STEP I

Project Evaluation

November 2000

Contents

STEP I

PROJECT EVALUATION

BACKGROUND

STEP I begins the process of developing curricular materials for photonics technicians enrolled in two-year AAS degree programs in postsecondary community colleges and technical schools. Based on national studies and trends, data indicate that a critical shortage of photonics technicians exists—a shortage that will become even more critical in the next five years (See Appendix A). The end goal of the complete STEP project—divided into three phases—is to develop, disseminate, and maintain current curricular materials for the education of photonics technicians and to increase the flow of students into the educational pipeline from which will come the needed numbers of photonics technicians for business and industry. To accomplish this, STEP I undertakes the creation of three-level outlines for all eight photonics courses of instruction—containing some 60 to 70 separate modules—and the development of 10 modules of instruction for the first of the eight courses, *Fundamentals of Photonics.* STEP II is planned to continue the development of the instructional materials and train faculty in the effective delivery of the materials. STEP III will complete the instructional materials' development and will focus on setting up a national network for dissemination, specialized adaptation, and constant updating of the photonics materials.

The stakeholders in the overall STEP project involve the educational community that educates and trains the photonics technicians and the businesses and industries that hire them. The participants in STEP I include the authors selected to develop the 10 modules, community college and technical school faculty members and students to field-test the modules, business and industry to pass judgment on the appropriateness of the three-level outlines and the 10 developed modules, and the University of Connecticut and CORD (Center for Occupational Research and Development) to administer the project.

The specific outcomes of STEP I are to have developed (1) the three-level outline for each of the 60 to 70 modules included in the eight courses of instruction, (2) 10 modules of instruction for the first course, *Fundamentals of Photonics,* and the field-test results from the use of these modules in five two-year postsecondary schools across the country. The STEP I project is to be completed in two years from the initial grant award.

EVALUATION STUDY QUESTIONS

In the first phase of the overall STEP project, STEP I addressed the following questions and concerns:

1. Did the project establish an initial connection with the photonics industry and the educational community?
2. Did the project produce its anticipated deliverables of three-level outlines for eight photonics courses and develop 10 modules for the first (overview) course, entitled *Fundamentals of Photonics*?
3. Were the developed curricular materials at the appropriate level for photonics technicians in two-year colleges?
4. Would the anticipated photonics curricular materials—both those developed in STEP I and those to be developed later—support and enhance the ability of current photonics instructors to provide needed instruction in photonics?

EVALUATION PROCEDURES

Regarding the first evaluation study question, STEP I planned to bring together representatives from the photonics industry and photonics educators from two-year colleges to work side by side to (a) review the *Photonics Skill Standards* developed earlier by the photonics industry and academe, (b) engage selected representatives from industry and education to identify needed photonics courses for photonics technicians and develop appropriate three-level outlines for the modules that are to make up the courses, (c) involve individuals with technical competency—from both the photonics industry and education—to author the modules for the first course and to appoint individuals from industry and education to serve as a technical review committee for the developed modules, and (d) involve both the photonics industry and photonics educators in assessing the effectiveness of the developed materials.

Regarding the second evaluation study question, STEP I was to determine its ability to produce the stated deliverables—three-level outlines for the complete set of modules making up the identified eight photonics courses for technician preparation and 10 modules for the first of the eight courses, entitled *Fundamentals of Photonics.*

Regarding the third evaluation study question, STEP I planned to involve a group of community colleges and technical schools—those already involved in laser/electro-optic technician education—as field-test sites to evaluate the *Fundamentals of Photonics* modules in the classroom. To assess the effectiveness of the modules as instructional materials, a pretest—developed by the author of the module—was to be administered to

each class of students in the field-test program, followed by a posttest (same questions). In addition, a teacher questionnaire assessing the overall effectiveness and appropriateness of the module was given to each teacher—to be completed for each module taught.

Regarding the fourth evaluation study question, the STEP I project planned to make available on the web the 10 developed modules in *Fundamentals of Photonics* and to inform two-year community colleges and the photonics industry of their existence and intent. A questionnaire was to be sent to each interested "contact" with a hard copy set of the *Fundamentals of Photonics* modules and/or with access to the identical modules on the web. These "contacts" were then to fill out the module questionnaires, as reviewers of the materials, and inform the STEP I project team of their opinions concerning the ability of the materials to support and enhance photonics technician education at the two-year college level.

SAMPLE EVALUATION INSTRUMENTS

The instruments used to collect data on the effectiveness of modules in Course 1, *Fundamentals of Photonics,* in the classroom consisted of the following:

- pretest/posttest for each module taught (completed by students at the field-test sites)
- teacher questionnaire for each module taught (completed by instructors at the field-test sites)
- course review questionnaire (completed by all other evaluators of the *Fundamentals of Photonics* course)

A *pretest* was created by each module author, paying close attention to the development of questions that sought to measure the knowledge embedded in the module's stated *objectives*. The *posttest,* administered at the completion of study of the module material, contained the same questions found in the pretest. A copy of a sample pretest—for module 1-3, *Basic Geometrical Optics*—is shown in Appendix B.

The *teacher questionnaire* was designed to gather information from the teacher on

- course "logistics,"
- extent of the module covered in the classroom,
- time to complete the module,
- overall difficulty of the module,
- technical level of the module,

- reading level of the module,
- mathematics level of the module,
- number of concepts covered in the module,
- appropriateness of hands-on laboratories,
- availability of laboratory equipment,
- level of computational problem exercises, and
- specific evaluation of each major part of the module.

For each item above, the questionnaire invited specific comments. A sample *teacher questionnaire* is shown in Appendix C.

A *course review questionnaire*, designed much like the *teacher questionnaire*, was given to all nonfield-test persons who expressed interest in reviewing the set of 10 modules in *Fundamentals of Photonics*. A sample of the *course review questionnaire* is provided in Appendix D.

FINDINGS

To report on our findings, we repeat the four *evaluation study questions* listed earlier and make comments appropriate to each.

1. *Did the project establish an initial connection with the photonics industry and the educational community?*

   The project, from its inception, established a connection between the two major stakeholders—industry and education. The photonics industry included such representatives as ERIM, Melles Griot, I-Math Associates, NASA, JDS Uniphase, Science Applications International, Coherent Laser Group, Army Research Laboratory, Lambda Research Group, LEOMA, Silicon Valley Group, GSI Lumonics, and Photonics Research, Ontario. The two- and four-year college community of educators included Monroe Community College, Camden County College, Springfield Technical Community College, Central Carolina Community College, University of Central Florida, San Jose Community College, Texas State Technical College, University of North Carolina (Charlotte), University of New Mexico, Indian Institute of Technology, and Nanyang Technological University. These representatives, over the duration of the project, worked together in various subsets. One subset reviewed the *Photonics Skill Standards*—developed earlier under a USED grant—and used the skill standards to develop three-level outlines for the eight anticipated photonics courses. Another subset worked together to author the 10 modules in Course 1, *Fundamentals of Photonics*, and to review the

technical content of the modules. A third subset reviewed the technical context and layout of the modules at various stages of completion.

Without exception, the representatives from industry and education, firmly convinced of the need for a new generation of photonics education materials for technicians, worked together effectively and enthusiastically.

2. *Did the project produce its anticipated deliverable of three-level outlines for eight photonics courses and develop 10 modules for the first (overview) course entitled* Fundamentals of Photonics?

   The project succeeded in developing (1) a complete set of three-level outlines for the eight courses (66 modules), (2) Course 1, *Fundamentals of Photonics*, with 10 modules, and (3) the 10 modules formatted on the web for easy examination and access.

3. *Were the Course 1 curricular materials developed at the appropriate level for photonics technicians in two-year colleges?*

   The project devoted considerable effort to answering this question, since it goes to the heart of the use of the photonics curricular materials in the classrooms of two-year postsecondary schools. In Appendix E we provide a few logistics/pedagogical details for the five community colleges participating in the field test. Following this, we provide the tabulated responses on the *teacher questionnaire* for each module taught at each site. It is of interest to note that no site was able to complete more than six of the 10 modules—one site completing only three, one site completing five, and the three remaining sites completing six. As a result, four of the 10 modules developed remain untested in the classroom.

   In Appendix F we show the pretest/posttest data for one of the five schools—Central Carolina Community College, the only site that attempted to cover all the material in each module. Even though similar data were collected at each site, we could not use the results from four of the sites, since these sites elected to pick and choose topics from the overall contents of the modules. This "arbitrary" selection of module contents invalidated posttest results since the posttest questions did not measure knowledge gained over a study of the *entire* module and were no more useful than the pretest responses.

   This failure at four of the five sites to cover the entire module contents as specified in the pretest/posttest evaluation plan, and therefore to validate the test results, was a disappointment to the project evaluators. However, it indicated to us that it will be difficult to ensure complete coverage of a set of materials in a given classroom. The vagaries of student progress, tight schedules, course syllabi, and other factors often determine how much material a teacher will elect to cover,

independent of carefully prescribed evaluation criteria. In the future, if the pretest/posttest evaluation component is to contribute useful information, careful discussions and agreements between project staff members and participants at field-test sites will have to occur up front.

4. *Would the anticipated photonics curricular materials—both those developed in STEP I and those to be developed later—support and enhance the ability of current photonics instructors to provide needed instruction in photonics?*

We found that the answer to this question would depend heavily on the level of rigor of the photonics programs in place in the community colleges across the nation. We found a rather large range in academic rigor required in various two-year photonics technician-training programs. In our field-test sample of five community colleges, three stated that the materials were sorely needed, usable, and on target for most of their students. These three did observe, however, that the density of concepts in each module was too high, the pace required for coverage was too fast, and the mathematics level required was too high. Two of the colleges in the field-test sample concluded that the materials were technically "over the heads of their students." They acknowledged a real need for the up-to-date content in the modules and indicated that a revision in scope, concept density, coverage pace, and mathematics level would be required before they could effectively use the materials in their classes.

The initial sample of five community colleges in STEP I should be increased and more data should be gathered. Some of that is ongoing, with other community college educators and several industry representatives reviewing the materials to provide additional input. (See Appendix D, *Revised Questionnaire for Course 1 Reviewers.*)

To make the 10 modules for Course 1, *Fundamentals of Photonics*, more accessible to those interested in photonics technician education—both industry and academe—the project has made the 10 modules available on the web for easy access and review. We hope that through this immediate accessibility, the project will continue to receive valuable feedback—to guide us on a revision of the Course 1 materials as well as on the development of new materials for the remaining seven courses.

CONCLUSIONS

STEP I succeeded in bringing together key stakeholders from industry and education. Thirteen photonics industry representatives worked together with eleven educators from two-year and four-year colleges. In various teams they contributed to (a) a review of the previously developed *Photonics Skill Standards*, (b) development of three-level content outlines for 66 modules in eight courses (c) development of 10 instructional modules for the first of the eight courses, *Fundamentals of Photonics,* and (d) review of the 10 modules formatted for placement on the web.

The curricular classroom materials, 10 modules for Course 1, *Fundamentals of Photonics*, were field-tested in five community colleges. The evaluation instruments included a pretest/posttest combination and a comprehensive teacher questionnaire. The pretest/posttest results from one site—the only site to cover the materials in the prescribed manner—showed an increase in mean score from roughly 42% on the pretest to 76% on the posttest. The teacher questionnaire revealed the following:

- No more than six of the 10 modules in Course 1 could be covered in a semester period.
- The diversity of the main topics in the 10 modules was found to be appropriate for photonics students.
- The reading level of the modules was judged to be appropriate for students.
- The mathematics level of the technical content was judged to be too high.
- The density of technical concepts per module was judged to be too high.
- The pace required for timely completion of a module was judged to be too fast.

The project has witnessed an increasing interest in the availability and content of the 10 modules in *Fundamentals of Photonics*, both those available as hard copy and those on the web. Without exception, potential users in the field have asked the project team about availability of the remaining seven courses.

Appendix A

Survey of Need

for

Photonics Technicians

Survey of Need for Photonics Technicians

In the summer of 2000, CORD carried out a study* of the current and anticipated photonics workforce needs. The study attempted to determine the demand for photonics technicians now and in the year 2005. As a beginning point, CORD used the *Photonics Corporate Guide* produced by Laurin Publishing Company as the "population" of companies belonging to the photonics industry. After removing all companies from the database with international operations—in order to study domestic U.S. photonics companies only—a frequency analysis was performed and the population was classified into groups or class intervals. The class intervals are as shown in Table 1:

Table 1. Population

Class Interval	Number of Companies
Small companies: 5–25 Employees	1366
Medium companies: 26–200 Employees	1031
Large companies: 201–1000 Employees	277

Companies with less than 5 employees were not considered since they were assumed to be consultant organizations. Likewise, sixty-two "Jumbo" companies with more than 1000 employees were not considered, given that they are at an extreme end of the distribution and might bias the results. A questionnaire was designed that asked companies to provide information about the number of photonics technicians currently employed as well as the number expected in the year 2005. The questionnaire also sought information on the desired preparation for employment of a photonics technician. The questionnaires were administered by phone, with the questionnaire readily available on the web for respondents to refer to during the conversation on the phone. A random sample of 321 companies was drawn, assuring that a valid representation of each of the three class intervals was included in the sample.

An alpha level of 0.1 was used to yield a 90% confidence interval. To compute confidence intervals, a t-distribution confidence coefficient with (n-1) degrees of freedom was used. The result of the study indicated that by the year 2005 a total of 62,682 technicians will be required—even with the omission of "Jumbo" companies from the population surveyed. Currently, there are 23,845 technicians working, so the required increase over the entire 5-year period is 38,837. Along with the quantitative results,

* Details of the study are in the process of being published in a national journal.

companies reported that they almost exclusively prefer to hire technicians with a two-year degree from a community college or technical school.

Using information from several sources (SPIE, CCI Publishing, OSA, CORD, LEOMA) about Associate Degree programs that specifically focus on education in photonics or closely related technologies such as Laser/Electro-Optics, CORD then attempted to evaluate today's supply of photonics technicians. CORD found that there are approximately 35 postsecondary programs of this kind across the U.S. Data was available on 13 of these programs regarding number of graduates in the past year. The mean number of graduates produced by these 13 programs was 46, with a standard deviation of 30. If each of the 35 programs produced 46 graduates each year (a safe assumption, since programs that did not report graduate data likely did not approach the mean of 46), just over 8,000 graduates who satisfy the educational requirements of industry would have entered the labor market from these kinds of two-year programs by the year 2005!

While these supply and demand figures are estimations, they are conservative. It is safe to conclude that by the year 2005 the industry will require at least 31,000 additional workers with associate degrees in lasers, optics and photonics technology.

Appendix B

Module 1-3

Sample Pretest

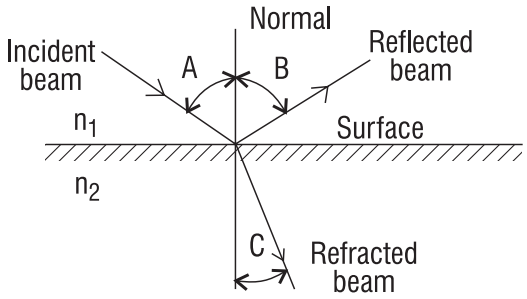
Basic Geometrical Optics

MODULE 1-3: BASIC GEOMETRICAL OPTICS

Pretest

1) The shadow of a flagpole as formed on a sunny day is best understood by treating light as
   a) light waves.
   b) electric fields.
   c) light rays.
   d) waves similar to sound waves.

Use the following information and accompanying sketch for Questions 2, 3, 4. A beam of light in a medium of refractive index n_1 is incident on a transparent medium of refractive index n_2, as shown in the sketch. The angles A, B, and C are measured relative to the surface normal.



2) The *Law of Reflection* for the sketch requires that
   a) angle C = angle A
   b) angle B = angle A
   c) angle B is greater than angle A
   d) angle C = angle B

3) *Snell's Law* for the sketch states that
   a) $n_1 A = n_2 B$
   b) $n_1 A = n_2 (B + C)$
   c) $n_1 \sin A = n_2 \sin B$
   d) $n_1 \sin A = n_2 \sin C$

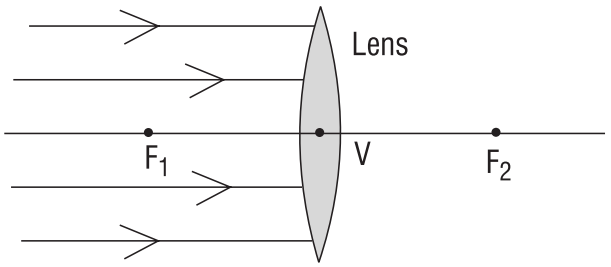
4) For the refraction of the light ray shown in the sketch, you know that
   a) the value of n_2 must be greater than the value of n_1.
   b) the value of n_2 must be less than the value of n_1.
   c) angle C must be greater than angle A.
   d) angle A plus angle C is equal to angle B.

5) When a light beam passes from water into air
   a) total internal reflection at the water/air interface cannot occur.
   b) total internal reflection at the water/air interface can occur.
   c) Snell's law does not work.
   d) the light beam is always totally transmitted through the water/air interface.

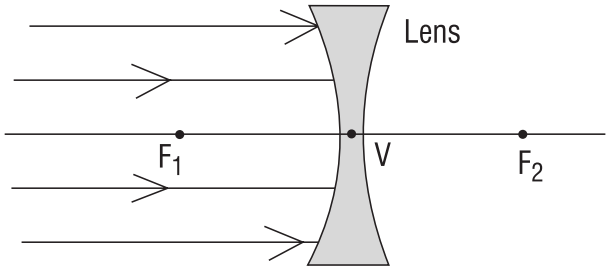
6) When a narrow beam of white light passes through a prism, the beam
   a) is bent at the prism faces but remains a beam of white light.
   b) is dispersed and separated into many beams of white light.
   c) is dispersed and emerges as beams of separate colors varying from red to blue.
   d) passes straight through but flares out as it does so.

7) A positive thin lens
   a) is always thinner at its edges than at its center.
   b) is always thicker at its edges than at its center.
   c) is the same size at its edges as at its center.
   d) causes light passing through it to diverge or spread out.

Use the following drawings to answer questions 8 and 9.



a)



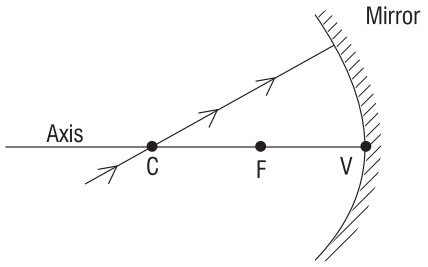
b)

8) In sketch a), parallel light rays are incident on the thin lens of vertex V with focal points F_1 and F_2. After passing through the lens, the light rays
   a) bend and head for some point between V and F_2.
   b) spread out as if they are coming from the focal point F_1.
   c) converge and pass through the focal point F_2.
   d) bend and converge toward some point beyond F_2.

9) In sketch b), parallel light rays are incident on a thin lens of vertex V and focal points F_1 and F_2. After passing through the lens, the light rays
   a) bend and pass through the focal point F_2.
   b) bend and spread out as if coming from the focal point F_1.
   c) go right on through without bending.
   d) bend and converge to a point to the right of F_2.

10) If parallel rays of light from a distant star are incident on a concave mirror, the rays of light
   a) are refracted according to Snell's law.
   b) are reflected and pass through the mirror's focal point.
   c) are reflected and spread out as they leave the mirror.
   d) are reflected and remain parallel to one another.

11) A ray of light passing through the center of curvature *C* and heading toward the mirror, as shown in the sketch, will



a) reflect and pass through the focal point *F*.
b) reflect back along itself.
c) reflect as a ray that is parallel to the mirror axis.
d) reflect and intersect the axis between *C* and *F*.

12) The *mirror equation* which relates the object distance *p*, image distance *q*, and radius of curvature *r* of the mirror is given by

a) $p + q = r$
b) $p - q = r$
c) $1/p + 1/q = -2/r$
d) $m = \left(-\frac{q}{p}\right) r$

13) The *sign conventions* adopted for carrying out calculations related to image formation by lenses and mirrors

a) are convenient but not necessary.
b) are absolutely necessary for correct results.
c) are necessary for lenses but not for mirrors.
d) differ for each different optical system.

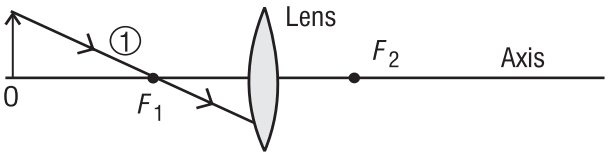
14) If the radius of curvature of a spherical mirror is 15 centimeters, the focal length of the mirror is

a) 15 centimeters.
b) 30 centimeters.
c) 7.5 centimeters.
d) 60 centimeters.

15) The *f-number* and *numerical aperture* of a lens are both indications of the

a) absorption coefficient of the lens.
b) light-gathering power of the lens.
c) specific gravity of the lens.
d) thickness of the lens at its center.

16) For ray-tracing techniques, we know that ray 1 shown passing through focal point F in the diagram will emerge from the lens



a) as a ray bending and passing through focal point F_2.
b) as a ray reflecting back along itself.
c) as a ray continuing along the same direction, without bending.
d) as a ray parallel to the axis.

17) If you hold a thin, positive lens in your hand and form a sharp image of the sun on an index card, the distance from the lens to the card is a good measure of the
a) focal length of the lens.
b) f/stop of the lens.
c) numerical aperture of the lens.
d) diameter of the lens.

18) The thin-lens equation relating object distance p, image distance q, and lens focal length f is given by
a) $p + q = f$
b) $1/p + 1/q = f$
c) $p + q = 1/f$
d) $1/p + 1/q = 1/f$

19) If you form a real image with a positive thin lens, and the image is farther from the lens than the object is, you can be sure that
a) the image is brighter than the object.
b) the image is larger than the object.
c) the image is smaller than the object.
d) the image is on the same side of the lens as the object.

20) The lensmaker's equation for a glass lens is given by the formula

$$\frac{1}{f} = \left(\frac{n_g - n}{n}\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

If $n_g = 1.5$, $n = 1.0$, $r_1 = +10$ cm and $r_2 = -10$ cm for a certain lens, the focal length of the lens is
a) +10 cm.
b) −10 cm.
c) $+ 1/10$ cm
d) infinite.

Appendix C

Sample Teacher Questionnaire for Individual Courses

Fundamentals of Photonics

Module 1-2 — *Light Sources and Safety*

Teacher Questionnaire

Professor: _____

School: _____

Class Schedule for Course:

Weeks per term _____

Lecture classes per week _____

Minutes per class _____

Lab classes per week _____

Minutes per lab _____

1. Overall, was the material in this module difficult for your students to understand?

_____Yes, most was.

_____Yes, some was.

_____No, most was not.

Other comments: _____

_____

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

_____ Yes.

_____ No (The parts I did not cover were (please identify)_____

_____

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

_____ one week or less?

_____ about two weeks?

_____ more than two weeks (specify length of time) _____

Other comments: _____

_____

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

_____ too high a technical level for photonics technicians?

_____ at about the right technical level for photonics technicians?

_____ too low a technical level for photonics technicians?

Other comments: _____

_____

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

_____ too high?

_____ about right?

_____ too low?

Other comments: _____

_____

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

_____ too high for photonics technicians?

_____ about right for photonics technicians?

_____ too low for photonics technicians?

Other comments: _____

_____

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

_____ too many for the time you have allotted?

_____ about right for the time you have allotted?

_____ too few for the time you have allotted

Other comments: _____

_____

8. Concerning the *hands-on laboratories* for this module,

_____ I found them to be appropriate and I completed all of them.

_____ I found them to be appropriate but I was unable to complete them in the time I had.

_____ I found them to be inappropriate so I substituted my own labs.

Other comments: _____

_____

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

_____ reasonable for your course?

_____ unreasonable for your course?

Other comments: _____

_____

10. Regarding the *problem exercises* for this module, did your students find them to be

_____ too difficult?

_____ about the right level?

_____ too easy?

Other comments: _____

_____

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each one for this module.

	Good	**Acceptable**	**Poor**
Opening Demonstration			
Basic Concepts (text)			
Figures			
Examples			
Hands-on Laboratory			
Problem Exercises			

Specific comments for any of the above: _____

_____

_____

_____

Appendix D

Revised Questionnaire

for

Course 1 Reviewers

Fundamentals of Photonics
Course Review Questionnaire

Name: _____

Institution: _____

1. What is the basis for your interest in this course? _____
   _____
   _____

2. **Overall,** what do you consider the **level of difficulty** of this course for students in two-year college programs to be?
   ____ difficult
   ____ moderately difficult
   ____ appropriate
   ____ too easy
   Other comments: _____
   _____

3. Based on typical laser optics/photonics courses you are familiar with, or would like to see taught, is the **technical content** in this course presented at
   ____ too high a level for photonics technicians?
   ____ about the right level for photonics technicians?
   ____ too low a level for photonics technicians?
   Other comments: _____
   _____

4. Based on typical laser optics/photonics courses you are familiar with, or would like to see taught, is the **reading level** of this course?
   ____ too high?
   ____ about right?
   ____ too low?
   Other comments: _____
   _____

5. Based on typical laser optics/photonics courses you are familiar with, or would like to see taught, is the **mathematics level** presented in this course
   ____ too high for photonics technicians?
   ____ about right for photonics technicians?
   ____ too low for photonics technicians?
   Other comments: _____
   _____

6. Based on typical laser optics/photonics courses you are familiar with, or would like to see taught, is the **total number of concepts** presented in this course
   ____ too high for photonics technicians?
   ____ about right for photonics technicians?
   ____ too low for photonics technicians?
   Other comments: _____
   _____

7. Concerning the *hands-on laboratories* for this course, do you feel that they are
   ____ too academic?
   ____ too simple?
   ____ appropriate but not connected to the real world?
   ____ appropriate and connected to the real world?
   Other comments: _____
   _____

8. Regarding the *problem exercises* for this course, did you find them to be
   ____ too academic?
   ____ too simple?
   ____ appropriate but not connected to the real world?
   ____ appropriate and connected to the real world?
   Other comments: _____
   _____

9. The modules for the course *Fundamentals of Photonics* have been designed primarily for technicians at the two-year college level. In terms of your perception of the course's overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each module you have reviewed below:

	Good	**Acceptable**	**Poor**
Nature and Properties of Light			
Light Sources and Safety			
Basic Geometrical Optics			
Basic Physical Optics			
Lasers			
Optical Detection and Human Vision			
Optical Waveguides and Fibers			
Fiber Optics Telecommunications			
Photonic Devices for Imaging and Display			
Basic Principles and Applications of Holography			

Please return to: Darrell Hull, CORD, fax 254-772-8972

Appendix E

Field-Test Site Data with
Results of Teacher Questionnaire for
Modules 1-1, 1-2, 1-3, 1-4, 1-5, and 1-8

Field Test Sites
(1999-2000)
Fundamentals of Photonics

Site A: **CENTRAL CAROLINA COMMUNITY COLLEGE**

Professor **Glenn Oliver — (completed modules 1-1, 1-2, 1-3, 1-4, 1-5, 1-8)**

School **Central Carolina Community College, North Carolina**

Class Schedule for Course:

- Weeks per term **16**
- Lecture classes per week **2**
- Minutes per class **50**
- Lab classes per week **1**
- Minutes per lab **100**

Site B: **DOÑA ANA COMMUNITY COLLEGE**

Professor **Scott Pollat/Oscar Perez — (completed modules 1-1, 1-2, 1-3)**

School **Doña Ana Community College, New Mexico**

Class Schedule for Course:

- Weeks per term **18**
- Lecture classes per week **2**
- Minutes per class **120**
- Lab classes per week **2**
- Minutes per lab **60**

Site C: **SPRINGFIELD TECHNICAL COMMUNITY COLLEGE**

Professor **Barbara Washburn — (completed modules 1-1, 1-2, 1-3, 1-4, 1-5, 1-8)**

School **Springfield Technical Community College, Massachusetts**

Class Schedule for Course:

- Weeks per term **18**
- Lecture classes per week **2**
- Minutes per class **90**
- Lab classes per week **1**
- Minutes per lab **180**

Site D: **TEXAS STATE TECHNICAL COLLEGE**

Professor **Tom Hammans — (completed modules 1-1, 1-2, 1-3, 1-4, 1-5)**

School **Texas State Technical College, (Harlingen) Texas**

Class Schedule for Course:

Weeks per term **12**

Lecture classes per week **3**

Minutes per class **50 on Mon.; 100 on Wed.**

Lab classes per week **2**

Minutes per lab **120 on Tues.; 120 on Thurs.**

Site E: **THREE RIVERS COMMUNITY-TECHNICAL COLLEGE**

Professor **Judy Donnelly — (completed modules 1-1, 1-2, 1-3, 1-4, 1-5, 1-8)**

School **Three Rivers Community-Technical College, Connecticut**

Class Schedule for Course:

Weeks per term **15**

Lecture classes per week **3**

Minutes per class **50**

Lab classes per week **1**

Minutes per lab **100**

Fundamentals of Photonics
Module 1-1 — *Nature and Properties of Light*
(Completed at All Sites)*

TEACHER QUESTIONNAIRE

* **A: CENTRAL CAROLINA COMMUNITY COLLEGE**
B: DOÑA ANA COMMUNITY COLLEGE
C: SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
D: TEXAS STATE TECHNICAL COLLEGE
E: THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   C,E Yes, most was.

   A,B,D Yes, some was.

   _____ No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   B,D Yes

   A,C,E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   D one week or less?

   A,B,C,E about two weeks?

   _____ more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   A,E too high a technical level for photonics technicians?

   B,C,D about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   A,B,D about right?

   E too high?

   C too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

A,E too high for photonics technicians?

B,C,D about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

A,C,E too many for the time you have allotted?

B,D about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

A,D I found them to be appropriate and I completed all of them.

B I found them to be appropriate but I was unable to complete them in the time I had.

C,E I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

A,B,D reasonable for your course?

_____ unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

E too difficult?

A,B,C,D about the right level?

too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability), rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration		**A,C,E**	**D**
Basic Concepts (text)	**B,C**	**A,D**	**E**
Figures	**C,D**	**A,B**	**E**
Examples	**C,D**	**A**	**B,E**
Hands-on Laboratory	**B**	**A,D**	
Problem Exercises		**B,C,D**	**A,E**

Fundamentals of Photonics
Module 1-2 — *Light Sources and Safety*
(Completed At All Sites)*

TEACHER QUESTIONNAIRE

* **A: CENTRAL CAROLINA COMMUNITY COLLEGE**
B: DOÑA ANA COMMUNITY COLLEGE
C: SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
D: TEXAS STATE TECHNICAL COLLEGE
E: THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   _____ Yes, most was.

   A,D Yes, some was.

   B,C,E No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   A,B,D Yes

   C,E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   B,C one week or less?

   A,D,E about two weeks?

   _____ more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   _____ too high a technical level for photonics technicians?

   A,B,C,D,E about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   _____ too high?

   A,B,C,D,E about right?

   _____ too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

B too high for photonics technicians?

A,C,D,E about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

B,E too many for the time you have allotted?

A,C,D about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

A,B,D,E I found them to be appropriate and I completed all of them.

_____ I found them to be appropriate but I was unable to complete them in the time I had.

C I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

A,B,D,E reasonable for your course?

_____ unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

_____ too difficult?

A,B,C,D about the right level?

_____ too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability), rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration	**A**	**C,D,E**	
Basic Concepts (text)	**A,C,D**	**B,E**	
Figures	**A,C,D**	**E**	**B**
Examples	**A,C,D**		**B**
Hands-on Laboratory	**A**	**B,D**	
Problem Exercises	**A**	**B,C,D**	**E**

Fundamentals of Photonics
Module 1-3 — *Basic Geometrical Optics*
(Completed At All Sites)*

TEACHER QUESTIONNAIRE

* **A: CENTRAL CAROLINA COMMUNITY COLLEGE**
B: DOÑA ANA COMMUNITY COLLEGE
C: SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
D: TEXAS STATE TECHNICAL COLLEGE
E: THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   A, B, E Yes, most was.

   C, D Yes, some was.

   _____ No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   A, B, D Yes

   C, E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   _____ one week or less?

   B, C, D about two weeks?

   A, E more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   B, E too high a technical level for photonics technicians?

   A, C, D about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   _____ too high?

   A, B, C, D, E about right?

   _____ too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

B, E too high for photonics technicians?

A, C, D about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

A, B, E too many for the time you have allotted?

C, D about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

D I found them to be appropriate and I completed all of them.

A, B, E I found them to be appropriate but I was unable to complete them in the time I had.

C I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

B, D, E reasonable for your course?

A unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

A, B, D, E too difficult?

C about the right level?

_____ too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration	**A**	**C, E**	**D**
Basic Concepts (text)	**A, D**	**C**	**B, E**
Figures	**A, C, D**	**B, E**	
Examples	**C, D**	**A, E**	**B**
Hands-on Laboratory		**A, B, D, E**	
Problem Exercises		**C, D**	**A, B, E**

Fundamentals of Photonics
Module 1-4 — *Basic Physical Optics*
(Completed At Four Sites)*

TEACHER QUESTIONNAIRE

* **A. CENTRAL CAROLINA COMMUNITY COLLEGE**
C. SPRINGFIELD TECHNICAL COLLEGE
D. TEXAS STATE TECHNICAL COLLEGE
E. THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   E Yes, most was.

   A, C, D Yes, some was.

   _____ No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   _____ Yes

   A, C, D, E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   _____ one week or less?

   C, D about two weeks?

   A, E more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   E too high a technical level for photonics technicians?

   A, C, D about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   _____ too high?

   A, C, D, E about right?

   _____ too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

A, C, D, E too high for photonics technicians?

_____ about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

A, E too many for the time you have allotted?

C, D about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

D I found them to be appropriate and I completed all of them.

_____ I found them to be appropriate but I was unable to complete them in the time I had.

A, C, E I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

D reasonable for your course?

A unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

A, D, E too difficult?

C about the right level?

_____ too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration	**A**	**C, D**	**E**
Basic Concepts (text)	**A, C, D**		**E**
Figures	**A, C, D**	**E**	
Examples	**C, D**	**A, E**	
Hands-on Laboratory	**D**		**A, E**
Problem Exercises	**C**	**A, D**	**E**

Fundamentals of Photonics
Module 1-5 — *Lasers*
(Completed At Four Sites)*

TEACHER QUESTIONNAIRE

* **A. CENTRAL CAROLINA COMMUNITY COLLEGE**
C. SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
D. TEXAS STATE TECHNICAL COLLEGE
E. THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   A Yes, most was.

   D, E Yes, some was.

   C No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   D Yes

   A, C, E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   C one week or less?

   A, D about two weeks?

   E more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   A, E too high a technical level for photonics technicians?

   C, D about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   A too high?

   C, D, E about right?

   _____ too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

A, E too high for photonics technicians?

C, D about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

C, D, E too many for the time you have allotted?

A about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

D I found them to be appropriate and I completed all of them.

_____ I found them to be appropriate but I was unable to complete them in the time I had.

A, C, E I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

D reasonable for your course?

A unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

A, E too difficult?

C, D about the right level?

_____ too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration	**D**	**C**	**A, E**
Basic Concepts (text)	**C, D**	**E**	**A**
Figures	**D**	**A, C, E**	
Examples	**C, D**	**E**	**A**
Hands-on Laboratory	**D**		**A, E**
Problem Exercises	**D**	**C**	**A, E**

Fundamentals of Photonics
Module 1-8 — *Basics of Fiber Optics Telecommunications*
(Completed at Three Sites)*

TEACHER QUESTIONNAIRE

* **A. CENTRAL CAROLINA COMMUNITY COLLEGE**
C. SPRINGFIELD TECHNICAL COMMUNITY COLLEGE
E. THREE RIVERS COMMUNITY-TECHNICAL COLLEGE

1. Overall, was the material in this module difficult for your students to understand?

   E Yes, most was.

   A Yes, some was.

   C No, most was not.

2. Did you teach the module as written—covering all major parts, including opening demonstration, content with examples, hands-on laboratory, and end of module problem exercises?

   A Yes

   C, E No

3. Based on your teaching schedule for this course and your answer to Question 2 above, did you complete the module in

   A one week or less?

   C, E about two weeks?

   _____ more than two weeks?

4. Based on typical laser optics/photonics courses you have taught or are now teaching, is the material in this module presented at

   _____ too high a technical level for photonics technicians?

   A, C, E about the right technical level for photonics technicians?

   _____ too low a technical level for photonics technicians?

5. Based on typical laser optics/photonics courses you have taught or are now teaching, is the reading level of this module

   _____ too high?

   A, C, E about right?

   _____ too low?

6. Based on typical laser optics/photonics courses you have taught or are now teaching, is the mathematics level presented in this module

_____ too high for photonics technicians?

A, C, E about right for photonics technicians?

_____ too low for photonics technicians?

7. Based on typical laser optics/photonics courses you have taught or are now teaching, is the number of concepts covered in this module

A, E too many for the time you have allotted?

C about right for the time you have allotted?

_____ too few for the time you have allotted?

8. Concerning the *hands-on laboratories* for this module,

A I found them to be appropriate and I completed all of them.

E I found them to be appropriate but I was unable to complete them in the time I had.

C I found them to be inappropriate so I substituted my own labs.

9. Regarding those *hands-on laboratories* you did complete, was the equipment required

A reasonable for your course?

_____ unreasonable for your course?

10. Regarding the *problem exercises* for this module, did your students find them to be

_____ too difficult?

A, C about the right level?

_____ too easy?

11. The modules for *Fundamentals of Photonics* have been designed with the major parts listed below. In terms of their overall impact on the learning process (instructional effectiveness, student interest, manageability) rank each one for this module.

	Good	Acceptable	Poor
Opening Demonstration	**A**	**C, E**	
Basic Concepts (text)	**A, C**	**E**	
Figures	**A, C**	**E**	
Examples	**C**	**A, E**	
Hands-on Laboratory	**A**		
Problem Exercises	**A, C**		

Appendix F

Pretest/Posttest Results

for Modules 1-1 through 1-5 of

Course 1, *Fundamentals of Photonics,*

at Central Carolina Community College

Distribution of Student Scores on Pretest/Posttest Evaluations for Modules 1-1 Through 1-5, Course 1, *Fundamentals of Photonics*, at Central Carolina Community College