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CURRICULUM DOCUMENTATION

Northwest Center for Sustainable Resources (NCSR)
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A TOOLBOX FOR CURRICULUM DOCUMENTATION AND TESTING

The Northwest Center for Sustainable Resources (NCSR) is a national resource center for natural resource and environmental science curriculum products. The Center's core mission is the development, documentation, and testing of natural resource curriculum materials. Over the last 12 years the Center has designed an effective process for the documentation and testing of its curriculum products. The process focuses on ensuring reliability in achieving the educational outcomes of the materials through post-development testing and revision. The documentation template used by the Center facilitates both product testing as well as adaptation of the materials by other educators.

The TOOLBOX is intended to assist faculty in documentation and testing of their instructional materials. It is adaptable to newly developed materials as well as to revision of existing materials.

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I. DEVELOPMENT PROTOCOL

NCSR's approach to the development of a curriculum product is based on ensuring that the educational outcomes of the instructional activity are clearly identified. Although the toolbox is not focused on content development, it is essential that curriculum development be based on defined educational objectives. The educational objectives vary with the type of curriculum and the scope of the development. For technical curriculum a major component of the educational process includes developing work-based competencies. These competencies are determined via various methods through a structured process that results in their identification and validation. For curriculum not tied to specific work-based discipline outcomes, objectives are often based on a consensus of educators and professionals in the field. Regardless of the type of curriculum or method used to determine the student outcomes/competencies, these elements must be clearly identified and articulated since they are the basis for the curriculum content and instructional methodology.

The scope of curriculum development undertaken determines the type of product produced. NCSR has established three levels of curriculum products:

A. PROGRAMS

A program is a sequence of instructional elements designed to provide an overall set of student competencies appropriate to the specific area of study. Programs lead to an award of a recognized credential such as an educational degree or other formal certification.

B. COURSES

Generally a course is a distinct component of a program and consists of a series of instructional activities designed to achieve a specific educational outcome. Courses are usually the sequenced building blocks of a program and their successful completion most often are expressed in the award of academic credit.

C. MODULES:

A module (often referred to as a lesson) is a subset of an instructional unit (i.e. a course) designed to develop specific knowledge and skills that contribute to the attainment of the larger educational objective. A module may cover one or more instructional periods. As used by NCSR, modules are stand alone units designed for adaptation by faculty into their course offerings.

Each product has its own unique documentation format and testing protocols. These are discussed below.

II. CURRICULUM DOCUMENTATION

A critical element in any curriculum development process is the creation of documentation containing the objectives, content, teaching strategies, and protocol for assessment of student learning. Appropriate documentation facilitates the teaching and learning process by:

1. Ensuring a structured sequence of activities and materials that lead to the essential outcome competencies envisioned for the learner
2. Providing guidance for instructors on the content and activities of the course/module
3. Identifying appropriate pedagogical approaches to insure student learning
4. Providing assessment strategies and approaches to evaluate student learning
5. Supporting course/module evaluation and revision as needed

Our experience with partner colleges indicates that the faculty seldom accomplish adequate documentation of new or revised courses/modules. The process presented below is designed to assist faculty in the documentation of their courses or instructional modules.

A. PROGRAM DOCUMENTATION

Programs are the most comprehensive curriculum product produced by educational professionals. Due to the broad scope of program course materials component elements are often developed by a number of faculty representing a variety of disciplines. Also, the program content is generally influenced by external requirements imposed by accreditation bodies, institutional governance units, and the institution's process. Irrespective of these influences, program documentation has a set of common principles and documentation features. These are:

1. A summative description of the purpose of the program, its general content, and expected outcomes for program completers
2. The requirements, including student readiness, need for entry into the program
3. A sequenced program of study that results in program completion
4. Identification of prerequisites or co-requisites associated with specific program components/courses;

For new offerings, program documentation serves as the blueprint for course development and is drafted early in the development process. As the building block courses are developed or selected from existing courses, the program sequence is refined and a final program description and course sequence/requirements produced. For program revision the program documentation is revised to reflect new or revised content.

The most significant issue confronting program developers is the sequence of courses and the extent students are required to adhere to the sequence. The guiding principle of sequencing is the concept of "building blocks". Competencies needed for success in higher level instructional units must be developed prior to admittance to these units. This principle requires formative or fundamental general education offerings to precede more advanced instruction. This is not usually an issue in non-technical programs but often is an issue in technical programs, particularly at the associate degree level. To preserve program enrollment, faculty are often willing to waive sequencing general education courses to ensure technical courses have the required student load. This behavior lends credence to the feeling by some technical students that supporting general education such as communications, mathematics, and science offering are unimportant and a bureaucratic requirement. It is not enough to sequence courses in a program based on building student competencies, the sequence needs to be used in managing student matriculation.

Appendix A is an example of a program sequence and supporting information for an associate degree technical program. It is used with permission from Oregon Coast Community College.

B. COURSE DOCUMENTATION

1. LECTURE, DISCUSSION, LABORATORY AND/OR FIELD COURSES

For lecture, lecture/discussion, lecture/laboratory and/or field courses comprehensive documentation consists of the following:

Student syllabus

1. Course identification data
2. Catalog description – a general narrative description of the course content and objectives
3. Outcome competencies of the course
4. Identification of text and other resource materials
5. List of pre- or co-requisite course(s) and expected levels of readiness for student
6. Grading approach

Course activities

Courses are a chronological summary of sessions. The information for each session includes:

1. Outline of lecture/discussion sessions
    a. Content and plan of activities
    b. Pedagogical approach to presenting material
    c. Supporting aids and visuals
    d. Student assignments
    e. Resource materials - web sites, video/DVD, print
2. Detailed description of laboratory (both classroom and field labs) and field trip sessions
    a. Purpose of activity
    b. Equipment and supplies needed
    c. Procedures for instructor and students
    d. Student assessment guide
    e. Logistical arrangements
3. Course assessment strategies and materials
4. Notes to instructors

2. WORK-BASED EDUCATIONAL EXPERIENCES

For work-based educational experiences (practicum, internship, or cooperative work experience) documentation should include:

Student syllabus

1. Course identification data
2. Catalog description – a general narrative description of the course content and objectives
3. Outcome competencies of the course
4. Identification of text and other resource materials
5. List of pre- or co-requisite course(s) and expected levels of readiness for student
6. Grading approach

Course activities
Work-based courses vary in design based on the discipline and available instructional venues. Specific documentation content will vary depending on these factors. The general components for work-based education courses include the following:

1. Outcome competencies of the work experience (include skills, knowledge and behavioral competencies)
2. Student activity and self assessment guide
    a. Responsibilities for performing the work-based learning objectives
    b. Expected work place behavior and performance standards
    c. Journal procedures to document activities and experiences
    d. Template to record self-assessment of expected learning outcomes
3. Workplace supervisor's guide
    a. Purpose of the work-based experience
    b. Students attendance and responsibilities in the work environment
    c. Recording and reporting of student experiences and performance
    d. Management and legal responsibilities of institution and work site organization
4. Supervisory instructor's guide
    a. Procedures for monitoring student progress
    b. Evaluation and grading strategies/procedures

C. MODULE DOCUMENTATION

As used here, *module* refers to each separately identified course component and consists of classroom lecture/discussion sessions, laboratory sessions, and field trip sessions. Modules are teaching/learning templates for presenting specific instructional material. They vary in scope from covering part of a session to covering multiple connected teaching sessions. Although limited in scope, they follow the general principles cited above. Module documentation format includes:

1. For lecture/discussion:
    a. Title and Introduction
    b. Content and plan of activities
    c. Pedagogical approach to presenting material
    d. Supporting instructional aids and visuals
    e. Student assignments
    f. Resources - web sites, video/DVD, print

2. For laboratory (both classroom and field labs):
    a. Title and Introduction
    b. Purpose of activity
    c. Equipment and supplies needed
    d. Procedures for instructor and students
    e. Data sheets (if applicable)
    f. Student assessment guide
    g. Logistical arrangements
    h. Resources - web sites, video/DVD, print
    i. Notes to instructors

D. DOCUMENTATION TIMELINES

Documentation should be drafted during the course/material development phase and prior to initial teaching of the content. The documentation should be revised and refined during pilot testing. The updated draft documentation should be used as a guide during the second teaching of the course. A final document for the course should be completed after the second offering. For courses being revised it may be necessary to complete comprehensive documentation of existing and revised content if such documentation does not already exist.

III. CURRICULUM TESTING

Testing curriculum is an essential component of validating the achievement of the educational outcomes of the product. The testing process has multiple components and their results are used to modify instructional activities to enhance achieving intended student knowledge and skills. Testing is based on the teaching/learning process documented in curriculum products and the results are reflected in document modifications. The testing components are presented below.

A. PROGRAM TESTING AND VALIDATION

Validation of the overall outcomes of a program presents unique challenges for educators. The major obstacle to effective program testing is the scope of the courses component parts and the timelines involved in completing these elements. Associate and bachelor degree programs range from a minimum two to five years. In, actuality, the timelines may extend over a significantly longer period depending on a students rate of matriculation. Notwithstanding the challenges, program validation is a needed element in the curriculum development process.

Testing programs is generally pursued in one or more of three approaches. These approaches are graduate feedback, employer feedback, and/or capstone courses. The feedback process requires a sophisticated tracking system to maintain a contact database to support longitudinal gathering of information. The information gathering technique is generally based on survey instruments completed by program graduates and their employers (particularly for technical programs). In some situations, survey data are combined with interview results. The scope and focus of the survey/interview will vary with the type of program.

A capstone unit is an alternative to obtaining feedback via surveys. The appeal is in obtaining information on competency attainment at the conclusion of a program. The drawback is most capstone units do not measure post-completion performance. They are also generally limited to a display of academic competencies rather than performance-based measures. (An exception to this performance limitation is a structured work-based course such as a end-of-program internship or practicum designed to demonstrate the application of knowledge and skills attained in the program.) However, in spite of these limitations, a well-constructed capstone unit (a course or modules in an end of program course) should be included in programs. The unit should require students to demonstrate use of major program competencies in the specific discipline and in general education.

B. PILOT TESTING

As used here *pilot testing* is the process of evaluating the efficacy of the course or stand-alone modules in attaining the intended student outcome. Pilot testing involves the implementing, evaluating, and revising of each discrete part of the new or revised course or module. This is normally done during the initial offering of the material under “real world” circumstances.

1. ELEMENTS OF PILOT TESTING

As each unit is taught there is a concurrent evaluation of

1. Content and relevance in attaining student outcomes
2. Effectiveness of time allocation to cover the materials/activities
3. Student readiness to learn the knowledge, skills, and behaviors intended in the module
4. Appropriate identification of equipment, supplies, and resource materials
5. Pedagogical approaches used to deliver the content/materials of the module
6. Student interest and participation in the learning process
7. Appropriateness and effectiveness of the student assessment processes
8. Appropriate sequencing of modules to attain the overall course outcomes

Although new and revised courses are generally subject to some degree of pilot testing, this process is seldom formalized. As in the case of curriculum documentation, the mega-evaluation of the ATE program found that projects did not pilot test products in a systematic manner and recommended more effort be placed on this process.

2. TIMING OF PILOT TESTING

The value of pilot testing in verifying the efficacy of modules and any modification need is in direct proportion to the time lines for implementing the process. Ideally, the instructor creates a preliminary document of the results of the pilot testing immediately after the module is taught. The preliminary focus is on what worked and what may need modification (and why). Determining strategies for actual modifications and updating of the course document follows the preliminary evaluation but should be completed in a timely manner. Delays such as waiting to prior to the next offering should be avoided. If the instructor is not the original developer, the developer should be involved in the revision effort. Revisions and modifications to modules should be incorporated into the second draft of the course documentation as developed.

3. PROCEDURE FOR GATHERING DATA

To facilitate pilot testing, the use of a checklist for preliminary evaluation should be used. The checklist should be an easy to use guide for recording pertinent observations by the instructor. Caution is urged in avoiding “yes or no” responses to the area of the module being evaluated. Adequate descriptive comments are needed to ensure an understanding of what occurred and signal what appropriate modifications should be considered. Conversely, the pilot testing activity should not demand extensive narratives or polished prose. Succinct comments for each area evaluated should be the norm. See appendix xxx for a general outline of specific components of pilot testing. Appendix xxx is a sample checklist for gathering pilot testing information.

Student feedback is also helpful in pilot testing. Use of checklist comments from students is especially helpful in evaluating laboratories and field trips. Group interviews at the mid-point and end of the course can also prove useful in pilot testing.

Appendix B contains an outline guide to Pilot Testing.

Appendix C and D are outline checklists for recording information gathered during pilot testing. The checklists' format provides a convenient way to document critical aspects of the pilot testing process. Two formats are provided to accommodate lecture-discussion modules and laboratory – field modules.

C. FIELD TESTING

Field testing of curriculum products is the process of evaluating the adaptability of the product (e.g., course, module, or total program) for use by others and verification that the intended outcomes such as student competencies are achieved in various settings.

1. FIELD TESTING PROCESS

The process occurs after pilot testing and uses the "final document" as the basis for evaluation. In technical programs a special element of field testing is participation of business and industry representatives in confirming that students are achieving intended workplace competencies. Verifying the appropriate workplace competencies is addressed in the course and supporting instruction is part of the development process and pilot testing. A major focus of field testing is that these competencies are being achieved in various settings by diverse student populations.

2. TIMING OF FIELD TESTING

In a technical degree program there are two time phases for field testing. Individual components such as modules or courses can be field tested once pilot testing and final documentation is completed. Obviously, "field testing" a technical degree program is a complex process. It is only possible after program completers are in the field and employed in their discipline of study, or under some circumstances, transferring into baccalaureate programs. In reality, there is little formal field testing of technical programs and therefore limited empirical data about the actual success of these programs. Most data about "program success" is anecdotal and, if gathered, tends to be received shortly after completion of the program. Based on the funding timelines of the ATE grant project there is no possibility that "degree program field testing" can be achieved prior to the end of the grant. However, the ATE program may be able to achieve some limited component field testing. "Employer feedback" may be obtained from using practicum/internship supervisors who serve as surrogates for future employers.

3. APPROACHES TO FIELD TESTING

The approach to field testing is usually via surveys completed by new users, students/completers, and employers. Unless there is an institution-to-institution agreement on providing data about transfer students, data about these student's success are not normally available. Structured interviews with students and employers are also a source of field testing data. Generally, a limitation to any field testing data is the few responses that are available for analysis. At best, the data serve as indicators of success rather than a statistically significant presentation.

Under most external funding there will not be many opportunities to gather field test data during the grant period. The best-case scenario will be the use of surveys of and possibly structured interviews with intern supervisors and second-year students.

Appendix E is a comprehensive description of the development and testing of an environmental science course sequence. The sequence was developed by Wynn Cudmore, Ph.D., Principal Investigator for the National Science Foundation's Northwest Center for Sustainable Resources (NCSR) and represents the rigorous curriculum development, documentation, and testing process used by the Center.

IV. APPENDIX A: AQUARIUM SCIENCE PROGRAM

TERM	NUMBER	COURSE TITLE	TOTAL CREDITS
TERM 1:			
	AQS100	Introduction to Aquarium Science	3
	BI101	General Biology	4
	CA118F	Computer Applications - PowerPoint	1
	MTH095	Intermediate Algebra	4
	PSY104	Psychology in the Workplace	3
			15
TERM 2:			
	AQS110	Aquarium Science Practicum 1	2
	BI102	General Biology (or Higher)	4
	CA118B	Computer Applications - Worksheets	1
	CH110 / CH110R	Fundamentals of Chemistry	5
	SP111	Fundamentals of Public Speaking	3
	WR121	English Composition - Exposition	3
			18
TERM 3:			
	AQS111	Aquarium Science Practicum 2	2
	AQS141	Interpretation & Communication	4
	AQS165	Current Issues in Aquarium Science	2
	BI103	General Biology (or Higher)	4
	PE185SA	Scuba Diving - Beginning	1
		Aquarium Science Electives (Consult with AQS Staff)	3
			16
		First Year Total Credit Hours	**49**
TERM 4:			
	AQS215	Biology of Captive Fish	4
	AQS220	Biology of Captive Invertebrates	4
	AQS240	Life Support System Design and Operation	4
	CA118C	Computer Applications - Database	1
	WR227	Technical Writing	3
			16
TERM 5:			
	AQS226	Biology of Diverse Captive Species	3
	AQS232	Nutrition and Reproduction in Aquatic Species	4
	AQS250	Principles of Exhibit Design	4

TERM 6:			
	AQS275	Aquarium Science Internship	12
			12
		Total Second Year Credit Hours	**43**
		Total Program Credit Hours	**92**

The college offers a 2-year Associate of Applied Science degree in Aquarium Science and a 1-year certificate. The 2-year degree is for individuals who do not have a B.S. degree or higher in a Life Science. The 1-year certificate is available for individuals who have earned a B.S. or higher in a Life Science. Both options require that you apply to the program.

All Aquarium Science students enroll in a required 12 credit hour internship at a facility of their choice which includes both classroom learning as well as a hands-on, real work environment approach to develop aquatic animal husbandry skills. These courses are designed to qualify individuals for work the aquatic animal husbandry profession. Potential employment opportunities include:

- Public aquariums and zoos
- Ornamental fish trade
- Aquaculture businesses
- Research programs
- Educational centers
- Self employment
- State and federal natural resource agencies

AQUARIUM SCIENCE COURSES

Aquarium Science courses include both classroom learning as well as a hands-on, real work environment approach to develop aquatic animal husbandry skills. These courses are designed to qualify individuals for work the aquatic animal husbandry profession.

AQS 100 Introduction to Aquarium Science 1 class and 2 lab hrs/wk, 2 cr.	Examines the history of animal keeping and present-day aquatic animal husbandry industries. Explores the biological processes occurring in the aquarium environment. Learn proper set-up and maintenance of home aquaria.
AQS 110 Aquarium Science Practicum 1 6 lab hrs/wk, 2 cr.	Introduces aquatic animal husbandry work environment and the care of captive aquatic animals. Emphasizes daily animal care and exhibit readiness.
AQS 111 Aquarium Science Practicum 2 6 lab hrs/wk, 2 cr.	A continuation of AQS 110. Incorporates record keeping for animal health, behavioral observations and feeding.
AQS 141 Interpretation and Communication 3 class and 2 lab hrs/wk, 4 cr.	Examines the techniques used to present educational experiences to guests and clients. Students will develop skills to conduct informational research, assimilate information into a presentation, while taking into account individual learning styles.
AQS 165 Current Issues in Aquarium Science 2 class hrs/wk, 2 cr.	Industry professionals share their experiences about facility operations and challenges facing their organization. Discussion topics may vary by term.
AQS 199 Special Projects Number of credits vary.	Provides for the opportunity to study or conduct research in a specific area of Aquarium Science. Contract between student and instructor establishes performance based outcomes. Prerequisite: Consent of instructor.
AQS 215 Biology of Captive Fish 3 class and 2 lab hrs/wk, 4 cr.	Examines the anatomy and physiology of freshwater and marine fishes and the constraints placed upon them in a controlled environment. Increases an understanding of fish behavior through the use of ethograms. Prerequisite: BIO 103 or consent of instructor.
AQS 220 Biology of Captive Invertebrates 3 class and 2 lab hrs/wk,	Reviews the life history and captive care requirements of invertebrates commonly cultured in the aquatic animal industry/profession. Prerequisite: BIO 103 or consent of instructor.

4 cr.	
AQS 226 Biology of Diverse Captive Species 3 cr.	Examines the basic husbandry requirements and the most commonly experienced health ailments of different phyla found in public aquarium animal collections. Reviews the natural history and wild population status of selected species.
AQS 232 Nutrition and Reproduction in Aquatic Species 4 cr.	Examines the reproductive strategies of fishes and invertebrates in a controlled environment and the manipulation of environmental and physiological parameters that initiate reproduction. The nutritional requirement of selected aquatic animals throughout their life history is explored. Industry standards for food handling and HACCP requirements are also discussed.
AQS 240 Life Support System Design and Operation 3 class and 2 lab hrs/wk, 4 cr.	Examines the role of life support systems in maintaining a balanced, stable aquatic environment. Presents how to design, construct, maintain and troubleshoot semi-closed, closed and open systems. Prerequisite: Completion or concurrent enrollment in AQS 215 and AQS 220, or consent of instructor.
AQS 250 Principles of Exhibit Development 3 class and 2 lab hrs/wk, 4 cr.	Presents the issues, materials, and technologies to consider when developing exhibits. Emphasis is placed on integrating goals, information, and personnel as an effective exhibit team. Prerequisite: Completion or concurrent enrollment in AQS 270, or consent of instructor.
AQS 270 Fish and Invertebrate Health Management 3 class and 2 lab hrs/wk, 4 cr.	Reviews the common infectious and non-infectious diseases of captive fish and invertebrates. Examines the common techniques of fish and invertebrate health management. Prerequisite: AQS 215 and AQS 220, or consent of instructor.
AQS 275 Aquarium Science Internship 40 lab hrs/wk, 12 cr.	Exposes students to daily animal care and facility readiness routines. Includes assisting life support staff and animal health management professionals, and to evaluate operational aspects of the facility. Prerequisite: AQS 250 and AQS 270, or consent of instructor.

V. APPENDIX B: GUIDE TO PILOT TESTING

Considerations for Pilot Testing

1. Failure to provide a high priority to curriculum documentation and testing is the most common problem in creating effective and transportable products
2. Effective teachers are not necessarily effective curriculum designers
3. Instructors may need to engage in professional development activities to develop the knowledge and skills need to create, document, and test curriculum products
4. Allocation of sufficient time to documenting and testing curriculum is critical to insure high quality products

General Approach

1. Presentation of materials to representational students
    a. Use of materials in scheduled class is most common protocol
    b. Normally done when teaching a module or course the first time
    c. Do not prejudice outcomes by emphasizing testing aspect of presentation
2. Keep limited reminder notes during presentation
3. If possible, get student feedback
    a. Devise approach to gauge student post-session reaction
    b. Use results to evaluate reaction to new materials
4. Use of colleague to observe can be used but guard against interference with “normal presentation”
5. Identify assessment performance associated with new materials
    a. Determine assessment efficacy in relation to new materials
6. Results recorded as part of the pilot testing evaluation
    a. Evaluation of teaching/learning effectiveness made immediately after session
7. General items considered
    a. Suitability of time allocations
    b. Flow of presentation and/or activity
    c. Appropriateness of media
    d. Student engagement in session
    e. Material match to expected/actual student outcomes
8. Laboratory/Field activities considerations
    a. Adequate set-up and/or travel time allocated
    b. Availability of needed materials
    c. Field site meets instructional need
    d. Adequate student preparation
    e. Student ability to follow procedures
    f. Anticipated results achieved
    g. Safety issues adequately addressed
9. Use checklist to organize and record evaluation remarks
10. Use checklist and documentation to determine revisions

Materials Revision

1. Review of results made at appropriate time delay
    a. Avoid knee-jerk changes
    b. Group multiple session activities
    c. Courses should be reviewed holistically
2. Revision of curriculum products
    a. Outline changes needed
    b. Integrate changes in documentation
    c. Re-test as needed to evaluate changes

VI. APPENDIX C: LECTURE/DISCUSSION PILOT TESTING DATA SHEET

LECTURE – DISCUSSION

Identification:____

Date presented: ______________________ **Students:** _________

Class: ____________________________________

Timing considerations: ____

Available materials & handouts: ____

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Visual aids: ____

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Student interaction & participation: ____

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Student preparation: ____

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Student feedback: ____

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Adjustments needed: ____

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Assessment results: ____

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Additional notes: ____

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VII. APPENDIX D: LABORATORY – FIELD ACTIVITY DATA SHEET

Identification: ____

Date presented: ________________ **Students:** __________

Class: ____

Timing considerations: ____

Preparation activities: ____

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Materials: ____

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Introduction & student instructions: ______________________________________

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Student readiness – preparation: ____

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Student activities & participation: ______________________________________

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Student reports: ____

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Student feedback: ____

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Adjustments needed: ____

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Logistics: ____

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Assessment results: ____

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Additional notes: ____

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VIII. APPENDIX E: AN EXAMPLE OF NCSR CURRICULUM

Environmental Science was developed and taught at Chemeketa Community College in Salem, Oregon for the first time in 1996 by Wynn W. Cudmore, Ph.D. Although initially developed solely for Chemeketa, with funding by the National Science Foundation (NSF), the course became a national model for curriculum development and is now taught in various forms across the nation. Although new courses are routinely developed and taught in community colleges, this sequence of courses is unique in the process by which it was developed, the funding provided for development, testing, modification and dissemination and the degree of scrutiny it has undergone. This document describes the process of curriculum development and the feedback that has been received from students, faculty and independent evaluators.

COURSE DESCRIPTION

Environmental Science is a three-term sequence of a four quarter hour-credit courses that examines the scientific basis for environmental issues. Each course requires a 3-hour lab that meets once per week and 3 hours of lecture. The courses are targeted towards several audiences including:

- ✓ Students in natural resource areas (e.g., Forestry, Fisheries, Wildlife, Agriculture)
- ✓ Transfer students in areas other than biology who need a lab science course or sequence
- ✓ Biology majors who wish to broaden their background in environmental biology
- ✓ Any student interested in learning more about environmental issues

I consider the courses to be "Environmental Science for the Citizen" and emphasize those concepts and issues that in my judgment should be understood by all citizens. The approach is science-based and a distinct effort is made to present opposing viewpoints in contentious environmental issues. The three-term sequence was added as a requirement for students in the Forest Resources Technology Program at Chemeketa where it serves primarily to introduce students to basic ecological concepts and environmental issues that relate to natural resource management. The following goals have been established for the sequence:

- ✓ Introduce students to science as a "way of knowing"
- ✓ Introduce students to basic ecological concepts
- ✓ Introduce students to environmental problems at local, national and global scales
- ✓ Work cooperatively in small groups
- ✓ Communicate effectively in written and oral formats
- ✓ Apply appropriate technology to scientific exploration
- ✓ Access and use supplemental information relevant to course topics
- ✓ Engage students in hands-on, field and laboratory experiences that require critical thinking
- ✓ Use ecosystem management as a major theme in natural resource management
- ✓ Introduce students to societal aspects of environmental issues
- ✓ Apply mathematical concepts to scientific inquiry

THE DEVELOPMENT PROCESS

Environmental Science was developed according to a three-step NCSR curriculum development model (see details at www.ncsr.org) – a period of initial course development, followed by curriculum testing and revision and then, dissemination. These courses were developed with input from a number of sources including a DaCUM (Developing a Curriculum) process, national science education standards, research partners and current research. Curriculum development efforts were documented in "enhanced syllabi" – course documents that include a topics outline, detailed descriptions of laboratories and other course activities, complete citations for print, web and video resources and assessment tools designed for each course. This process of initial development and documentation was completed from 1996-1999. Completed enhanced syllabi were then sent to community colleges with similar programs (test sites) where they were reviewed and implemented to the greatest degree possible. Results from this testing process were used to make modifications to the enhanced syllabi (see details below).

EVALUATION

Environmental Science course materials have probably been scrutinized far more closely than most curriculum development projects. This is primarily a result of NSF requirements and their use as national models. The sequence of courses has been evaluated in part or in its entirety by students at several colleges and universities, environmental science and natural resource faculty at several institutions, research scientists at major universities, an independent evaluator for the grant, a regional advisory board for the grant, a national visiting committee, NSF proposal reviewers, NSF program officers and an independent evaluation center at Western Michigan University.

The course has been field tested at Chemeketa Community College in Salem, Oregon since its development in 1996. Approximately 500 students have taken at least one term in the sequence and their feedback has been used on an ongoing basis to modify and improve course materials. Performance on course assessment tools, student-performed course evaluations and informal comments have been documented and used since 1996. These evaluations indicate that students are learning the essential components of the science behind environmental issues and problems and that they are satisfied with course design and delivery.

To ensure that course materials were "transportable" (i.e., they could be effectively taught outside of the institution where they were developed), major portions of course materials have been pilot tested at Everett Community College, in Everett Washington, Itasca Community College in Grand Rapids, Minnesota and Allegany College in Cumberland, Maryland. Formal reviews of course materials have been conducted by faculty and feedback from students has been solicited. This feedback from students and faculty has been used to modify and improve course materials since their development.

As part of NCSR's efforts to provide faculty with opportunities to improve their skills in teaching ecosystem-based curriculum, NCSR has offered several professional development institutes since its inception in 1996. These week-long, field-based learning opportunities for environmental science and natural resource faculty are designed to engage participants in hands-on field and laboratory activities that they can modify for use in their own courses. Seven of these institutes designed for college faculty have been conducted since 1996 serving a total of 84 participants. Selected activities from *Environmental Science* have formed the basis for materials shared with faculty from across the United States and Canada who have attended NCSR professional development institutes. Exchanges between curriculum developers and institute participants concerning the curriculum inevitably result in both an effective evaluation of the activity and some useful ideas for modification.

The Evaluation Center at Western Michigan University has been funded by NSF to evaluate the effectiveness of the Advanced Technology Education (ATE) program. In 2003, at their request, we submitted course materials for *Environmental Science I* for their evaluation. The materials were rated as one of the four best curriculum products produced by the entire NSF/ATE program. The Center has also evaluated the curriculum development *process* used to create these materials in the *ATE Materials Development Processes Report* (Appleton and Lawrenz, 2004).

Some *Environmental Science* activities have been designed to mirror current scientific research topics in natural resources/ecosystem research. Consultation with scientists in the field has often been required and these researchers are used to evaluate the curriculum materials and student results. The *Log Decomposition Laboratory*, for example, is a longitudinal study of the complex process of log decomposition in forests based on 200-year study designed by Dr. Mark Harmon of Oregon State University and the H.J. Andrews Experimental Forest in Blue River, Oregon.

In 2003, in an effort to develop an articulation agreement between Oregon State University's Environmental Science (ENSC) program and Life Science courses at Chemeketa Community College, course materials for *Environmental Science* were reviewed by OSU faculty members. As a result of this evaluation, students who take the *Environmental Science* sequence are awarded 9 full credits of requirements for the ENSC major including a laboratory experience requirement, a "human environment" requirement, and specialization credit. The entire sequence can even be plugged in as a *400-level* course on a student-by-student basis, a rarity for freshman/sophomore courses offered at community colleges.

"I looked over your lab packages, and was totally blown away. I showed them to Bob Mason, who is the head of Biology here, and he too totally flipped out -- what incredible stuff you have put together! We have absolutely nothing on campus that compares to this sort of lab experience and field experience."

Kate Lajtha
Co-Editor-in-Chief, Biogeochemistry
Dept. Botany and Plant Pathology
Oregon State University

In 2005, the Evaluation Center at Western Michigan University conducted a student achievement study comparing student performance using ATE-developed materials to those who were taught with non-ATE-developed materials (Appleton and Lawrenz, 2005). *Environmental Science I* was chosen as one of their ATE-developed test materials. This study concluded that, "even after considering preexisting educational background differences in the analyses, ATE-EnvSci students (N=77) performed significantly better than non-ATE students (N=68, $p<.001$) …". As a result of this study, the Center recommended to NSF that, "because these materials appear to help students learn environmental science content, efforts should be made to promote the availability of the materials across the country." Additionally, "because the process used to develop the environmental science materials resulted in an effective curriculum, that process might serve as a model for other materials development. The key features to the successful development of the environmental science materials were the expertise and personal commitment to the materials by the single developer and the extensive effort he exerted to utilize the results of several iterations of pilot testing to refine the materials over a long period of time."

SUMMARY

The *Environmental Science* sequence developed at Chemeketa Community College has evolved from a series of courses designed for a single institution, to a national model used in life science and natural resource programs across the nation. While students at Chemeketa have benefited from these courses, the impact well beyond the developing institution has been made possible by continued NSF funding. Since 1996, nearly 1000 course documents have been distributed to educators at over 500 institutions in hard copy or downloaded from the NCSR web site. A thorough evaluation of the courses by students, faculty, research scientists and independent evaluators suggest that the courses meet the need for the science foundations of a variety of ecosystem-based programs.

LITERATURE CITED

Appleton, J. and F. Lawrenz. 2004. ATE Materials Development Processes Report. The Evaluation Center, Western Michigan University

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