Int. J. Engng Ed. Vol. 22, No. 1, pp. 171–182, 2006
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Improving Interdisciplinary Geoenvironmental Engineering Education through Empowerment Evaluation*

E. MARIE STEICHEN, ALOK BHANDARI, STACY LEWIS HUTCHINSON, LAKSHMI N. REDDI, DAVID STEWARD and LARRY E. ERICKSON
College of Engineering, Kansas State University, Manhattan, KS 66506, USA. E-mail: emarie@ksu.edu

Evaluation of courses and programs has received greater attention recently because of efforts to improve engineering education following processes recommended by the Accreditation Board for Engineering and Technology. The empowerment evaluation process has been used at Kansas State University for both program development and the evaluation of a Geoenvironmental Engineering Design course. We have developed and instituted a Geoenvironmental Certificate Program through funding from the National Science Foundation Combined Research and Curriculum Development Program. The Geoenvironmental Engineering Design course was taught for the first time in the fall of 2004, and an empowerment evaluation of the course was conducted immediately after final grades were submitted. The empowerment evaluation process is illustrated in this manuscript, and the results of the evaluation are presented. A culture of evidence and a community of learners is fostered through the empowerment evaluation process. The results show that the students appreciated the opportunity to work in multidisciplinary teams on real design problems with an interdisciplinary team of faculty. The students considered the feedback that they received on written and oral progress reports to be a significant aspect in their learning.

Keywords: empowerment evaluation; geoenvironmental engineering; learning objectives; design project; course reform

INTRODUCTION

MANY ENVIRONMENTAL PROBLEMS are complex, and they are often addressed by interdisciplinary teams. Such problems are also transboundary in character; that is, they cross domain boundaries including, but not limited to:

- science and engineering disciplines
- regulatory agencies, courts, private and public lands
- political boundaries (city, state, bi-state, federal, international authorities)
- cultural/religious boundaries

To prepare engineering graduates to solve complex, interdisciplinary and transboundary environmental problems, a Geoenvironmental Certificate Program was created at Kansas State University.

An evidence-based evaluation model with sufficient flexibility to address complex environmental problems was needed to help stakeholders develop and evaluate this innovative curricular framework. After reviewing the relevant available literature, empowerment evaluation [11] was used to: (1) identify the concepts and applications that would frame the Geoenvironmental Certificate Program; and (2) assess the effectiveness of the interdisciplinary design course as a teaching strategy to equip engineers to solve complex environmental problems. In this paper, we discuss the application of empowerment evaluation as a tool to improve geoenvironmental engineering education.

Empowerment evaluation (EE) has been adopted in numerous education-related spheres [1, 3, 8, 9, 12, 14, 16, 18, 20, 22, 32]. However, its most frequent application has been with programs and program improvement including, but not limited to substance abuse prevention, HIV prevention, crime prevention, environmental protection, welfare reform, battered women's shelters, agriculture and rural development, adult probation, adolescent pregnancy prevention, tribal partnership for substance abuse, self-determination and individuals with disabilities [11]. A review of the relevant literature (evaluation and empowerment evaluation with engineering education, improving engineering education, engineering design course, interdisciplinary courses, interdisciplinary teams, engineering accreditation and accreditation) was conducted. Reporting on their examination of *Journal of Engineering Education* articles pertaining to the current state of assessment methods and practices for improving engineering education, Olds *et al.* [23] presented examples of methods being used, and pointed out their merits and drawbacks. However, neither review revealed the use of empowerment evaluation for geoenvironmental engineering programs. Neither did the reviews show the use of empowerment evaluation to assess the efficacy of innovative teaching strategies for improving engineering education.

* Accepted 21 April 2005.

One of the goals of this paper is to describe how empowerment evaluation fosters a community of learners and a culture of evidence that can be used for assessment and evaluation within engineering education. A second goal of the paper is to illustrate how empowerment evaluation builds capacity for evidence-based practice. A third goal is to provide information on the empowerment evaluation results for the Geoenvironmental Engineering Design course for the purpose of improving engineering education. The Accreditation Board for Engineering and Technology (ABET) considers the ability of graduates to work effectively on interdisciplinary teams to be a desired outcome of engineering education. The design teams included students from two or more disciplines, and the evaluation included the learning objective to effectively participate as a member of a multidisciplinary design team.

HOW EMPOWERMENT EVAUATION WAS USED

To help frame the Geoenvironmental Engineering program, a group of 20 experts from industry, academia, and state/federal regulatory agencies were invited to participate in a facilitated EE workshop. The purpose of this EE workshop was to gather information from practitioners and educators on the scope of geoenvironmental engineering, that is, what graduating environmental engineers should know and be able to do. The geoenvironmental engineering principles and concepts and their applications which emerged from this workshop provided scaffolding for the program, which included three courses: Principles of Geoenvironmental Engineering, Design of Groundwater Flow Systems, and Geoenvironmental Engineering Design. From the first workshop, the faculty team developed the learning objectives and instructional plan for the interdisciplinary design course.

Following the end of the first teaching of the interdisciplinary design course, an empowerment evaluation workshop was conducted. Workshop participants included the interdisciplinary teaching team and the students who had just completed the course. The overall purpose of this workshop was to examine the effectiveness of an interdisciplinary design course as a teaching strategy to improve the preparation of engineers to solve complex environmental engineering problems.

CULTURE OF EVIDENCE

The field of evaluation has been a leader in advancing the culture of evidence movement. The culture of evidence approach makes explicit the use of evidence-based decision making (judgments) over global subjective judgments [4]. The culture of evidence, or evidence-based practice, has had a pronounced impact on medicine and scientific research. The application of empowerment evaluation to engineering education fosters a community of learners for decision-making among stakeholders, particularly where a status differential may preclude an open exchange of information.

EMPOWERMENT EVALUATION AND GEOENVIRONMENTAL ENGINEERING

Empowerment evaluation

> Empowerment evaluation is an innovative approach to evaluation that has been adopted in higher education, government, inner-city public education, and foundations throughout the United States and abroad. It is being used in a wide range of programs, including substance abuse prevention, accelerated schools, adult probation, and doctoral programs [7].

Empowerment evaluation is the use of evaluation concepts, techniques, and findings to foster improvement and self-determination [11]. All evaluation/assessment methods, statistics, tools and techniques found in traditional evaluations are available for use with empowerment evaluation (EE). This approach aims to increase the probability of achieving program success by (1) providing program stakeholders with tools for assessing the planning, implementation, and self-evaluation of their program, and (2) mainstreaming evaluation as part of the planning and management of the program/organization' [13]. EE is collaborative and fundamentally democratic; that is, it facilitates the examination of issues of importance to the community in an open, participatory forum. Thus, the context of evaluation changes from assessment of a program's merit and worth (the traditional approach) to a context of an on-going program improvement. This new context recognizes a simple but often overlooked truth: merit and worth are not static values [11]. By this it is meant that merit and worth are no longer the endpoint of evaluation because goals change, populations shift, program knowledge increases, programs and practices change and their value to society changes.

Empowerment evaluation was introduced to the national evaluation community in the 1993 American Evaluation Association Presidential Address [6]. Since its introduction by then-President, Dr. David Fetterman, Director of Evaluation in the School of Medicine, Stanford University, EE has made significant contributions to the evaluation landscape. The EE approach, used to improve programs and organizations and build evaluation capacity through facilitated self-evaluation, has numerous and diverse applications from university accreditation, to government, non-profit corporations, inner-city programs, prevention programs, hospitals, and the Hewlett-Packard Digital Village. Empowerment evaluation typically has three steps facilitated by a critical friend/evaluation coach:

1. Mission statement: develop a vision or unifying purpose for the program or course.
2. Taking stock: determine the current status of the program—its strengths, weaknesses, activities, goals, etc.
3. Charting the course: plan for how a program would like to improve on what they do.

EE uses reflection and action, and knowledge creation to foster the development of the Collaborative as a learning organization with the capacity to use empowerment evaluation to inform the planning, implementation and improvement of its initiatives [13].

While EE shares some methods and values with other evaluation approaches (such as participatory, collaborative, and utilization-focused evaluation), empowerment evaluation is distinguished from the others by its adherence to these 10 principles: improvement, community ownership, inclusion, democratic participation, social justice, community knowledge, evidence-based strategies, capacity building, organizational learning, and accountability [13]. The 10 principles place emphasis on participant involvement at every step of the process with the belief that people support what they help create. These principles are realized through the use of a neutral evaluation facilitator. This is particularly valuable in settings where structure and context create a power imbalance. In the case of a classroom, this is manifest as an inherent power differential between students and professors. Teaching situations present a special challenge because both students and faculty engage in activities that impact one another. Faculty engage in activities that assess the student's course work for a grade with outcomes impacting GPA, scholarship, career searches, and honors designation, and students engage in activities that evaluate professors' teaching with outcomes that may influence retention, promotion, and salary adjustments. Using empowerment evaluation creates a safer context for discussing sensitive issues.

Geoenvironmental engineering

Geoenvironmental engineering is defined in a broad sense as a field that encompasses the application of science and engineering principles to the analysis of the fate of contaminants on and in the ground; transfer of water, contaminant, and energy through geomedia; and design and implementation of schemes for treating, modifying, reusing, or containing wastes on and in the ground [27].

> Rapid growth in global population and industrial development in the past few decades led to several environmental problems related to soil and groundwater. As public agencies, private firms, and academia embarked on projects aimed at seeking solutions to waste management and subsurface contamination problems, it became clear that the scientific and engineering issues involved are very diverse and require adoption of interdisciplinary approaches. The need for interdisciplinarity in assessing and solving current and future geoenvironmental problems requires that students, program officers, researchers, and engineering project personnel synthesize and apply essential principles from a diverse set of disciplines. When this interdisciplinarity need is coupled with the immense growth in research activities over the past decade dealing with waste containment and site remediation, the need for combined research curriculum development in geoenvironmental engineering is overwhelmingly clear. To address this need, a curriculum framework for geoenvironmental engineering, Combined Research Curriculum Development (CRCD), was developed with support from the National Science Foundation [2].

The research-integrated curriculum in geoenvironmental engineering, the graduate certificate in geoenvironmental engineering, and the three courses are described elsewhere [2]. The K-State Geoenvironmental Certificate Program can be accessed at http://www.engg.ksu.edu/geoenviron/geoenviron_home.htm.

EMPOWERMENT EVALUATION IN PRACTICE: DATA GENERATION

Mission statement

Four learning objectives, informed by the first EE facilitated workshop, were established by the interdisciplinary faculty team for the design course. The mission statement for the second EE facilitated workshop was to understand which activities of the design course were effective for improving the preparation of engineers to solve complex environmental engineering problems. This was to be accomplished by examining the four learning objectives:

1. Apply the principles of groundwater flow, contaminant transport, and the processes affecting environmental fate of contaminants in soil and groundwater systems to *understand, evaluate,* and *design* engineered geoenvironmental systems for the remediation of real world contaminated sites.
2. Research and use non-textual resources to solve problems.
3. Communicate progress and results in the form of written reports and oral presentations.
4. Effectively participate as a member of a multidisciplinary design team.

Taking stock—Step 1 (TS–S1)

During Step 1 of the taking stock (TS–S1) process, participants listed the activities in which they participated to achieve the first objective. This process includes discussion and dialogue as the activities are identified and word sets are developed that describe them. They then prioritized or gave value to each of the activities by 'voting the dots'. Each participant received five dots per learning objective. All five dots may be placed on a single activity, spread across five activities, or any other combination. *Step 1 was repeated for each of the four learning objectives.* Tables 1–4 in the results section provide the lists of activities in rank order participants generated for learning objectives 1–4.

Taking stock—Step 2 (TS–S2)

During Step 2 of the taking stock process, there was discussion to clarify the criteria to be used to rate each activity. Participants rated each activity for each of the four learning objectives. Rating was done on a one to 10 scale, with 10 being the highest level and one being the lowest. Participants rated the activities while in their seats on their own paper. Then they recorded their ratings on a poster in the front of the room. Each person wrote their initials at the top of a column, in keeping with EE's focus on democratic participation. EE holds that participatory democracy (deliberation and authentic collaboration) around issues important to a community is a critical process for maximizing the skills, knowledge, and abilities of the community, in this case a community of students and faculty. Democratic participation promotes stakeholder buy-in and emphasizes that fairness, equity, and due process are fundamental to the process, and makes the process transparent. Tables 5–8 show the ratings of the activities by each individual and by each category (activity) as well as individual and group averages and standard deviations for Learning Objectives 1–4. Graphs of the category statistics by activity follow each table (Figs 1–4).

RESULTS

Discussion of each of the four objectives was facilitated by the evaluator during the empowerment evaluation workshop. Each objective was discussed and ranked individually. Participants generated types of activities in which they engaged over the course of the semester, and then discussed each activity with respect to the objective and their completed geoenvironmental project. Following the discussion, the participants were asked to rank how important each activity was to achieving each of the objectives. Discussants held varied views of the activities. Several examples are presented in this paragraph to illustrate how differential project experiences and differential world views influence the outcome of the process. In one example, the engineering project site was local; for the other group the engineering project site was out of state. Ready access to the project site impacted how participants thought about and talked about their experiences. In a second example, the shared experience of writing a resume and statement of purpose for taking the course was discussed. There was unanimity of response—all indicated they were better prepared to provide this type of documentation at the end than when they were asked at the beginning. In a third instance, the outcome of the ranking process precipitated a lively discussion between faculty and student participants centered on peer-reviewed research. Faculty held this activity of higher value than students. Through the EE process, the two groups (faculty and students) engaged in meaningful dialogue about this activity. In the absence of this democratic discussion approach, it is likely that students would have continued to misunderstand and misinterpret the value of prior research in the form of referred journal articles to their practice of engineering. In a fourth example, students expressed their dislike for in-process reviews that were an *oral format only*. Through discussion, it became apparent that the students were not averse to making oral presentations; rather, they felt strongly that the preparation for oral presentations was time consuming as they pulled pieces of information from multiple sources. Their concern was that, having pulled pieces of information from multiple sources, they were left with no complete written document as a baseline for the next phase. As a result, they suggested to the faculty that written reports be required for each in- process review and that oral presentations be made from the written report. Although it seemingly incurred more work on their part, they thought by writing a report for each review, this actually reduced the amount of time they spent later in recreating the evidence for the next stage.

The results of the taking stock Step 1 and Step 2 of the empowerment evaluation are presented in Tables 1–8 and Figs 1–4.

Charting the course

The final step in empowerment evaluation is charting the course. With the focus on improving engineering education, participants (faculty and students) were asked during the charting the course segment of the workshop: What other activities should we do the next time the class is taught to more effectively prepare students to meet these four objectives? Table 9 below lists the activities generated during the discussion.

Table 1. Rank order of activities for learning objective 1

Rank order of activities for learning objective 1: Apply principles	All tally	%
Research design project	10	22.0%
Lectures	9	20.0%
Practical examples	8	18.0%
Guest lecturers	8	18.0%
Previous knowledge	4	8.9%
List remediation options	3	6.7%
Evaluate options	3	6.7%
Summarized peer-reviewed papers	0	0.0%
Totals	45	100.3%

Table 2. Rank order of activities for learning objective 2

Rank order of activities for learning objective 2: Research and non-textual resources	All tally	%
Web/Internet	12	27.0%
Journals	8	18.0%
People with special knowledge	6	13.0%
Site visits	6	13.0%
Calls to companies	4	8.9%
Peer discussions outside of class	4	8.9%
Reports on the site	4	8.9%
Conferences, materials, handouts	1	2.2%
Other electronic resources	0	0.0%
Totals	45	99.9%

Table 3. Rank order of activities for learning objective 3

Rank order of activities for learning objective 3: Communicate progress	All tally	%
Written presentations (2 progress reports and a final presentation)	12	27.0%
Instructor feedback	11	24.0%
Oral presentations (2 progress reports and a final presentation)	10	22.0%
Team meeting communication	7	16.0%
Final interview with instructors	4	8.9%
Summarize peer review research	1	2.2%
Resume and statement of purpose on why taking course	0	0.0%
Totals	45	100.1%

Table 4. Rank order of activities for learning objective 4

Rank order of activities for learning objective 4: Design team participation	All tally	%
Each group member contributed important and different ideas, information	11	24.4%
Something to learn from each team member within and between groups	10	22.0%
Group experience (practice in group process)	9	20.0%
Encouragement from other members	7	16.0%
More than just technical	5	11.0%
Shared leadership	3	6.7%
Totals	45	100.1%

DISCUSSION

The facilitated empowerment evaluation process allowed students and faculty to discuss the strengths and weaknesses of the design course in an open, inclusive, professional, and non-threatening environment. This mutual respect placed the discussion in the context of stakeholders seeking to learn from one another. Faculty wanted to learn which teaching strategies worked and which did not. They also sought other suggestions of other strategies that would improve the course from the student's perspective. Students wanted to learn ways to improve their performance and to be more prepared for the work world. Both groups engaged in this reflective process on the common ground of improving engineering education (community of learners).

Tables 1–4 report the relative importance (ranking) the students assigned to each of the activities. The design project, lectures, and the practical examples that were presented contributed to meeting learning objective 1. Tables 5—8 report the value (rating from 1 to 10) the students assigned to each of the ranked activities. The teaching and learning strategies that emerged from the data support a high level of hands-on activity, interspersed with in-process reviews (IPR). The students advocated adding written reports to each of the oral reports given during the IPR. Students indicated they learned best when practical examples were used to illustrate information and processes.

The design project required the students to find information from a variety of sources. The faculty defined non-textual as any resource beyond the formal textbook(s). The evaluation shows that the students used a variety of non-textual resources. In Table 2, in the initial ranking of sources, the Internet was ranked highest; however, when rating the sources in Table 6, the reports on the site received a slightly higher rating than the Internet.

The importance of being part of an interdisciplinary team was valued highly (Table 4).

Table 5. Individual ratings matrix—learning objective 1

Activities for LO1: Apply principles	Ratings by individuals								Category summary statistics		
	A	B	C	D	E	F	G	H	Total	Avg.	StDev
Research design project	7	10	10	9	9	9	8	9	71	8.9	1.0
Lectures	8	8	9	9	9	6	7	7	63	7.9	1.1
Practical examples	10	6	8	8	8	7	9	6	62	7.8	1.4
Guest lecturers	10	6	8	8	9	8	9	7	65	8.1	1.2
Previous knowledge	7	10	9	5	8	9	1	9	58	7.3	3.0
List remediation options	10	8	8	6	8	8	4	7	59	7.4	1.8
Evaluate options	8	7	8	7	9	8	5	8	60	7.5	1.2
Summarize peer reviewed papers	10	5	9	9	7	8	6	7	61	7.6	1.7
Individual TOTALS	70	60	69	61	67	63	49	60			
Average	8.8	7.5	8.6	7.6	8.4	7.9	6.1	7.5			
Standard deviation	1.4	1.9	0.7	1.5	0.7	1.0	2.7	1.1			

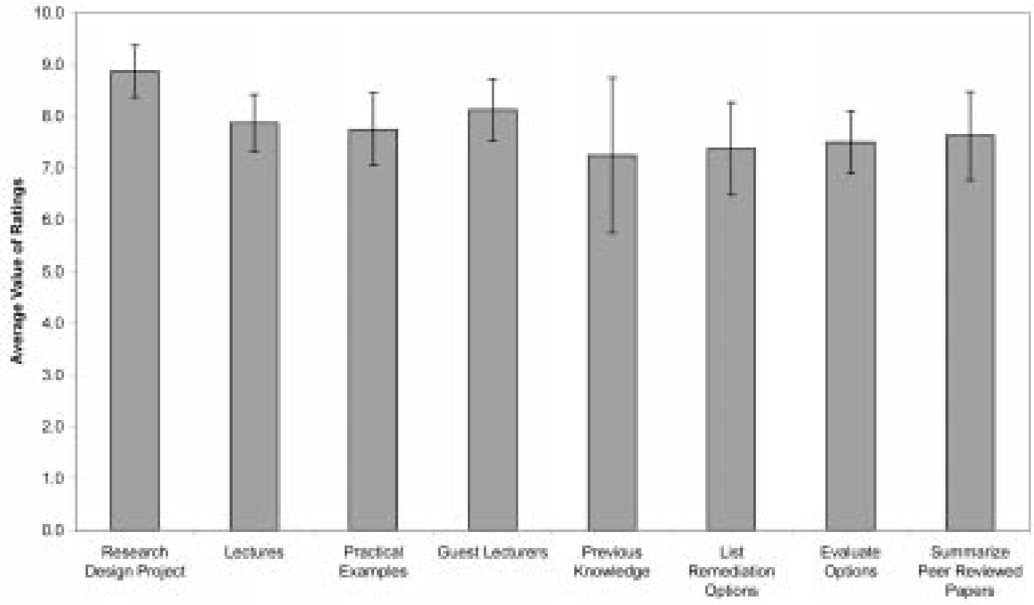

Fig. 1. Individual ratings for LOI—apply principles.

Table 6. Individual ratings matrix—learning objective 2

Activities for LO2: Non-textual resources	Ratings by individuals								Category summary statistics		
	A	B	C	D	E	F	G	H	Total	Avg.	StDev
Web/Internet	10	10	8	8	9	10	7	9	71	8.9	1.1
Journals	10	7	10	9	8	8	7	7	66	8.3	1.3
People with special knowledge	10	10	9	5	9	8	6	8	65	8.1	1.8
Site visits	10	9	10	5	9	9	5	9	66	8.3	2.1
Calls to companies	10	10	9	7	8	10	3	7	64	8.0	2.4
Discussions w/peers outside of class	8	6	9	9	8	8	3	6	57	7.1	2.0
Reports on the site	10	9	10	10	10	8	7	8	72	9.0	1.2
Conferences handouts	8	7	8	6	9	8	2	7	55	6.9	2.2
Other electronic resources	8	6	8	5	6	8	6	9	56	7.0	1.4
Individual TOTALS	84	74	81	64	76	77	46	70			
Average	9.3	8.2	9.0	7.1	8.4	8.6	5.1	7.8			
Standard deviation	1.0	1.7	0.9	2.0	1.1	0.9	2.0	1.1			

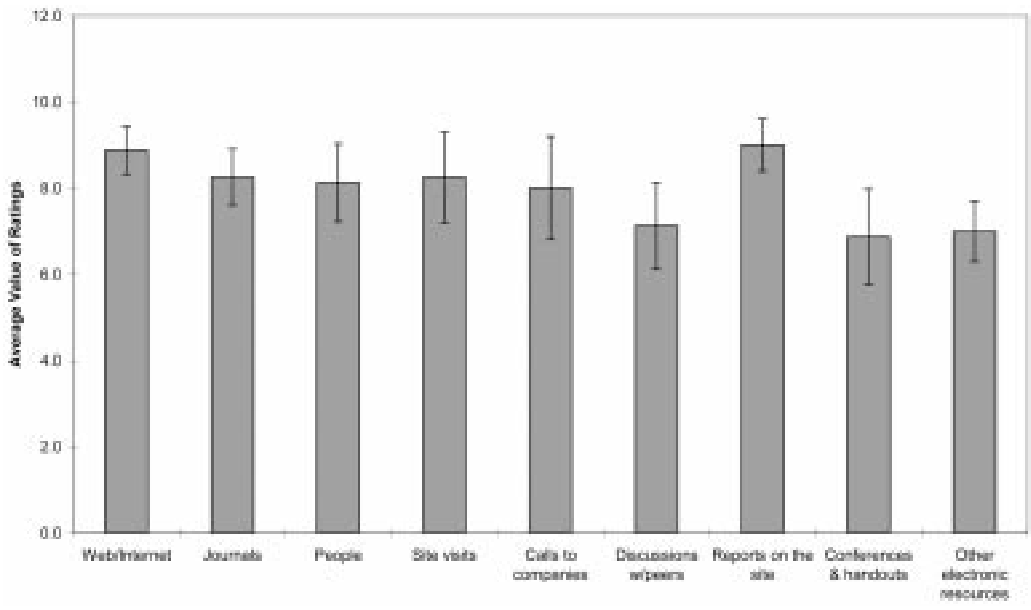

Fig. 2. Individual ratings for LO2—non-textual resources.

Table 7. Individual ratings matrix—learning objective 3

Activities for LO3: Communicate progress	Ratings by individuals A	B	C	D	E	F	G	H	Category summary statistics Total	Avg.	StDev
Written reports	10	9	10	8	9	8	8	8	70	8.8	0.9
Instructor feedback	10	10	10	9	9	7	7	7	69	8.6	1.4
Oral presentations	10	10	10	8	9	9	9	8	73	9.1	0.8
Team Communication	9	9	9	10	9	9	5	6	66	8.3	1.8
Final interview	8	10	7	7	7	8	7	9	63	7.9	1.1
Summarize peer reviewed research	8	8	10	10	5	6	5	9	61	7.6	2.1
Resume & Statement Of purpose	6	7	7	4	5	7	4	10	50	6.3	2.0
Individual TOTALS	61	63	63	56	53	54	45	57			
Average	8.7	9.0	9.0	8.0	7.6	7.7	6.4	8.1			
Standard deviation	1.5	1.2	1.4	2.1	1.9	1.1	1.8	1.3			

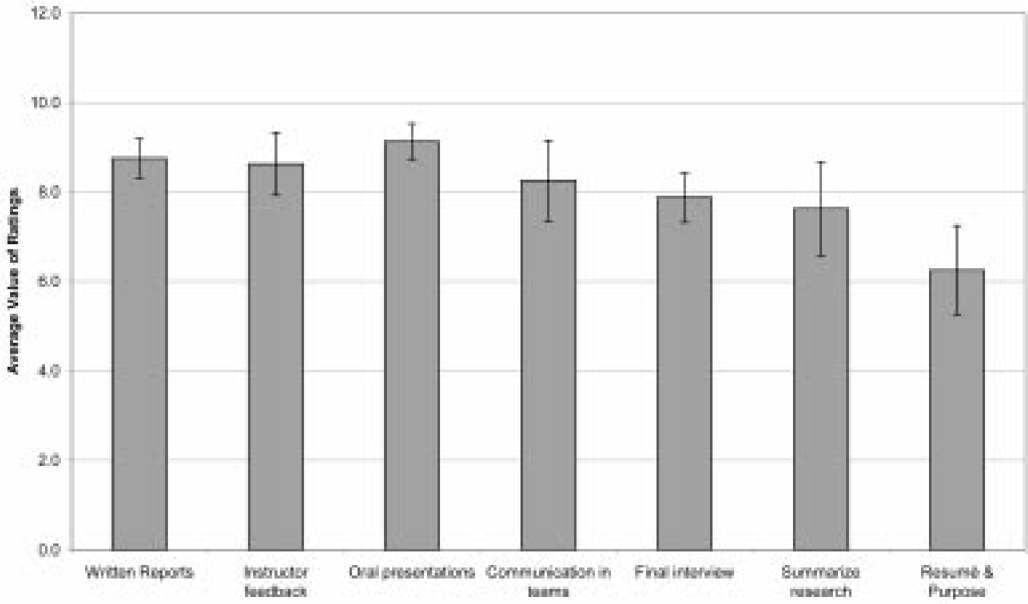

Fig. 3. Individual ratings for LO3—communicate progress.

Table 8. Individual ratings matrix—learning objective 4

Activities for LO4: Design team participation	Ratings by individuals A	B	C	D	E	F	G	H	Category summary statistics Total	Avg.	StDev
Each member contributed important & different ideas	10	10	10	8	9	9	8	7	71	8.9	1.1
Learning within & between groups	10	10	10	10	10	10	8	7	75	9.4	1.2
Group experience	9	10	10	10	9	9	7	6	70	8.8	1.5
Encouragement	8	9	8	10	8	10	7	7	67	8.4	1.2
Communication more than technical support	9	10	8	7	8	9	8	8	67	8.4	0.9
Shared leadership	8	9	8	9	9	9	8	8	68	8.5	0.5
Individual TOTALS	54	58	54	54	53	56	46	43			
Average	9.0	9.7	9.0	9.0	8.8	9.3	7.7	7.2			
Standard deviation	0.9	0.5	1.1	1.3	0.8	0.5	0.5	0.8			

The follow-up discussion revealed that many students in the course had worked on teams in their academic career; however, working across disciplines was a new experience. In this regard, student's ratings revealed they highly valued learning from other team members (Table 8).

Multiple features of the EE model set it apart from traditional evaluation models. Empowerment evaluation uses both quantitative and qualitative methodologies as well as all methods and strategies of traditional evaluations, and it meets the professional standards of the field. What distinguishes

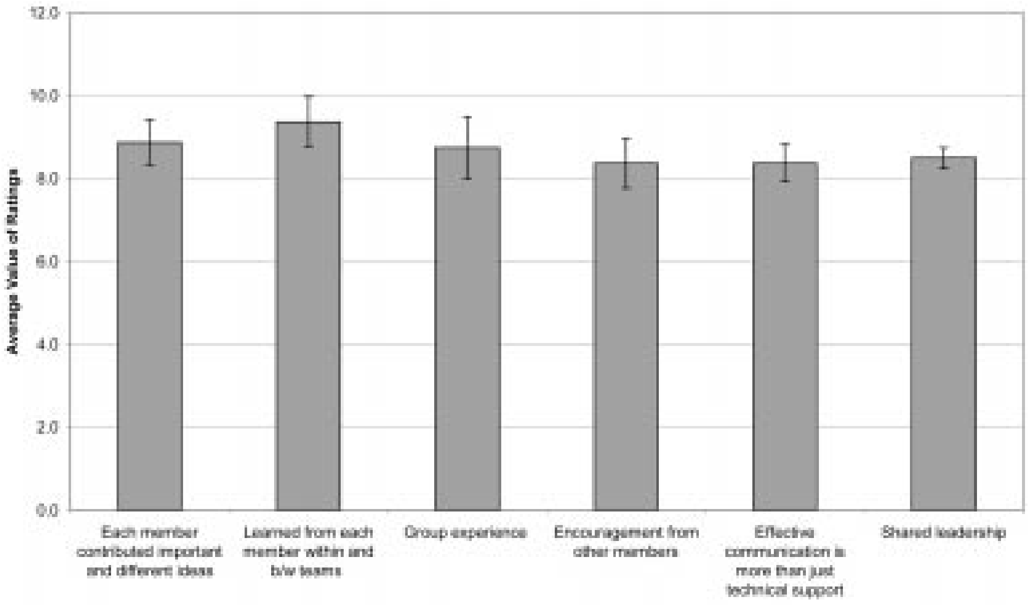

Fig. 4. Individual ratings for LO4—design team participation.

Table 9. Course improvement suggestions

Activities
Identify areas of concern/uncertainty and discuss them with faculty—permission to not know answer
Invite outside professionals to review projects
Obtain additional information from outside people
Assign formal homework assignments (problems, look at web sites, etc.) related to design, rather than simply directing students to websites or articles
Provide informal progress report during help sessions
Provide better discussion of estimating and costing during class
Turn in draft final project for faculty to help identify missing pieces
Invite an outside person to read draft report for oversights
Written report each time, not just oral report because written feedback is valuable. The speaker clarified this to mean that it saves time to produce a written report each time rather than alternating two written and two oral reports because when an oral report is put together, it takes pieces from various places and is not a cohesive report to build from; there is no record of the steps, etc.
The students thought all four in-process reviews should include a written report.
Final draft is fourth report—written. Students would like feedback on a final draft before turning in the final report. One reason they cited for this added step was because they wanted to use the final report as part of their portfolio for job interviews and they wanted a report of highest quality.

Table 10. Interface of quantitative and qualitative data—learning objective 2

Category	Rating	Participant's reasoning*
Calls to companies	3	Made no calls to companies.
Discussion with peers outside of class	3	This is a new program so had no peers other than my classmates with whom to discuss this.
Conferences and conference materials/handouts	2	Did not attend any conferences, but would like the opportunity to.

* Comments paraphrased from data

Table 11. Interface of quantitative and qualitative data—learning objective 3

Category	Ratings	Participant's reasoning*
Resume and statement of purpose on why taking the course	4	Didn't think my resume was as good as it could be—could write a much better resume at the end of the course rather than the beginning.
	5	Respondent agreed with previous participant; preferred the exercise at the end to reflect growth from course participation
	4	Didn't see the reason for writing a statement of why we wanted to take the course.

* Comments paraphrased from data

Table 12. Student progress ratings on course objectives

Course Objectives	Adjusted T score[a]	Adjusted score[b]
1. Learn to apply course material to improve thinking, problem solving, and decisions.	54	3.9
2. Develop specific skills, competencies, and points of view needed by professionals in the field	53	4.0
3. Acquire skills in working with others as a member of a team.	57	4.2
4. Learn how to find and use resources for answering questions or solving problems.	58	3.8
5. Acquire an interest in learning more by asking questions and seeking answers.	50	3.4
6. Learn to analyze and critically evaluate ideas, arguments and points of view	53	3.7

[a] T Scores: <37 (low), 37–44 (low average), 45–55 (average), 56–63 (high average), >63 (high)
[b] 5-point scale

Table 13. Strategies and methods found to be effective using the IDEA survey instrument

Strengths to retain
1. Explained the reasons for criticisms of students' academic performance.
2. Involved students in hands-on projects such as research, case studies, or real-life activities.
3. Gave projects, tests, or assignments that required original or creative thinking.
4. Scheduled course work (class activities, tests, projects) in ways, which encouraged students to stay up-to-date in their work.
5. Formed teams or discussion groups to facilitate learning.
6. Encouraged students to use multiple resources (e.g. data banks, library holdings, outside experts) to improve understanding.
7. Related course material to real life situations.
8. Asked students to share ideas and experiences with others whose backgrounds and viewpoints differ from their own.

EE from traditional evaluation modes is the focus on self-determination, capacity building, program improvement, fostering a community of learners, and adherence to the 10 principles described earlier. Among the EE model's unique features is the *real-time interface between quantitative and qualitative data*. Because of the extensive data available from the EE process, only a few examples were chosen to illustrate this feature.

Example 1: To understand this interface, learning objective 2 (LO2) will be used to illustrate. After the students and faculty prioritize the activities in empowerment evaluation taking stock—Step 1 (TS–S1), posters with activities in their rank order were posted. Paper copies with the rank ordered activities were then given to each participant to rate how well they thought they did on these activities (TS–S2). Participants first rate the activities individually at their table, and then record their ratings on the poster at the front of the room. Because the EE process is open and democratic, each participant is asked to put his or her initials at the top of the column where they record their ratings. Once all participants have recorded their ratings, averages are calculated by column (participant) and by row (category). Averaging by column allows examination of individual rater's internal rating schema. For example, some participant raters do not use '10' because they believe a perfect score is not possible; others tend to rate consistently in the middle range. Averaging by category provides a balanced view of the overall experience.

The facilitator then leads a discussion of the quantitative findings among all stakeholders, examining first for outliers in the data. Both the participant and the category data are examined. Table 6 (LO2) shows that participant 'G' has given ratings of '2' or '3' to several activities. By looking at these same activities across all raters, G's ratings seem low. However, by examining all of this participant's ratings, we see that G rates no higher than '7' on any activity. This typically indicates a person who does not rate the full scale. In the discussion that followed, G indicated that he/she never gives a '10' or a perfect score to anything. Participant G further indicated that he/she gave a low rating to three categories for the reasons shown in Table 10. This interface between quantitative and qualitative data not only increases the stakeholder's understanding of a shared experience from different perspectives in real time, that is, as part of the data generation process, but it is also a democratic and empowering process, giving voice to all participants.

Example 2: Table 11 provides another example of the value of toggling between quantitative and qualitative data in real time. By examining the scores on the Individual Rating Matrix for LO3, we see that *Resume and statement of purpose on why taking the course received* ratings with a more pronounced dispersion than all other categories for this learning objective. Probing the spread of scores resulted in an informative discussion by the students. One participant whose rating across the activities is generally high, rated this activity '10', indicating he/she found it to be very valuable. Four participants gave this category average ratings (6, 7). Three participants gave this activity a relatively low rating (4, 5). Qualitative data was collected from all participants to provide feedback to faculty for course improvement. The reasons cited provide information about the timing and use of this activity in this course. The explanations for the relatively low ratings by some participants for this category are shown in Table 11.

Results from Student Assessment Instrument

Conventional university-wide student course evaluations were conducted using a survey tool developed by the Individual Development and Educational Assessment (IDEA) Center, Manhattan, KS. The IDEA assessment uses statistically derived scores (T-scores) that make it easy to compare various measures. T-scores all have an average of 50 and a standard deviation of 10 meaning that 40% of all T-scores are in the range of 45–55. Students rated the teaching effectiveness and their progress on relevant course objectives. Table 12 summarizes the student progress ratings for course objectives selected by instructors as important or essential. The IDEA assessment report also provided a summary of instructional approaches that were particularly effective for this course. These strategies and methods are summarized in Table 13.

CONCLUSIONS

By co-constructing their understanding of a shared experience (geoenvironmental engineering design course), a community of faculty and graduate student learners was engendered. Knowledge was created about teaching and learning strategies to improve the design course and, thus, strengthening the Geoenvironmental Certificate Program. The empowerment evaluation process provided significant information that will be used to improve the course. Engagement in this evidence-based, self-evaluative process was inclusive and democratic. Both stakeholder groups took community ownership of the design course. The students and faculty offered constructive recommendations in an open environment that encouraged everyone to participate in a positive manner (community of learners). Through this process of reflective thinking, participants identified important events that contributed to the teaching and learning process. The following specific conclusions listed below were the direct result of the empowerment evaluation workshop.

1. The design project was affirmed as an important part of the course.
2. The student comments indicated they considered the feedback from the faculty to be a significant part of their learning.
3. The course should be restructured to allow time for a draft final report to be submitted and reviewed by the faculty. The feedback on the draft final report would help the students to submit a better final report.
4. Communication is important for the project work. Discussions revealed the need for greater emphasis being placed on having teams meet regularly to discuss the work that is being done and the plans for the work that needs to be done.
5. Each written progress report provides an opportunity for review and feedback. The written progress reports also provide a record for the work that follows. All four in-process reviews should be based on a written report, rather than the current format of alternating two written and two oral reports. When oral reports are scheduled, a written report should be submitted as well.
6. Organizational learning advanced at the individual and institutional level with the involvement of stakeholders in an empowerment evaluation process.
7. Capacity was built for implementing evidence-based accountability strategies through a self-reflective empowerment evaluation process that engages all stakeholders in an inclusive, democratic process.

Acknowledgements—This work was partially supported by award EEC-0203133 through the National Science Foundation Combined Research and Curriculum Development program.

REFERENCES

1. D. Baggett, *Using a Project Portfolio: Empowerment Evaluation for Model Demonstration Projects*, Paper presented at the Illinois evaluation Technical Assistance Workshop, Champaign, IL (25 January 1994).
2. A. Bhandari, L. N. Reddi, L. E. Erickson, S. L. Hutchinson, and D. R. Steward, Research-integrated curriculum in geoenvironmental engineering, *Proceedings of the 2004 American Society for Engineering Education Annual Conference and Exposition* (2004).
3. B. Cambourne and J. Turbill, *Responsive Evaluation: Making Valid Judgments about Student Literacy,* Heinemann, Portsmouth NH, (1994).
4. D. M. Eddy, Practice policies: Where do they come from?, *Journal of the American Medical Association,* **263** (1990), pp. 1265–1275.
5. D. M. Fetterman, *Empowerment Evaluation: A Form of Self-Evaluation*, Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA (18–22 April 1994).
6. D. M. Fetterman, Presidential address: Empowerment evaluation, *Evaluation Practice*, **15**(1) (February 1994), pp. 1–15.
7. D. M. Fetterman, In response to Dr. Daniel Stufflebeam's, Empowerment evaluation, objectivist evaluation, and evaluation standards: Where the future of evaluation should not go and where it needs to go, *Evaluation Practice*, **16**(2) (June 1995), pp. 179–199, retrieved on January 21, 2005 (http://www.stanford.edu/~davidf/stufflebeamresponse.html).
8. D. M. Fetterman, S. Kaftarian and A. Wandersman, (Eds.) *Empowerment evaluation: Knowledge and Tools for Self-Assessment and Accountability,* Sage, Thousand Oaks, CA (1996).

9. D. M. Fetterman, W. Conners, K. Dunlap, G. Brower, T. Matos and S. Piak, *Report to the President: Stanford Teacher Education Program, 1997–98* (1999), retrieved on 21 January 2005. (http://www.stanford.edu/~davidf/PresidentReport.pdf).
10. D. M.Fetterman, Reflections on empowerment evaluation: Learning from experiences, *Canadian Journal of Program Evaluation*; (1999), pp. 5–37.
11. D. M. Fetterman, *Foundations of Empowerment Evaluation,* Sage, Thousand Oaks, CA (2001).
12. D. M. Fetterman and C. Bowman, Experiential education and empowerment evaluation: Mars Rover educational program case example, *Journal of Experiential Education*, **25**(2) (2002), pp. 286–295.
13. D. M. Fetterman, and A. Wandersman, (Eds.) *Empowerment Evaluation Principles in Practice,* Guilford Press, New York (2005).
14. M. W. Frank and W. Walker-Moffat, *evaluation of Urban After-School Programs: Effective Methodologies for Diverse and Political Environment*, Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA (April 10–14, 2001), retrieved on 21 January 2005 (www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED458230).
15. Harvard Family Research Project, Cambridge, MA, The evaluation exchange: Emerging strategies in evaluating child and family services, *The evaluation Exchange: Emerging Strategies in Evaluating Child and Family Services*, **5**(1, 2/3) (1999).
16. Patrick Jenlink, *Systemic Change: Touchstones for the Future School*, IRI/Skylight Training and Publishing, Inc. Collected works, opinion papers, (1995).
17. J. Lackey, D. P. Moberg and M. Balistrieri, By whose standards? Reflections on empowerment evaluation and grassroots groups, *evaluation Practice*, **18** (2) (1997), pp. 137–146.
18. L. E. Lee, Building capacity for school improvement through evaluation: Experiences of the Manitoba school improvement program, Inc., *Canadian Journal of Program evaluation*, (1999), pp. 155–178.
19. B. E. Lentz, P. S. Imm, J. B. Yost, N. P. Johnson, C. Barron, M. C. Lindberg and J. Treistman, Empowerment evaluation and organizational learning. In D. M. Fetterman and A. Wandersman (Eds.), *Empowerment Evaluation Principles in Practice*, Guilford Press, New York (2005).
20. L. R. Martino, Peer tutoring classes for young adolescents: A cost-effective strategy, *Middle School Journal*, **25**(4) (1994), pp. 55–58.
21. M. Miller-Whitehead, Efficacy, outcomes, and empowerment evaluation of a school district NET project, Tennessee Valley Educators for Excellence, Muscle Shoals, AL.(2001) (www.tvee.org).
22. M. Miller-Whitehead and G. Abbott, Efficacy, outcomes, and empowerment evaluation of a school district NET project, Part III: Theoretical model, Tennessee Valley Educators for Excellence, Muscle Shoals, AL., (2001) (www.tvee.org).
23. B. M. Olds, B. M., Moskal and R. L. Miller, Assessment in engineering education: Evolution, approaches and future collaborations, *Journal of Engineering Education, Special Issue,* **94**(1) (2005), pp. 13–25.
24. M. Patton, Toward distinguishing empowerment evaluation and placing it in a larger context, *Evaluation Practice*, **18**(2) (1997), pp. 147–163.
25. M. Q. Patton, Organizational development and evaluation, *Canadian Journal of Program Evaluation*, (1999), pp. 93–113.
26. N. L. Porteous, B. J. Sheldrick and P. J. Stewart, Enhancing managers' evaluation capacity: A case study from Ontario Public Health, *Canadian Journal of Program Evaluation*, (1999), pp. 137–154.
27. L. N. Reddi and H. I. Inyang, *Geoenvironmental Engineering: Principles and Applications,* Marcel Dekker, Inc., New York (2000).
28. C. J. Schnoes, V. Murphy-Berman and J. M. Chambers, Empowerment evaluation applied: Experiences, analysis, and recommendations from a case study, *American Journal of Evaluation*, **21**(1) (2000), pp. 53–64.
29. M. Scriven, Empowerment evaluation examined, *Evaluation Practice*, **18**(2) (1997), pp. 165–175.
30. Lynne M. Smith, '*When the Bell Say*' to '*In the Almost Dark*': *Learning from Children's Concepts of Time*, Paper presented at the annual meeting of the American Evaluation Association, Orlando, FL, (November 3-6, 1999), retrieved on January 21, 2005 (www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED435676).
31. M. K. Smith, Empowerment evaluation: Theoretical and methodological considerations, *evaluation and Program Planning*, **21**(3) (1998), pp. 255–261.
32. N. L. Smith, A framework for characterizing the practice of evaluation, with application to empowerment evaluation, *Canadian Journal of Program Evaluation*, (1999), pp. 39–68.
33. D. L. Stufflebeam, Empowerment evaluation, objectivist evaluation, and evaluation standards: Where the future of evaluation should not go and where it needs to go, *Evaluation Practice*, **15**(3) (1994), pp. 321–338.
34. H. Tang, D. W. Cowling, K. Koumjian, A. Roeseler, J. Lloyd and T. Rogers, Building local program evaluation capacity toward a comprehensive evaluation, *New Directions for Evaluation*, **95** (2002), pp. 39–56.
35. M. L. Wehmeyer, Assessment of self-determination—negotiating the minefield, *Focus on Autism and Other Developmental Disabilities*, **15**(3) (2000), pp. 157–158.
36. C. Worthington, Empowerment evaluation: Understanding the theory behind the framework, *Canadian Journal of Program Evaluation*, **14**(1) (1999), pp. 1–28.

E. Marie Steichen is a Research Assistant Professor and Senior Evaluator in the Institute for Civic Discourse and Democracy at Kansas State University. She has been a lead evaluation of educational programs with the university for eight years. Steichen has experience conducting empowerment evaluation for a range of community applications. Steichen conducts research into policy analysis, youth civic engagement, social problem

construction, community empowerment, and evaluative research on indigenously-informed evaluation frameworks. She is a member of the American Evaluation Association, the Society for the Study of Social Problems, the National Indian Education Association, and the Smart Growth Network.

Alok Bhandari is a licensed Professional Engineer and an Associate Professor at Kansas State University. He teaches undergraduate, graduate, and distance education courses in environmental engineering and conducts research on the environmental fate of organic pollutants in air, water, and soil, and is the author/coauthor of 45 scientific/scholarly papers and 60 presentations. Alok Bhandari is a member of the Association of Environmental Engineering and Science Professors and serves as Associate Editor of the *Journal of Environmental Engineering* and the *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management.*

Lakshmi N. Reddi is Professor and Head of Civil Engineering at Kansas State University. His teaching and research over the past 15 years are in the areas of seepage in porous media and geoenvironmental engineering. Author of two textbooks on seepage and geoenvironmental engineering, Dr. Reddi worked on several interdisciplinary research projects funded by federal and local agencies. His current research projects are related to waste reuse and containment.

Stacy Lewis Hutchinson is an assistant professor in Biological and Agricultural Engineering at Kansas State University. She conducts research in the area of ecological/environmental engineering focusing on the use of vegetated systems for mitigation of non-point source pollution and the remediation of contaminated soil and water. Prior to joining the faculty at Kansas State University, she worked for the United States Environmental Protection Agency, Ecosystem Research Division in Athens, Georgia, as part of a multidisciplinary team on modeling efforts for assessing risks from chemicals to human health and the environment. Her current education interests include multidisciplinary team problem solving and design.

David Steward is Associate Professor of Civil Engineering at Kansas State University. He teaches and conducts research in groundwater modeling and the analysis and design of groundwater flow systems. He teaches the course Design of Groundwater Flow Systems that is part of the Geoenvironmental Certificate Program.

Larry E. Erickson is Professor of Chemical Engineering and Director of the Center for Hazardous Substance Research at Kansas State University. He directed the Great Plains/Rocky Mountain Hazardous Substance Research Center, and has conducted research in environmental engineering for more than 30 years. He has worked with several interdisciplinary research teams on biochemical and environmental engineering projects. His current educational interests are in design education and problem solving by interdisciplinary teams. He is a member of the American Society for Engineering Education.