and the other articles. To do so will require an unprecedented partnership between local schools, industries, government and scientists. To help inspire us to achieve this goal let us look at what is possible.

Conditions for excellence

One thing excellent programs seem to have in common is that the school community values education and feels that a solid mathematics and science background is invaluable for students with widely varying career goals. Some of these schools are "magnet" schools or schools devoted to the single theme of mathematics, science and technology. Among these are the Bronx High School of Science, the Houston Magnet School for Science, and North Carolina's School for Science and Mathematics. Far more common, however, are the general-purpose high schools with strong programs in a variety of areas including science. Some typical examples of the latter include Oak Park and River Forest High School in Chicago (see figure 1), Westside High School in Omaha, Nebraska, Bay City High School in Bay City, Texas, Clover Park High School in Tacoma, Washington, as well as many others.

These outstanding programs are well recognized in the physics community, and universities vie for their graduates. The February issue of PHYSICS TODAY (page 53) describes one high school (Bronx High School of Science) with a generally excellent reputation in which a single graduating class produced two Nobel laureates in physics.

Why do these "islands of excellence" exist? What are the conditions leading to their formation? Can other schools emulate these programs? Answers to these questions have been the goal of a search for excellence in physics education conducted by the American Association of Physics Teachers in conjunction with the National Science

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Teachers Association. While NSTA has been concerned with the broad view of science education, several committees in AAPT have focused on the situation in physics. Willa Ramsey of the Gompers Secondary School Center in San Diego, California, chairs an AAPT committee charged with defining excellence. This committee has identified the following goals for successful physics programs:

▶ Do students with different interests and backgrounds pursue, enjoy and profit from the study of physics?

▶ Do students understand the relation of physical principles as they apply to their personal experience?

▶ Are students able to complete and explain the results of guided experiences related to their physical environment?

▶ Are students able to distinguish between observation and inference, opinion and fact?

▶ Are students able to recognize the important physical principles underlying a given issue?

▶ Can students gather, record, organize and explain implications of data?

▶ Do students understand the nature of scientific "theory," its value and implications?

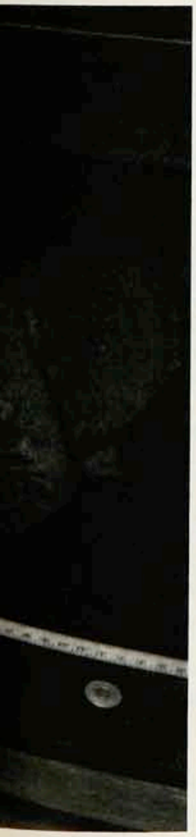
▶ Is the student encouraged to build a structure of ideas and concepts within the physics course that will help him or her to evaluate the problems of the real world?

▶ Does the course involve qualitative and quantitative analysis based on estimates, thereby approximating real-world situations?

▶ Do students develop skills necessary for continuing growth and knowledge of science throughout life?

▶ How does the physics program fit within the goals, objectives and philosophy of the total school?

To these goals we would add several other qualifications to be used in the selection of typical examples of good physics programs, such as "What fraction of the student population is reached by the physics program?" and "How have the students fared in further scientific study?"



Joe Meyer teaches physics of optics at Oak Park and River Forest High School near Chicago; last year over 75% of the school's students were enrolled in a science course. Figure 1

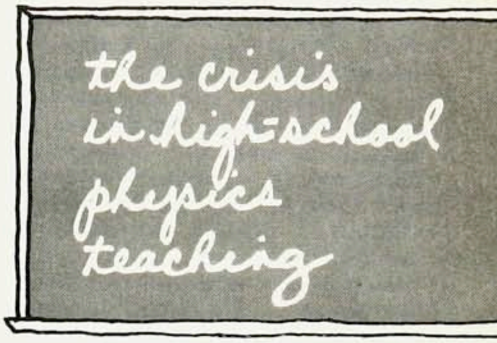
Magnet high schools

A look at a few of the outstanding programs and the teachers involved should provide a glimpse of what is possible. Comparison of these programs with those found at most schools yield striking results. The "magnet" or theme high schools provide some illustration of what can be done with the best students in a controlled environment that emphasizes science and attenuates much of the distractions faced by science students at other schools.

Bronx High School of Science. When it comes to preparing future physicists, the Bronx High School of Science is the school to which all others are compared. It is the oldest exemplar of the "magnet" school, it still leads the nation in the number of National Merit Scholars produced, and it is nearly always represented in the top groups at the International Science and Engineering Fair, The Westinghouse Science Talent Search and other national and international secondary science competitions.

As mentioned in the February news story, the remarkable class of 1950 at the Bronx High School of Science included two of the three Nobel laureates from Bronx Science, Sheldon Glashow and Steven Weinberg (Leon Cooper, class of 1947, is the third). The list of alumni who have gone on to become physics PhDs from the period 1940 to 1960 is only slightly less remarkable. At a reunion of his class, New York Councilman Henry Stern (class of 1950) said, "There has not been such an assemblage of genius under one roof since yesterday, when the current classes of the Bronx High School of Science let out for the weekend," indicating that the standards have remained high.

In many ways Bronx Science has a



very traditional program. Students study for four (sometimes three) years during which they are expected to take science and mathematics every semester. All students are exposed to the study of each of the basic sciences, physics, chemistry, and biology, during their tenure. The particular courses selected depend upon the student's interests and abilities. Freshmen would be expected to take one of the sciences at the introductory, freshman or "double honors" level. The "double honors" course is reserved for the best-prepared students and is a ten-period course instead of the standard six-period course. As in most schools, biology is the most popular choice for the first science, but physical science is increasing in popularity. The sophomore year is similar to the freshman. In the junior year students take regular or honors sections of physics, chemistry or biology and begin a research project in their field of interest. Although a certain amount of equipment is available for research projects, physics students have traditionally undertaken their projects in conjunction with local universities and laboratories. Students also take a course at Bronx Science in the techniques of physics, including an introduction to shop practice. The research projects can be continued into the senior year, which may also include an Advanced Placement course in physics or chemistry; the physics course is taught out of Resnick and Halliday, or Sears, Zemansky and Young.

Admission is determined by the student's performance on a special test. Although interviews were used in the early years, they have since been discontinued. At present the student body of 3100 includes seven percent Hispanic, thirteen percent Black, and sixteen percent Oriental. By graduation, virtually all of the students will have taken at least some physics. Administratively, physics is part of the department of physical science, chaired by Larry Finkelstein. The faculty of eleven is assigned as part of the normal pool available to the New York City Schools, and no faculty have been specially recruited for service.

Perhaps the most important thing that the Bronx High School of Science accomplishes is bringing together a large number of students who have similar interests and abilities in the sciences. In many other high schools such interests can be overwhelmed by peer pressures from the vast majority of students with no interest in the sciences.

North Carolina School of Science and Mathematics. While the excellent mass transportation available in New York and the extensive use of busing in Houston allow science and mathematics schools at these locations to operate as day schools, the fact that North Carolina's population is chiefly rural and in small cities rules out such an arrangement there. The state thus chose to develop a residential school to provide service to a much larger geographic area. In 1980 the first 150 students were admitted as juniors, and subsequent admissions have brought the total enrollment to 400 in the two-year program.

There are four physics teachers, all with PhD degrees, on the staff. Charles Brittain, a physicist, is the chairman of the science department. According to John Kalena, physics instructor, the residential aspect of the school is very important to its success, because it gives students time for the extended interactions with the faculty they are anxious for. The residential aspect and the fact that faculty are actively recruited rather than assigned are two areas in which the North Carolina school differs from Bronx Science and the Houston Magnet School.

Every student is required to take at least one course in each of the basic sciences, biology, chemistry and physics. To accommodate the different interests and ability levels of the students, introductory physics is offered at three levels of mathematical sophistication. The algebra-level course is taught from one of the standard high-school physics texts, the trigonometry-level course is taught out of the college physics text authored by Giancoli and the calculus-level course is offered from Resnick and Halliday. One major departure from among other schools is the availabilty of a complete smorgasboard of physics elective courses which include: modern physics, astronomy, electronics, biophysics and energy. Three of these electives are offered each semester. Students fit these electives into a program that requires English and mathematics each year as well as at least one year of history, foreign language, American literature, computer science, and art and music electives.

Selection of students for the North Carolina School of Science and Mathematics is based upon SAT scores, grades, interviews, recommendations and special tests. The school makes an effort to achieve geographic, racial and sexual balance.

Local schools

While the magnet schools undoubtedly do an outstanding job of educating some of the best future scientists in the US, most of our future scientists are studying at schools that do not emphasize science and mathematics. These local schools are trying to maintain a complete variety of programs for an entire spectrum of interests and abilities. Science teachers at these schools have to compete with the football team, the band and the other academic areas for resources, and it is not always easy. Yet these schools are vital to efforts to provide access to scientific and technical careers for the bulk of the population. Ultimately our success or failure at developing a technically literate population and work force depends upon these schools. The following examples of some excellent high-school physics programs may give us some grounds for optimism as well as providing a recipe for success for other schools.

Omaha Westside High School. One of the largest public schools in the state of Nebraska, Westside High School in west-central Omaha serves a population of about 25 000 residents. What began 35 years ago as a small, rural school system for kindergarten through eighth grade has evolved into an urban school district, kindergarten through twelfth grade, with a large (enrollment of 1800 in grades 10–12) and comprehensive high-school program. While not the most exclusive area in Omaha, the Westside community is dominated by upper-middle-class professional people who value education highly. Consequently, over 75% of the students in a typical graduating class will go on to college and will choose a wide variety of colleges. In a typical year, Westside graduates will be accepted by universities such as Harvard, Yale, Stanford, Caltech, Rice and Northwestern, along with prestigious midwestern colleges and universities such as Macalester College, Creighton University and Iowa State. Westside will also send more than 150 graduates to the University of Nebraska each year (and these graduates will account for upwards of 10% of the Regents Scholarships awarded to freshmen by the University).

The physics faculty at Westside is led by department chair Charles Lang. Nearly 50% of the school's graduates will have taken a year of physics, 20% will have completed three semesters of physics and an additional 20% will have credit for at least one semester of electronics.

Westside High School in Omaha uses a swimming pool ("World's Largest Ripple Tank") to demonstrate wave phenomena. Half of the students take at least a year of physics. Figure 2 ▶

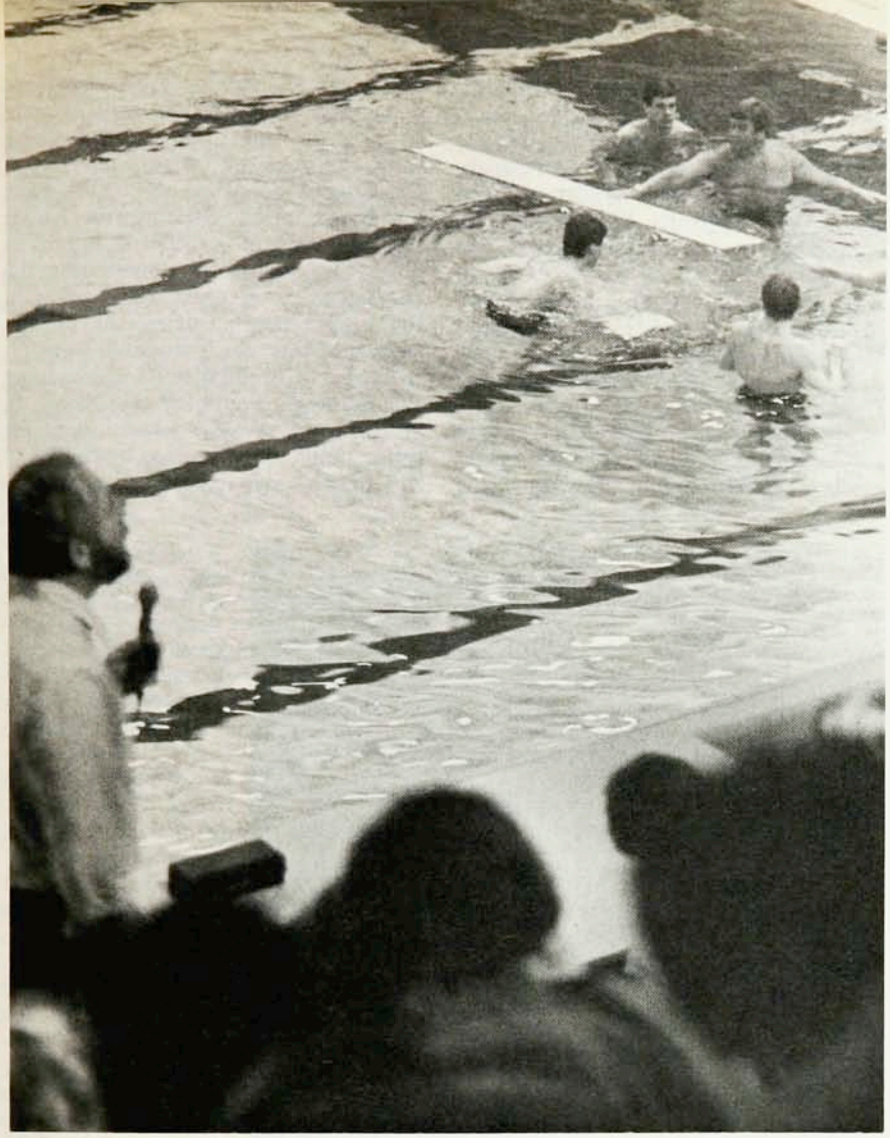
The strategy adopted by Westside has been described[1] as a "multi-faceted approach" to physics. The physics program is built around a weekly "cycle" of class meetings. The goal each week is to learn a particular topic or set of topics. All activities within a cycle relate to that goal. For efficient utilization of the staff, four separate types of class meetings occur each cycle.

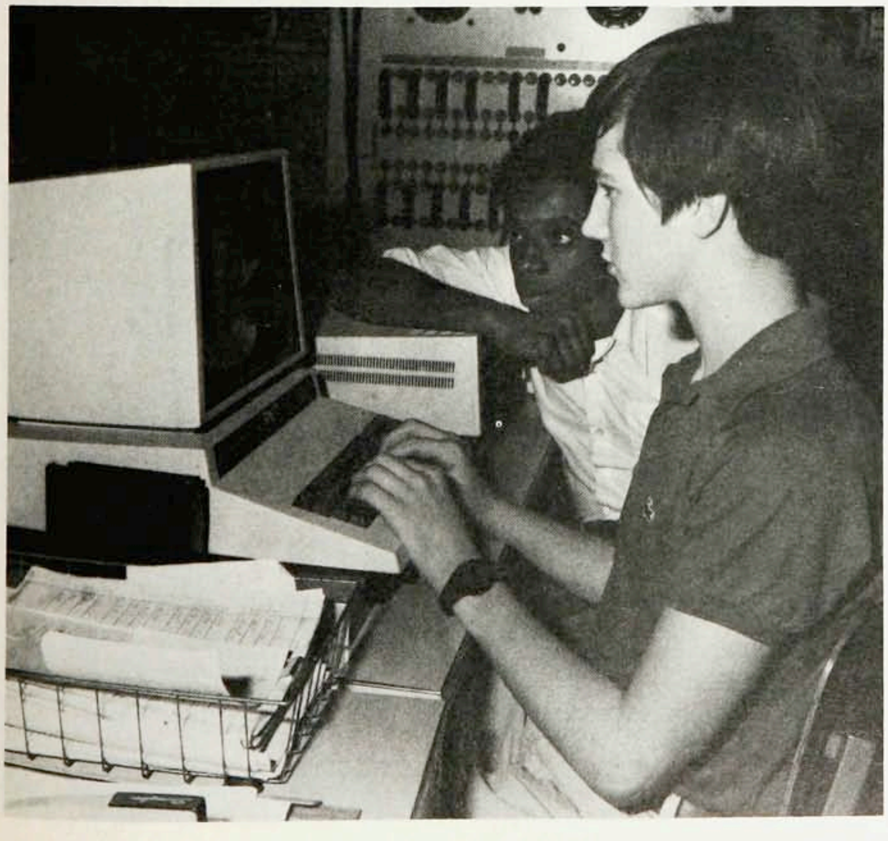
The cycle begins with a presentation to the entire class of 300, requiring a great deal of preparation. At these full-class meetings, the teachers make an effort to involve the students in the classes as participants in demonstrations or other activities. (Some of the full-class meetings are used for administering exams.) When appropriate, large group meetings will be held in locations other than the lecture hall—for example, for the introduction to waves the entire class meets at the swimming pool ("the world's largest ripple tank," see figure 2), where demonstrations of interference, superposition, traveling waves and standing waves take on real meaning to students. Another special meeting, held at the football stadium during the introduction of Newton's Laws, is a demonstration experiment conducted using identically shaped model rockets but carrying different masses and charges (to produce different total impulses). A beneficial side effect of such special class meetings is an increased visibility for the physics course among the entire school population, which teachers in both of these two programs mentioned was important.

Without question, the focal activity for each cycle is the common lab, allowing all students to participate in the investigation of the physical principle under study that week. For example, when they study Newton's Laws, the students' common lab activity is using stroboscopic photography to measure the acceleration of a "dynamics cart." All labs are written up in an abbreviated format and graded by one of the instructors.

During the week there are two small meetings, limited to about 25 students

Computers at Oak Park and River Forest are an integral part of the physics class and laboratory. Figure 3 ▶





per section. The first is used for pre-lab discussion, problem-solving assistance and demonstrations that would not be visible in a larger setting. A second small meeting is for post-lab discussion and to summarize the important ideas of the cycle and check for student understanding.

The final activity of each cycle is the primary activity that provides for differentiation among student abilities and needs. All students attend an "interest lab" designed to provide a wide spectrum of additional activities related to the topics of study for the cycle. Students select one or more activities based on their abilities and interests. Topics of study for interest labs are carefully chosen to represent a wide variety of mathematical and conceptual levels.

One final feature of every cycle is a provision that eliminates much of the fear that students often have toward physics. The "Help Room" is a classroom staffed every hour of every day with a physics teacher ready to provide individual assistance to students; students know that a physics teacher will be available in the Help Room ready to help them learn physics.

Not only does the mode of instruction vary from day to day within each cycle, but the instructional approach to a particular unit of study changes throughout the year. Other techniques include open laboratories, student contracts, mastery quizzes and team testing.

The physics program at Westside does not stand apart from the rest of the school curriculum. Students are actively encouraged to take as many science and mathematics (and solid English!) classes as possible. Physics forms the core of the junior-year science curriculum, but accelerated sophomores (those co-enrolled in advanced algebra) and a few seniors also take the course. Over 95% of the physics students continue on to an equally excellent chemistry program, and there is a conscious coordination of topics between the two physical sciences. Fully the last third of the physics class concerns atomic and nuclear physics, which leads well into the atomic model topics at the start of the chemistry course. Also, heat, thermodynamics and kinetic theory are given light treatment by physics but covered in depth in the chemistry program. Another option for seniors is a third semester of physics, which treats topics omitted in the first two semesters but important for scientific careers (field theory, rotational motion, relativity and selected concepts from biophysics and radiation physics). Finally, a full spectrum of electronics courses, taught from a physical viewpoint, is available to students throughout their high-school career. Those completing all six semesters of electronics will have the equivalent preparation (analog and digital electronics, microcomputer programming and interfacing) of many two-year technical college programs. Advanced Placement physics is *not* offered. The science faculty at Westside feels that breadth of preparation is the proper focus of high-school science; thus, students are encouraged to select a wide range of courses rather than intense study of a single discipline (such as the calculus-based AP physics course requires).

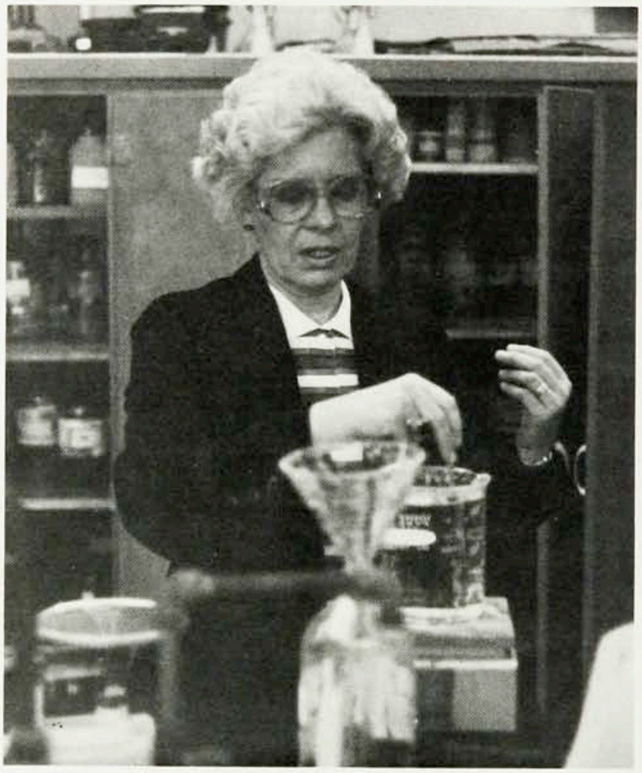
Westside's program has produced a solid record of achievement. For example, the Class of 1983 included 19 National Merit Finalists, a Space Shuttle project finalist and a Westinghouse Science Talent Search award winner. This class of 600 received approximately \$500 000 in scholarships.

Oak Park and River Forest High School. Oak Park and River Forest are residential suburbs adjacent to Chicago with a combined population of about 70 000. Excellent cultural and recreational opportunities, with many hospitals and churches, make this community a people-centered place with extraordinary emphasis on its schools. The communities include minority populations of approximately 5.3% Black, 1.8% Asian American and 1.4% Hispanic. Oak Park and River Forest have large percentages (37.7% and 50.6%, respectively) of adults with the occupational status of "professional, manager or administrator," which indicates an educationally oriented population. Historically, the board of education has been very supportive of excellence in education.

The enrollment in the four-year high school is 3329 and the trend is downward (from a peak of over 4400 in the early 1970s). Enrollment is expected to bottom out in about 1985, with a gradual increase foreseen thereafter. The per-pupil cost for education is \$3900/year. Certified staff number 256, for a student/teacher ratio of 13 to 1. The main portion of the school building is approximately 50 years old, but many additions and remodelings have been completed since its initial construction. The school district dates to 1873 and claims an illustrious list of graduates, including Ernest Hemingway, John La Montaine and Ray Kroc. Specialized science facilities are limited to a recently acquired greenhouse donated by a district resident.

The physics curriculum at Oak Park and River Forest High School provides offerings suitable for nearly all of the college-bound portion (over 77%) of the school population; it includes Physics 1P, a less mathematical introduction to physics emphasizing the concepts of physics and using Paul Hewitt's text, *Conceptual Physics*; Physics 1, a traditional algebra-level approach to high-school physics using the text *Concepts in Physics* by Miller, Dillon and Smith; Physics 1H, an honors version of Physics 1, using Beiser's *Physics* and designed to prepare students for the Advanced Placement Level B (non-calculus) Examination; and AP Physics, a second course in physics using Sears, Zemansky, and Young for serious science students expecting to take the Level C (calculus) Advanced Placement Physics Examination. Another course taught in part by physics teachers is Freshman Science Survey. This course, newly developed by the science department at the school, is an attempt to provide incoming students with some exposure to the broad offerings of the science department at Oak Park and River Forest. Students receive six six-week units of instruction, taught by different instructors representing the various areas of science education in the high school. During the physics segments this year, students were introduced to problem-solving involving the personal computer (see figure 3) and scientific analysis techniques for solid, liquid and gaseous systems.

All of the introductory physics offer-



◀ **Katherine Mays** at Bay City High School on the Texas Gulf coast mixes a solution for an electroplating experiment in her physics class. Figure 4

Bay City computer specialist, Sophia Kabler, writes programs that students can use to analyze data taken in the laboratory. Figure 5 ▼

ings of Oak Park and River Forest High School are laboratory-based. While the AP physics course does not have a weekly scheduled laboratory period (the demands for coverage of the topics in the AP physics Level C curriculum do not permit time for weekly laboratory investigations), students are expected to complete quarterly projects that require the development of experimental skills. Project topics for the 1982–83 school year include bridge-building, mousetrap cars and other "physics olympics" events.

There is clear agreement among the administration, other faculty and students of Oak Park and River Forest High School that the prime key to the success of the physics program at the school is the talented, dedicated physics staff, led by veteran instructor Joe P. Meyer. These teachers have worked hard to develop a learning environment that encourages all students to consider physics an exciting subject for study. Some team teaching occurs in Physics 1 and Physics 1H, but throughout the offerings the emphasis is on substance rather than strategy.

Perhaps the overriding characteristic of the science program at Oak Park and River Forest High School is the support shown by science teachers of one particular discipline for the offerings of the other areas of science. No student is permitted to enroll in a second year of a particular science without having taken at least one year of the other basic science offerings (biology, chemistry and physics). This emphasis on *breadth* of preparation, rather than *depth* in one particular area, is a prime consideration in the identification of an outstanding college-preparatory physics program. Nearly 70% of the graduating class of 1981 had at least one year of life science and one year of physical science. More than 70% of the students enrolled in biology as sophomores continued with chemistry as juniors and over 60% of the chemistry students continued with physics as seniors. Including the Freshman Science Survey, in excess of 50% of the graduating class has received at least some instruction in physics. Physics is only one of many science programs with high enrollments. In fact, science, with only a one-year graduation requirement, is second only to English, with a four-year graduation requirement, in terms of course offerings and enrollment! (Over 75% of the student body is enrolled in a science course in 1982–83.)

Any examination of the achievement of students in the Oak Park and River Forest High School physics program indicates a high level of success. Students from the school attend a broad range of institutions, from the most prestigious universities to the local community college. Follow-up studies of graduates indicate overwhelming satisfaction with their preparation in science. Of those students enrolled in Physics 1H and AP Physics taking the Advanced Placement Examination in 1982, nearly 90% received scores of 3, 4, or 5.

Probably the most significant measure of excellence of the physics program is the performance of Oak Park and River Forest High School on the Junior Engineering Technical Society Contest over the course of the past three years. The school entered this competition for the first time in 1979–80. The Oak Park and River Forest JETS Team placed as state runner-up; in 1980–81 the Team was state winner and national runner-up; in 1983 Oak Park and River Forest High School was the national winner. (The JETS competition involves tests in graphics, English, mathematics, biology, chemistry, and physics. Each team member takes only two examinations. Thus, the overall team score is a reflection of the total program, rather than the extraordinary abilities of one or two students.) Oak Park and River Forest has also provided past winners of the Westinghouse Science Talent Search and finalists for the Space Shuttle Project.

Bay City High School. Located in a rural area of the Texas Gulf coast, Bay City High School is well known to the college and university science departments in Texas. Just as some schools have a reputation for producing "blue chip" football players, Bay City has the reputation for producing "blue chip" science students, particularly physics and chemistry students. Although many of the graduates go on to the better known Texas schools, such as the University of Texas, Texas A&M and Rice University, MIT has been known to recruit successfully at Bay City.

The science program at Bay City is typical although somewhat accelerated. Starting as early as eighth grade, students are invited to participate in an after-school science program for roughly four hours each week. In ninth grade the best students are placed in biology so that the last three years are free for the physical sciences. Two years are offered in each of the sciences. Extensive laboratory work is part of each course and a research paper is required each semester.

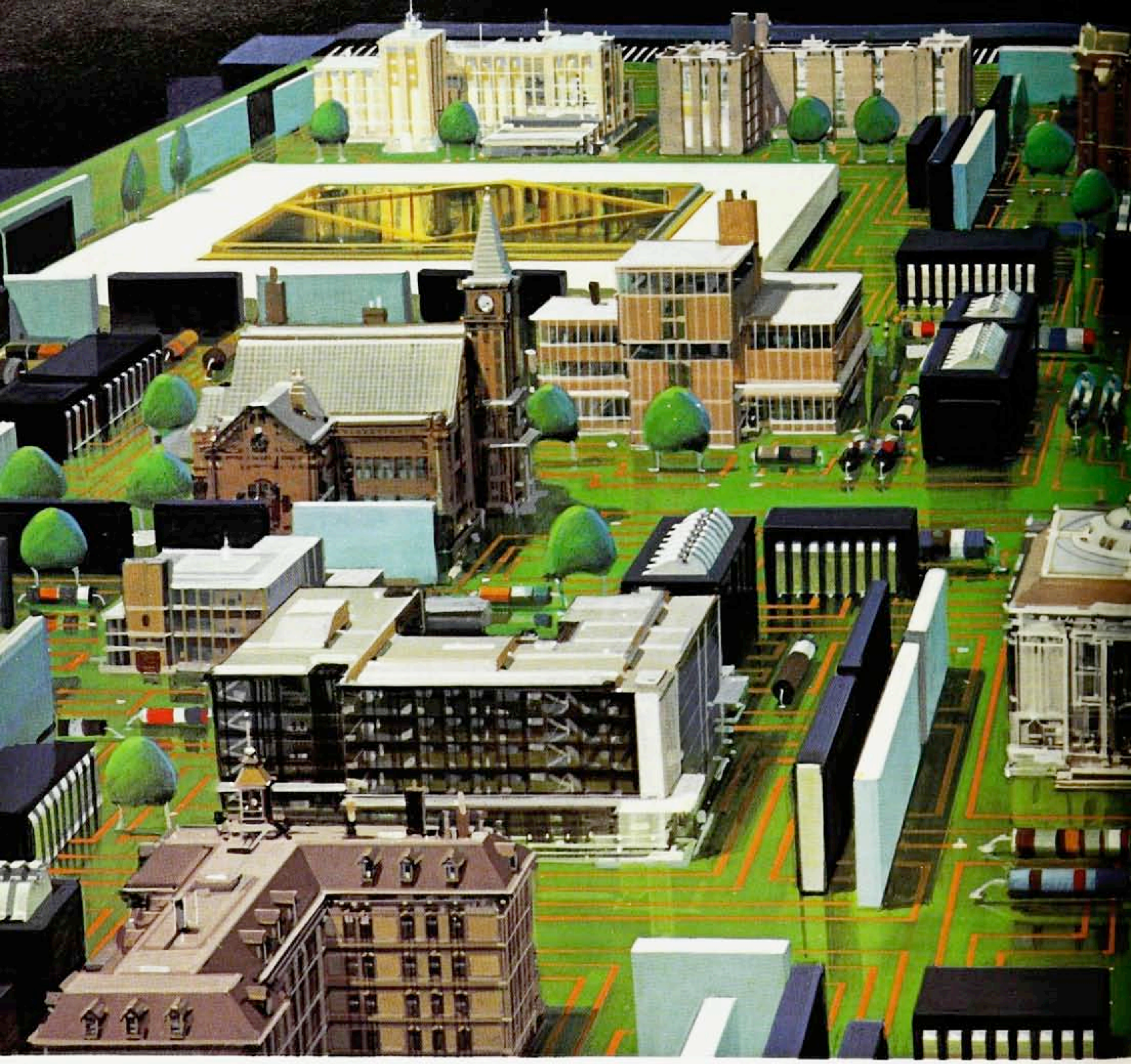
As is the case with many of the most successful physics programs, an outstanding teacher, Katherine Mays (see figure 4), can be identified as responsible for much of Bay City's success. Mays credits a number of her college physics professors with teaching her that she should "not worry about the amount of material covered, but to teach well the concepts introduced." She also points out that teachers should have a love for physics and an enthusiam for communicating that love to the students. Students describe her lecture techniques as "getting a high on physics." She herself asks "have you ever seen a little old white-haired lady pivot on her toes to demonstrate rotational inertia?" Her classroom has something of a "carnival atmosphere" with numerous devices and demonstrations hanging from the ceilings, walls and covering the tables. Toys, used to introduce many topics in mechanics and optics, are everywhere. Computers are available to all of the physics students; they all learn how to write programs for graphing, data analysis and simulation (see figure 5).

Bay City has an unusually well-equipped science department, and the teachers attribute this to the excellent support that they receive from the school board and adminstration. There is also a lot of interaction with the community and local industries. Industry and local doctors have donated such equipment as a spectroscope, electrophotometer, balances, pH meters, recorders and a gas chromatograph. The school also calls on local scientists and engineers to act as mentors for special research projects, to assist with field trips, and to teach short (3–5 day) courses in such areas as statistics, data analysis or computer programming. Each year at least one scientist from local industries acts as the liason between the students and other local scientists. During the 83–84 school year five local scientists have agreed to assist by acting as resource people or even by repairing equipment.

Depending upon the year, 35–70% of the graduates will have taken physics. Mays sees an increase in state requirements as deemphasizing some of the "frill" courses and strengthening the science areas. When asked what is the most important thing that a physics teacher can do, Mays replied "Recruit, recruit, recruit! I have to let the students know that physics is important and can be interesting. If I do not tell them, no one else will."

Clover Park High School. Just south of Tacoma, Washington, Clover Park High School is another excellent suburban school district with an active program in physics. An enrollment of 1200 students supports a science faculty of six. Over 50% of Clover Park's students go on to college and most of them take two years of science. There are four physics courses offered, as well as an independent study course and an atomic-science course. This year the independent study group is working on a course entitled "The Mechanics of Motion." This entails applying the concepts of classical mechanics to amusement park rides.

The 1983 Washington State Educa-



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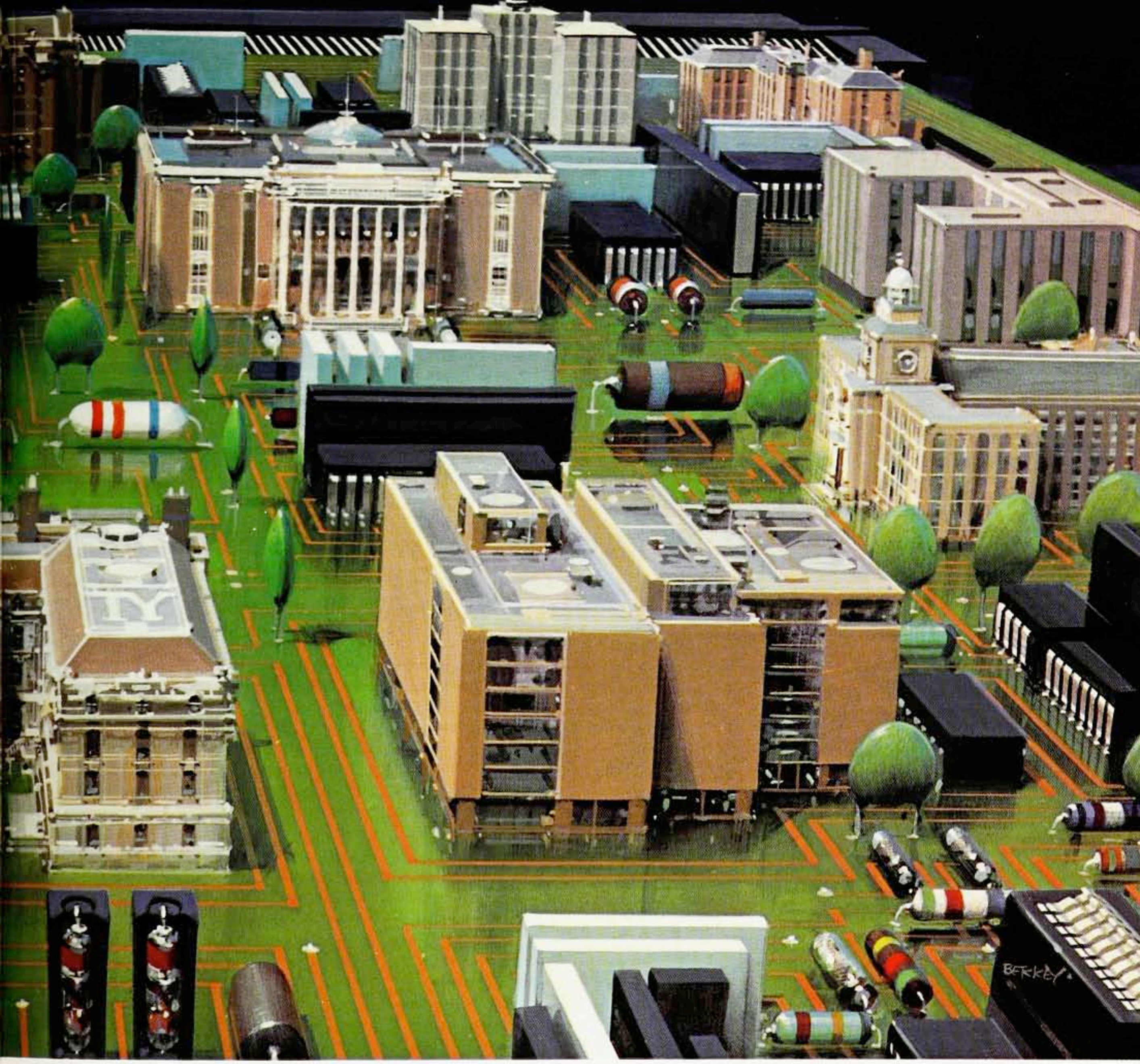

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Jack Dombrosky, 1983 Washington State Educator of the Year, teaches physics and heads the science department at Clover Park High School near Tacoma. Figure 6

tor of the year, Jack Dombrosky (see figure 6), teaches physics and heads the science department at Clover Park. His example may provide ammunition for those who feel that teachers may be retrained by workshops and institutes of the sort offered by NSF in its early years, because Jack Dombrosky entered teaching twenty-five years ago prepared as a biology teacher.

Then, as now, there was an adequate supply of biology teachers and a short supply of physics teachers. The principal of the local high school told him that physics teaching might be his only chance to get into secondary education. He took that chance. In his own words, "Needless to say, I was very unprepared and learned much physics along with the students."

Fortunately for Dombrosky (and the state of physics education), the launch of Sputnik provided the impetus for major improvements in physics teaching. Through NSF grants and workshops, he was able to obtain an MA in physics, and a later workshop introduced him to PSSC. He still uses PSSC today, although he considers the fifth edition much less useful than earlier editions. Using earlier editions, he had built the course around the question "What is light?"—a mystery approach to be resolved by the end of the course.

Dombrosky echos Katherine Mays' exhortation to "Recruit, recruit, recruit!" His own recruiting efforts effected a dramatic increase in physics enrollments at Clover Park, in the face of a 20% decline in school enrollment. He suggests that one way to recruit students for physics is to survey the biology students to discover students with interests that should lead them into physics. He maintains that "Physics is for everyone, not just the select few."

Like the teachers at the other programs, he tries to make physics visible to others in the building through activities outside the classroom in the halls or even the streets. He runs a version of the Physics Olympics program each spring as a competition between classes. With teachers who proclaim "airplane-flying contests are not physics!" Dombrosky has little patience. He retorts that students "will remember the paper airplane more vividly than they will remember the formula for centripetal acceleration." He teaches by Dombrosky's first law, "Physics is Phun." His students may have fun, but they also learn a lot of physics. Many have gone on to success at prestigious universities. The problem-solving teams he advises have been at the top of the state competitions, and he has high hopes for the national competition in the future.

As the head of the science department, he has had the opportunity to develop teaching strategies for others. Among his suggestions: Encourage females to study physics, don't try to cover everything, encourage note-taking, don't require formula memorization, develop objectives, use tests as teaching devices, use the computer in the classroom, subscribe to *The Physics Teacher* and *The Science Teacher*, attend professional meetings, take field trips and, above all, don't hesitate to try something new in the classroom.

Reference

1. Charles Lang, Bob Klein, Tim C. Ingoldsby, *Phys. Teach.* **13**, 409 (1975). □