

**Introducing optics education at the high school level:
the Kentucky approach**

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ABSTRACT

The Kentucky state legislature has recently instituted a program for public education reform at all levels. This effort is being watched by many states considering similar restructuring of their public school systems. An associated resolution mandates that state universities support this reform effort by serving as a resource for staff development, teacher education, and program development. In keeping with this mandate, the Physics Department of Murray State University (MSU) has adopted a strategic plan which includes the initiation of a series of workshops and seminars for the benefit of regional high school science teachers. A key element in this plan has been the development of a workshop in optics. The focus of this effort is: (1) to provide teachers with resource material, lecture and demonstration ideas, and an introduction to unfamiliar technology, and (2) to subsequently motivate good students toward study and careers in optical physics by involving them in their own learning. Details of this program are given, outlining the structure and content of the workshops as well as an assessment of their reception and success.

1. INTRODUCTION

The Kentucky Education Reform Act (KERA) of 1990 was offered by the Kentucky state legislature as a response to charges of inadequacy of the state's public school system.¹ Widespread dissatisfaction with the quality of public education and the method of funding the existing educational system prompted the sweeping reforms now taking place in Kentucky schools. This comprehensive public school restructuring program is being monitored by other states considering similar programs, and the KERA has become a national bellwether in the ranks of education reform legislation. It is hoped that the KERA will introduce a new spirit of educational opportunity, providing quality education to children across the state.

Accompanying this legislation is a resolution mandating Kentucky colleges and universities to support the public school districts in implementing the KERA. This support would consist primarily of

service as regional resource sites for staff development, teacher education, and curriculum development.

2. PROVISIONS OF THE KERA

The KERA is a comprehensive body of legislation, and the MSU Department of Physics is not equipped to address many of its provisions. However, three elements stand out prominently as areas in which all branches of science, including optics, should be focused. These elements are as follows:

(1) Professional Staff Development--The KERA provides for increased efforts to provide professional development opportunities for teachers at all levels both inservice and preservice. As an example, funds will be made available for professional development in the form of seminars, workshops, colloquia, or other training sessions designed to enhance the quality of science instruction in the schools. It is hoped that teachers who are better trained, better prepared, more confident of their abilities, and who possess a rich volume of demonstration ideas and equipment will in turn produce students who enter the university setting with increased enthusiasm and appreciation for science. We believe the teacher is the key to substantive change.

(2) Technology in Education--There will be an increased emphasis on the use of technology in the classroom. This opens new avenues for science instruction, as the scientific disciplines should be the driving force behind the new technology. The use of computers in the classroom, for example, offers opportunities for interactive learning on any subject as well as exposure to the field of computer science. The technology introduced into the curriculum should be student oriented and convenient to use, and should lead to an enhancement of the student's analytical and problem solving skills by allowing him or her to explore the subject more thoroughly.

(3) School-based Decision Making--A key provision of the KERA is the establishment of a policy for school-based decision making. The idea here is that decisions will be made by the people most affected by such decisions. The concept is designed to create a vested interest on the part of teachers as they have input into the decision making process. By 1996, each school in Kentucky must create an internal council composed of parents, teachers, and school administrators which will be responsible for setting policies relating to personnel, curriculum, instructional materials, and other areas of school management. It is reasonable to assume that the "elective" or "peripheral" fields of study included in these newly formed curricula will include those for which the council has some degree of familiarity, comfort, and appreciation. At present, optics is an unfamiliar field which would most likely be considered only a peripheral part of science in west Kentucky schools. This may result in the omission of optics in the science curriculum unless it is promoted by those who are active and interested in the field.

3. INTRODUCING OPTICS INTO THE SCIENCE CURRICULUM

In reviewing the KERA provisions outlined above, the MSU Department of Physics has recognized the opportunity to influence the direction of science education in the region. The department has maintained close ties to local high schools by virtue of an ongoing program of school visitation. These contacts, primarily a tool for student recruitment, have also provided an opportunity for an informal curriculum review of high school physics programs. In conversation with high school science instructors it became clear that the university faculty's cooperative involvement and support of the high school program would be welcomed.

This year, the physics department has adopted a strategic plan which includes the initiation of a series of workshops and seminars for the benefit of regional high school science teachers. The purpose of these workshops is to enhance the quality and quantity of high school programs in all areas of science, with optics constituting a primary area of emphasis. The goal of this effort is: (1) to address the provisions of the KERA by providing teachers with resource material, lecture materials, and student activity and demonstration ideas, as well as an introduction to unfamiliar technology, and (2) to motivate good students toward study and careers in optical physics.

4. THE OPTICS WORKSHOP

The 1991 spring optics workshop was planned as a one-day event. It was timed to take place near the end of the academic year, so that the ideas and demonstrations presented could be fully developed over the summer for implementation in the next year's curriculum. Publicity for the workshop was coordinated through the Director of School Services in the College of Education. This office is the liaison with teachers and instructional supervisors throughout the MSU service region.

4.1 Format

The workshop format was informal, with teachers encouraged to participate in demonstrations, experiments, and discussions of optical principles and their presentation in the classroom. The event was designed for high school physics and physical science teachers, and was originally to have been limited to 15 participants. Overwhelming response in the first week of publicity prompted the acceptance of 19 participants which was the limit allowed by available equipment.

4.2 Content

The workshop included topics in geometrical and physical optics phenomena appropriate for the high school classroom. These consisted of basic demonstrations and discussions of HeNe lasers and laser safety, using lasers to find the focal length of a lens, total internal reflection and optical fibers, reflection and refraction with water in an aquarium, and index of refraction. An extensive set of polarization demonstrations was performed, placing stressed plexiglas

rods between crossed polarizers, viewing optically active materials, and polarizing by reflection at the Brewster angle. When possible, the demonstrations were performed with a minimum of costly equipment, keeping in mind the budgetary constraints of most programs.

The experimental demonstration period was followed by a discussion and demonstration of interactive computer simulations of physical optics principles. This software was developed by university faculty members to illustrate electric field vector behavior in various polarization states, propagation of polarization states through birefringent and optically active media, ray trajectories in gradient index media, and Fresnel diffraction and its interpretation by Cornu's spiral.

The afternoon session began with a "How does it work?" segment, consisting of brief conceptual explanations and examples of optical applications in the everyday world. These included discussions of lasers, optical fibers, compact disc players, cash register scanners, and naturally occurring phenomena such as rainbows and mirages.

Every participant received a sample Optics Discovery Kit developed by the Optical Society of America. Though the target audience for this kit is slightly younger than high school students, the value of the kit was recognized in its simplicity, its versatility, and in its ability to prompt the user to explore various optical phenomena. Further, the manual asks the user to think about what he or she is seeing, analyze why it works, and predict what might happen in a related experiment. These kits are surprisingly intriguing instruments and were very well received. Each attendee was also given a substantial bibliography of optics texts and optics reference books. Ordering information and prices were provided for all equipment used in the demonstrations. A workshop registration fee of \$40 was charged to cover the cost of the optics kit, a noon meal, and all workshop equipment, literature, and resource material. The workshop schedule was flexible enough to accommodate special interests in specific areas of optics, and interested graduate and undergraduate students were present to aid two departmental faculty members in providing individual attention to each participant.

4.3 Reception

Each attendee completed an anonymous evaluation form before leaving the workshop. The participants were asked to critique the workshop's organization, content, leadership, and also to offer any comments or suggestions. Very few critical remarks were received, and the participants were unanimous in their praise for the numerous economical demonstration ideas. Discussion of optimum methods for presentation of material were beneficial to many. The consensus of the group was that events of this type are certainly worthwhile and important in providing teachers with the resources necessary for effectively teaching optics to students.

Many excellent suggestions were received concerning an on-going relationship between university faculty and high school teachers. A suggestion arose for the establishment of a summer workshop series where optics and other areas of physics could be covered in more detail. One participant suggested that university faculty could be of

great service by making themselves available as consultants in the selection and acquisition of appropriate optics demonstration equipment. It was also noted that there is a need for technical persons to troubleshoot instrumental problems and offer suggestions as to how to keep equipment in repair. Another attendee suggested offering workshops of this type to students who are preparing to teach science at the high school level, giving them the advantage of having these resources at hand prior to their entrance into the classroom. It is clear that our attempt to introduce optics to the high school science curriculum is only a first step, but follow-up efforts are underway to ensure that this foothold in the public school science program is maintained.

4.4 Future Considerations

The optics workshop described above will continue to be offered to high school teachers in the region. Plans are also underway to secure funding for intensive summer workshops to aid teachers in developing optics curricula. These extended courses would give ample time for teachers to generate class notes, develop their own set of experiments, demonstrations, and student activity assessment tools, and to present these to a class of students for evaluation. Extension of this program is also being considered for use at the middle and elementary school levels.

The Kentucky Department of Education has an existing program, the Activity Centered Elementary Science (ACES) initiative, whose purpose is to identify a set of modular activities and investigations for elementary science students. These modules consist of a complete kit of learning materials with an emphasis on direct, hands-on student experiences. This program encourages the use of technology in learning activities, and supports a comprehensive staff development program. An optics module would be well-suited to this program.

5. SUMMARY

The efforts described herein to introduce and support optics education in the high school curriculum are not particularly innovative in and of themselves. Optics workshops are frequently conducted by universities all across the country. What is unique, however, is the political climate and prevailing need of local school districts for assistance in meeting the standards set by the state's sweeping education reform legislation. Local public school systems must take part in developing an appropriate science curriculum. If optics is to be included in that curriculum, it is important that science teachers be given the resources to present the material in the most effective manner. Those involved in optics at the college and university level are in a good position to support the introduction of optics into public schools by introducing teachers to unfamiliar material, providing lecture and demonstration ideas, and serving as resource sites for teacher training, staff development, and equipment information.

6. ACKNOWLEDGMENTS

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7. REFERENCES

1. M.H. Miller, K. Noland, and J. Schaaf, A Guide to the Kentucky Education Reform Act of 1990, Kentucky Department of Education, April, 1990.