Systems Modeling by Interdisciplinary Teams: Innovative Approaches to Distance Education

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ABSTRACT

Teamwork organized around systems models can facilitate mastery of complex, multidimensional issues. To field test this proposition, we designed a graduate-level course in mariculture to help students synthesize what they had learned in traditional courses and to apply that higher-level understanding in a systematic and explicit way in evaluating complex issues. Students and instructors formed an intellectual team that interacted with each other and subject matter experts via site visits, videoconferencing, and the Internet to develop and communicate simulation models of mariculture-system components, and then integrate them. Assessment of student performance was product-based, the main products being a personal logbook and a documented simulation model. Students rated the course experience in three areas, on a scale from 1 (most negative) to 5 (most positive): teamwork (mean = 4.35); systems modeling (mean = 3.75); and collaboration tools (mean = 4.35). Qualitative comments from students via the course Web site suggested both enthusiasm for a new way to learn and frustration over technical problems with modeling and distance education. Despite difficulties, both a majority of students and the instructors judged the course a success, in that it provided a coherent and distance-friendly approach to the study of complex issues.

With technology affording the feasibility of working with students both inside and outside the classroom, many teachers are exploring new concepts in distance education. The technology can allow linkages for interactive teamwork among students, teachers, and other professionals. This interaction can provide students a beneficial view of the world beyond their classroom. Courses are often taught within disciplines, and students struggle or completely fail to see how these isolated courses fit together into a body of knowledge. Students within disciplines lack interaction with students in other disciplines and at other campuses. In addition, information technology is making access to new knowledge more readily available, so instructors strive to pack more and more content into an already packed curriculum sometimes without providing students with problem-solving and real world applications.

Neill (1995) and Neill et al. (1996) have proposed that teamwork organized around systems models could facilitate a needed shift toward more effective approaches to learning. This proposition has its roots in the notion that we should foster a learning system (Brentlinger, 1986) or learning organization (Senge, 1990), which focuses on competencies and outcomes emerging from systems approaches to problem solving. Experiential learning (Kolb, 1984; Salvador et al., 1995) and soft-systems methodology (Checkland, 1981; Lincoln and Guba, 1985) provide complementary tools for producing graduates who can cope with complex, multidimensional issues such as agricultural sustainability, resource conservation, and environmental health.

To field-test these propositions, we designed an academic course around the topic of mariculture using an integrated, multidisciplinary approach. We incorporated distance education technologies to facilitate communication and interaction among a team comprised of undergraduate students, graduate students, faculty, and other professionals to learn together and to solve complex problems in a cooperative way. At the outset, we adopted the following tenets (Neill et al., 1996): Students must be not only active participants but also full partners in their own education. Effective learning communities cannot be restricted to single disciplines or intellectual niches; instead, diversity of abilities, experiences, and goals must be sought. Only by embracing a systems approach can teams develop the intensity, competency, and sense of mission that are needed in dealing with today’s complex world. Only with systems thinking will it be possible to move higher education in agriculture and natural resources toward increased capability for generalized synthesis and problem solving. Systems thinking is essential in bringing together the parallel universes of matter (mathematics, science, and technology) and mind (humanities, liberal arts, sociology, economics, and policy) and their interfaces (psychology and philosophy) to understand the interactions between natural and human systems. And only with systems thinking can interdisciplinary teams communicate among themselves to effectively solve problems and convey their solutions to society.

COURSE OVERVIEW AND INSTRUCTIONAL APPROACH

The course objective was to guide students in organized teamwork leading to integrated systems analysis and synthesis of biological, ecological, technological, and socioeconomic issues associated with the commercial culture of marine organisms. Students and faculty at three campuses in the Texas A&M University System (College Station, Galveston, and Corpus Christi) worked as an interdisciplinary team to conceive a systems model of mariculture. The primary instructor (team facilitator) was in College Station. Two other faculty members assisted in the remote locations, although they were minimally involved in the overall instruction and assessment except to serve as instructors of record on those campuses. The Distance Education

Abbreviations: TTVN, Trans-Texas Videoconference Network; FTP, file-transfer protocol; SCE, standard course evaluation; ECC, evaluation for Corpus Christi; ECS, evaluation for College Station; EG, evaluation for Galveston.
Coordinator for The Agriculture Program with The Texas A&M University System served as a consultant and external evaluator. A graduate student, who was also enrolled in the course provided technical assistance.

The student team included graduate and undergraduate students in three locations. The 22 students comprised a very diverse group, with backgrounds ranging from biochemistry to marketing. Seven of the students were enrolled at College Station, 5 at Galveston, and 10 at Corpus Christi. There were 16 males and 6 females; 18 graduate students and 4 undergraduates; and 17 students from the USA, 2 from China, 2 from Mexico, and 1 from Ecuador.

Student team members were expected to bring to the overall effort their own disciplinary expertise, to communicate explicitly with their teammates via models, and to take away from the course a broad understanding of mariculture and how their own disciplines linked mechanistically with the whole. Their collective effort produced a series of working simulation models ranging from microbial processing of nitrogenous excreta, to seafood economics. As partners in the learning process, students contributed to discussions and gave presentations of their models via videoconferencing and the Internet. They participated in field trips and interacted with expert lecturers on course topics. Instead of exams, student assessment was product-based with a documented, working simulation model of some aspect of mariculture being the chief product. The working STELLA sub-models and documentation resources were shared among course participants via the Internet and a Web site (http://acs.tamu.edu/~wneill/wfsc615/maricult.htm). Course grades were based on: (i) participation in team activities; (ii) a personal logbook documenting model development, transactions during class meetings, outside readings, and personal reflections; and (iii) a model-based thesis.

Although some guest speakers and content-specific lectures opened course sessions, most of the course delivery was unstructured dialog and discussion among students and faculty. Interaction among team members was accomplished via an interactive video network supported through The Texas A&M University System. The Trans-Texas Videoconference Network (TTVN) has approximately 100 videoconference sites across Texas and at international locations in Mexico and Central America. It is a full-duplex system using dedicated T-1 circuits to transmit audio, video, and data. Visual information was delivered through PowerPoint presentations and STELLA windows via a notebook computer interfaced with the videoconferencing system and shown on TV monitors at the three locations. In addition to videoconferencing, participants also accessed course materials and interacted among themselves through the course Web site. File-transfer protocol (FTP) permitted exchange of data and model files among participants via the Web site. In addition, the Web site also provided a bulletin board that served as a team journal.

Over the semester there were three face-to-face meetings that supplemented course delivery via interactive video and the Internet. Early in the semester, a plenary meeting of all course participants was held in College Station. A half-day overview and a panel discussion of mariculture, involving aquaculture experts from the Texas Sea Grant Office and from an international consulting company, were followed by an evening social to help build faculty–student rapport. The next morning, a workshop was conducted to introduce systems thinking and to provide training in the use of the course Web site, the Internet, and STELLA software. In midsemester, the group made a site visit to The Texas A&M University System Shrimp Mariculture Project facilities in Port Aransas and Corpus Christi, and the Gulf Coast Conservation Association–Central Power and Light Company Marine Development Center in Corpus Christi. Toward the end of the semester, the team assembled in the Galveston area to visit the Marine Biomedical Institute’s National Resource Center for Cephalopods and a commercial red drum farm operated by HarvestFresh Seafoods. These field trips to investigate actual mariculture enterprises and the interaction with professionals who operate them helped the team strengthen their conceptual models with philosophical perspectives and a dose of reality not typically available in the classroom.

The instructional goal was to help students integrate what they had learned in traditional courses, apply higher-level understanding in a systematic and explicit way to evaluate complex issues, and work as intellectual partners. The main focus was the integration of bits and pieces of knowledge to form a functional knowledge base for practical problem-solving.

Based on the original tenets in evaluating course success, results were compiled in three categories: (i) students as active participants and full partners of an interdisciplinary team; (ii) the use of systems modeling to visualize and analyze relationships among elements of the diverse content; and (iii) the use of videoconferencing and the Internet/WWW as collaboration tools. Students were asked to rate items in these categories and provide comments. These data were collected through the university’s standard course evaluation (SCE) forms and instructor-developed evaluations transacted via FTP through the course Web site. Subsequent reference to the latter evaluations are labeled by origin as ECC for Corpus Christi, ECS for College Station, and EG for Galveston. The numbers represent the order the evaluations were received (student no. 1, no. 2, etc.). Fourteen evaluations were used for this data analysis with all responses being confidential. An external evaluator compiled a qualitative review of the student responses.

RESULTS AND DISCUSSION

Teamwork

Students were asked to rate their level of personal participation in the course on a scale from 1 (minimal) to 5 (maximal). Participation criteria included: (i) attending all, or almost all, videoconference sessions; (ii) participating in site visits/field trips; (iii) regularly accessing the course page; (iv) maintaining a course logbook; and (v) developing and communicating a working STELLA model. The student mean on self-assessment of their participation was 4.35.

Relevant student comments show the importance of participation in relation to learning in the course. “I personally feel the open discussion related to issues brought to the group is one of the most important qualities this course has to offer graduate students. The opportunity to meet everyone and begin a personal mariculture network is an invaluable

tool for professionals who remain in the field. I don’t see this happening in a conventional approach nearly as much” (ECC1). “I loved the ‘think tank’ approach of this course. I probably learned more than in many of my other courses combined… I am extremely satisfied with the knowledge and experience on interacting in an interdisciplinary environment… I wish all courses were taught with this approach!!!… Interacting extensively with people from other disciplines is as close as the educational environment can get to the real world” (ECC2).

There were also negative reactions to the self-directed, participatory approach and glitches in the technology or users’ lack of experience with it. “Sometimes discussions in class led nowhere…more formal classes should be given by [the primary instructor]” (ECS1). Students also sensed less commitment and participation from the distance students located in Corpus Christi and Galveston. “The three-way split did not work…because the Corpus group was only [minimally involved]” (ECS2). “The involvement of Galveston and Corpus Christi in this class was minimal, and I would not consider their involvement in future classes” (ECS1). Others commented on problems with group dynamics. “Groups didn’t (and won’t, in my experience) ‘just happen’… Only have 2 sites and make both of them full partners. Keep it an integrated graduate and undergraduate class” (ECS2). “Many communication ‘bugs’ need to be smoothed but I did learn, whether the learning directly pertained to mariculture, or whether the learning pertained to working in a group” (EG1).

Systems Modeling

In addition to the question on personal participation, the students were asked to rate their level of satisfaction with the course experience as a system. In responding, students considered aspects of the system external to themselves, such as the approach and logistics, the instructional team, classmates, and the technology. What about the course worked, and what did not? On a scale from 1 (very disappointing) to 5 (very gratifying), the mean was 3.75.

Students made enlightening statements concerning systems modeling. “The development of the model was excellent, and through other mariculture classes, it will be capable of involving everything in the literature… I see in STELLA a great potential… and I strongly agree that our model should not die, but be perfected in future Mariculture classes” (ECS1). Although students endorsed the concept of building systems models, the diversity in knowledge and skills made it extremely difficult to communicate on a level of understanding common to students from all disciplines and backgrounds. “Most students, graduate and undergraduate, are still needing education in general aquacultural practices and technology” (ECS3). “[We should] begin with a few common themes to practice our models and discuss the result and interaction of factors to help further everyone’s own model and connect with each other” (ECS5).

The primary instructor generated an initial outline that was shared at the beginning of the course (Fig. 1) and compared with the subsequent integrated model (Fig. 2) from the interdisciplinary team at the conclusion of the course. Analysis of student models confirmed an expected bias in favor of topics central to the individuals’ disciplinary interests. Thus, only a subset of the issues on the encyclopedic outline generated at the outset of the course was reflected in the integrated model. Physical, chemical, biological, engineering, and economic issues at the core of mariculture production (Categories 2, 3, 4, and 6 in Fig. 1) took precedence over consideration of resource availability, postproduction processes, and sociopolitical concerns. Despite its uneven coverage of subject matter, the integrated model revealed relationships not apparent in the outline—and not even apparent as the students built and discussed their individual submodels. Only when the submodels were integrated did it become evident to the entire team that mariculture systems always involve at least two sets of complementary processes, and that these lead to two kinds of accumulations or stocks (in STELLA language)—the seafood crop (HarvestableStock) and the financial value of the enterprise (SBalance). All submodels, except that dealing with economics, had their roles as modifiers of the rates at which HarvestableStock increased or decreased, or as a feed-back to those rates from HarvestableStock. The economics submodel used the rates of HarvestableStock production and loss and its magnitude to compute SBalance. With the integrated model in mind, it was simple for the group to see how future teams might expand and strengthen the concept of a mariculture system. The instructors had not encountered this before in the classroom and we are certain the systems-modeling approach was responsible.

Collaboration Tools

With our exploration of these learning approaches with distance technologies, we experienced successes as well as problems. Students were also asked to speculate on the level of potential satisfaction the course might have offered if everything had gone as planned with the distance education technologies. On this scale, 1 = none and 5 = much more than the conventional approach. The mean score was 4.35. “The technology has the potential when organized properly to allow all sites to offer their best guest lecturers within the immediate vicinity of the respective campuses” (ECC1). “Anymore, the world is becoming a smaller place and teleconferences between sites, I predict, are going to steadily increase. This therefore needs to be ‘taught’ prior to entering the job market” (EG1).

But students also experienced frustration with the use of the STELLA software for modeling and with the distance education technologies for class communication. Just as the level of knowledge differed among students, so did their abilities to use the technology. In addition, our own set-up was without a precedent to alert us of technological glitches that might and did occur. Students helped us to recognize these problems. “Technology is tricky and it may be of extreme help, but also difficult and confusing leading to loss of valuable hours of class” (ECS1). “The technology was not well integrated or supplied” (ECS2). “We never caught up with STELLA… Something fell through in the delivery and instruction of STELLA at our site. Just a little more coordination could solve this problem for future versions of this class” (ECC1). Even with the two-way audio–video technologies, students at distance sites felt isolated. One stu-
CONCLUSIONS AND RECOMMENDATIONS

Those students who participated enthusiastically in course activities, and adopted a pro-teamwork attitude left the course with very changed outlooks, regardless of their location. These students learned to think about mariculture as an interconnected system of physical, chemical, biological, ecological, and socioeconomic relationships. They learned that one does not have to learn everything, only how a particular disciplinary piece connects to everything. On the other hand, some students (particularly at the remote sites) never really got involved in the course, owing partly to technology difficulties with compressed video transmission and intimidation with being on camera. There was also a delay in availability of the modeling software at the distant sites and some difficulty in viewing the model intricacies on television monitors.

From our perspective as instructors, the course required considerable logistical planning and technical preparation. Although we had grant funds ($6000) to assist with the expenses of lodging for the field trips and hiring a graduate student to help with the Web site and other distance educa-

Fig. 1. The initial instructor outline of the knowledge/activity base for mariculture.
tion technologies, the primary instructor spent approximately three times the amount of preparation time typical for a traditional course. Course materials had to be formatted for television display; STELLA software and Internet access/training had to be provided for students at dispersed locations; field trips had to be planned (lodging, food, guest speakers); and, printed and video-based course materials had to be distributed via mail, fax, and Web site. Because of Texas A&M's telecommuting infrastructure, there were no additional expenses to use the interactive videoconference network. We taught this class again in Fall 1998 with the lessons learned from this experience and a much less demanding preparation time due to existing materials.

The course's main challenges included: (i) discomfort on the part of some participants with the unstructured team approach; (ii) too much novelty (new course, new methods, and new technology) for the instructional team; (iii) problems with student-access to the STELLA software and some unfamiliarity with information technologies; and (iv) too many technological glitches (transmission failures, computer compatibility problems, and viewing difficulties on monitors). But, there also were many positive and encouraging aspects of the project. They included: (i) the development of communication channels and rapport/immediacy over distance, through electronic correspondence and periodic face-to-face meetings; (ii) access to diverse expertise and content; (iii) integration of computer technology and telecommunications with content delivery; and (iv) integrated, multidisciplinary expertise to solve a complex, real-world problem. As we explore these systems approaches and problem solving in distance education, the positive outcomes should far exceed the technological difficulties.

Here are some recommendations for those who might want to initiate a course like this: (i) design the course with shared vision and commitment from an instructor at each participating location; (ii) make sure all remote sites have access to the simulation software before the start of the course and have local expertise to train students in the use of instructional technology; (iii) enlarge the simulation model for TV monitor display or use handouts; (iv) use a content survey to determine basic knowledge at the beginning of the course; (v) provide reading assignments (content and systems-thinking) and examples of models to ensure all students have some common background; and (vi) have a backup when the technology does not work.

Although everything did not work perfectly, much of the approach was successful and students were exposed to "a new way to think," as one student commented. This experience was the most difficult and, at the same time, the most promising we had ever had in the classroom.

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**MARICULT: Integrated Model of Mariculture System**

![Diagram](image)

**Fig. 2.** The composite conceptual model of mariculture, developed by the students. Note that not all topics listed in Fig. 1 appeared explicitly in the model. Model schematic created in STELLA, a simulation program marketed by High Performance Systems, Hanover, NH. Model component names are consistent with conventional usage in aquaculture, as reflected in such texts as Meade (1989) and Stickney (1994). Abbreviations: FeedQuant = feed quantity; FeedQual = feed quality; WasteMgmt = waste management; GenImprv = genetic improvement; 'WaterQual' = 'Water Quality' (physical and chemical properties of aqueous medium); StkngRecruit = stocking and recruitment.
REFERENCES


