Critical Features and Value in Assessing a Research Experience for Undergraduates: The Case of Engineering Cities

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Abstract

An important but commonly overlooked task for those who direct undergraduate research programs is to determine whether, in addition to producing quality research, the program is achieving its larger goals. Formal program assessment is an ideal means for determining whether an initiative is meeting its objectives and, additionally, for generating data needed to modify and improve a program. There are several steps that are typically involved in program assessment, including: (i) articulating clear learning/performance goals, objectives, and desired results, (ii) identification of metrics of success, and (iii) formulation of an assessment response plan. The critical features of a program assessment are presented herein and illustrated with a case study of the program assessment of the National Science Foundation-sponsored Research Experience for Undergraduates (REU) Site: *Engineering Cites*. It was determined that the *Engineering Cities* program is largely meeting its goals; however, certain areas requiring improvement were indentified. Assessment will continue to be used to document the impact of the modifications on the program outcomes.

Undergraduate research experiences, such as those provided by the U. S. National Science Foundation (NSF) Research Experience for Undergraduates (REU) program, among other similar initiatives, can be highly effective in motivating students to pursue advanced degrees (e.g. Van der Spiegel et al. 1997; May, 1997, Seymour et al. 2004, Lopatto 2004). The NSF REU program aims to increase undergraduate student participation in scholarly research in science, technology, engineering and mathematics (STEM). First established in the 1980s, the REU program remains one of NSF's best means for attracting a diverse group of qualified students to graduate study and careers in STEM-related fields. While the NSF REU program is perhaps the most prominent undergraduate training initiative in the U.S., similar programs are supported by a range of other organizations (e.g. AAMC 2009, APA 2009). The NSF, in particular, promotes undergraduate research experiences through small grants to support individual students on existing NSF-funded projects. In addition, they fund larger, multi-year, themed REU "sites" based primarily at universities. REU sites typically host small groups (~8–15) of visiting undergraduate students for 10 weeks during the summer months. During their visit, undergraduate students engage in an intensive research experience in close collaboration with faculty, graduate students, and/or staff mentors.

An important but commonly overlooked task for those who direct undergraduate research sites is to determine whether, in addition to producing quality research, the program is achieving its larger goals. Formal program assessment is an ideal means for determining whether an initiative is achieving pre-defined goals and objectives and, additionally, for generating data needed to modify and improve the program. Unfortunately, researchers in the STEM fields frequently have little if any background, familiarity, training, or experience with program assessment and evaluation. Therefore, this critical task is often conducted improperly or neglected altogether. This paper seeks to rectify this issue by presenting the critical features of program *assessment*, and then discussing a case study involving the design, application, and interpretation of a comprehensive *evaluation* plan for the REU program *Engineering Cities*, hosted by Drexel University. Although this paper features *Engineering Cities* as a case study, the critical features presented here are applicable to similar undergraduate research programs.

Program Evaluation

Purpose

One important component of a successful program is evaluation. Although the term *evaluation* is often used interchangeably with assessment, it is actually a higher-level process than assessment. Assessment refers to the collection of data to describe or better understand a program, whereas evaluation implies a judgment that may be made based on assessment information. Assessment is most usefully connected to some goal or objective for which the assessment is designed. The assessment tool seeks to measure whether or not the objective or goal has been obtained. Evaluation uses the results of the assessment to analyze the strengths and weaknesses of the program for the purpose of improving its effectiveness (Worthen, Sanders, & Fitzpatrick, 1997). For the purposes of this paper, evaluation is defined as the application of evaluation approaches, techniques, and knowledge to systematically assess and improve the planning, implementation, and effectiveness of a program (Chen 2005).

Periodic program review facilitates the improvement of an academic program and, thereby, the overall strength and reputation of the associated university. Evaluation assists with attaining future goals, developing relevant curricula, and meeting the needs of students, faculty, and other stakeholders. Without effective evaluation, program staff may fail to document important impacts the program has on its participants. It may also fail to recognize how different programmatic components are affecting participants or collaborating organizations. In addition, evaluation helps focus staff efforts and project resources on the specific goals of the program. Without well-articulated goals and specific objectives, staff may direct their efforts toward slightly different goals, thereby reducing the efficiency and efficacy of the overall program.

The goal of the *Engineering Cities* program evaluation is to provide formative feedback that helps guide the program as it is being implemented. It also provides summative data that clearly demonstrates whether the program is moving toward accomplishing its stated goals and objectives. If problems with program delivery become evident, those aspects can be remediated. Finally, evaluation provides program staff with useful data (such as which program components work, need improvement, or need to be removed in subsequent years) to drive decision-making. Typical program evaluations use program goals and interactions with stakeholders to create the evaluation plan.

Steps in Assessment

The first step in assessment is to generate the goals and objectives. These should be formulated as statements or questions that express what is most important for the program to achieve. The next step is to clearly articulate desired results and to design methods by which to achieve them. To help facilitate the articulation of goals and objectives, the program director, ideally in collaboration with the evaluator, must define the *enduring understandings*, or those ideas that give meaning and importance to facts. They are made up of the concepts, principles, and theories that weave many facts into revealing and useful patterns. They involve the few organizing priority ideas that enable one to make sense of past lessons, conduct current inquiry, and create new knowledge. An understanding is a generalization derived from inquiry. It is the specific insight that should be inferred from study of the topic—that is, what we want the participant leaving the program to realize, not just know or do. Enduring understandings identify what students should revisit over the course of their lifetimes in relationship to the content area. An example of an enduring understanding of *Engineering Cities*' participants is that students will understand and appreciate the complexity involved in developing and renewing urban infrastructure within the often competing contexts of sustainable growth, environmental quality, and protecting the public from natural and anthropogenic hazards.

After the goals and objectives are articulated and the enduring understandings are identified, the program director must determine the *essential questions* that will focus goals, stimulate conversation, and guide actions. Essential questions yield inquiry and argument that can serve as an entry to formulating a deeper understanding of a topic. They should uncover the subject's controversies, puzzles, and perspectives. These types of questions work best when they engage the student in sustained, focused inquiries that challenge unexamined assumptions or simplifications from earlier learning, and the arguments that heretofore have unthinkingly been taken for granted. The culmination of this process is demonstrated *via performance activities* that require the student to take the information given and create something new by reshaping, expanding, or applying what is already known. The best of such performance activities helps participants both develop and demonstrate their understanding. An example of an essential question for the *Engineering Cities* program is whether we can meet the needs of the present generation without compromising the ability of future generations to meet their own needs given current social, economic, and ethical contexts. The performance activity designed to synthesize student research results is the creation of a poster presented to peers and REU program faculty mentors at the end of the program.

Articulating the enduring understandings, essential questions, and performance activities will assist the program director in identifying the knowledge and skills participants need to develop in order to achieve program goals. The final step of preparing an assessment is to determine how to measure success. This includes defining the baseline data that will be collected as well as key indicators of short-term and long-term progress. This step results in an action plan that should address the following questions:

- What actions will help realize goals efficiently?
- What short- and long-term actions need to be taken?
- Who should be involved, informed, and responsible?
- What predictable concerns will be raised and how will they be addressed?

Using this deliberate process to construct both the assessment and the action plan results in a framework for evaluating the program's impact and programmatic efficacy with respect to student education.

Reporting

The purpose of reporting is to evaluate the work of the REU site as a whole and to provide program staff with a tool for reflection. The report should include a list of the outputs (e.g. papers or posters) that the program produced, as well as consideration of the process undertaken by the program, lessons learned, and any potential "hidden" outcomes of use to the community. For an assessment to be used as a formative tool, it must be done consistently, in a timely manner, and must provide frequent feedback to the program director(s). It is important to circulate a draft version of the report to the program director and staff to encourage triangulation of findings (defined as a method for corroborating findings to ensure that an account is rich, robust, comprehensive, well-developed, and valid), interpretation of results, comment, feedback, and buy-in of results.

To effectively communicate findings, the assessment report should have most or all of the following sections (Morris et al. 1987, Spaulding 2008, and Worthen et al. 1997):

I. Background & Project Purpose: This section contains an introduction with a brief history of the project, stated need for the project, program description, program goals and objectives, staff and resources involved, funding sources, and planned project deliverables.

II. Design of the Evaluation: This section comprises the aims and objectives of the evaluation, performance measures/standards/criteria used, key questions explored, staff involved, and design parameters such as data collection, analysis, and data sources and.

III. Findings: This results section contains a summary analysis of data collected, such as participant characteristics, survey results, participant selection criteria, and attitudes and opinions of participants. Graphs, tables, diagrams, etc. are used to aid in understanding and interpretation.

IV. Discussion: The discussion reports interpretations of the findings as they relate to project and evaluation goals. Any limitations or weaknesses in the findings, methods, data, or validity are identified and explicated. Also reported are any unintended consequences, criticisms of the evaluation criteria, and judgments of findings.

V. Conclusions, Recommendations, & Options: The purpose of this section is to encapsulate the outcomes of the evaluation (the good news and the "other" news) and clearly identify appropriate actions that arise from the findings. Overall judgments of the project's value and recommendations for improvement in process and outcomes should be reported. Further, any adjustments required in the evaluation design (i.e., lessons learned), also are to be identified.

Case Study: Program Assessment of *Engineering Cities*

Overview

The *Engineering Cities* REU site was established at Drexel University to address the need for qualified engineers who can address the unique challenges of urban growth. The majority of the world's population is living in urban centers for the first time in history. While the growth of cities offers many benefits for society, the rates of growth currently taking place pose an array of unique challenges to those who engineer the urban environment. Key among these challenges are developing and renewing the urban infrastructure (ASCE 2005), promoting sustainable growth and ensuring environmental quality (e.g. Rhman 1996), and protecting populations from natural and anthropogenic hazards (e.g. Mitchell 1999).

Recognizing these challenges, the primary goals of the *Engineering Cities* site are to:

1) Motivate students to pursue advanced degrees in engineering;
2) Improve students' research skills and encourage creative thinking in a laboratory or analytical setting;
3) Develop well-trained, highly qualified candidates for the nation's graduate programs;
4) Encourage students to pursue careers serving the urban community after completion of their graduate studies; and
5) Encourage the extended participation of students enrolled in co-op education programs.

A total of twelve students are selected annually for the program. Of the twelve students, two are six-month co-op participants and ten are ten-week summer participants. This paper reports on the assessment results for the ten-week students only. Recruitment efforts are directed at individuals from underrepresented groups and individuals who do not have access to advanced research facilities at their home institutions. The REU experience consists primarily of an intensive research experience in which each student works closely with a predetermined faculty mentor and her/his research group on a specific research problem. Students who participate in the program work as integral members of the faculty mentors' research team. Additionally, each student is paired with a graduate student who guides the day-to-day activities of the REU participant. Each REU student has weekly research meetings with his/her respective faculty mentor.

Since a primary objective of the program is to improve students' research and creative abilities, the REU experience is designed to encourage the development of key skills that will serve participants throughout their careers, including (i) identification of a research problem, literature review methodology, and critical review of the literature, (ii) design and implementation of a research plan and timeline, (iii) conducting research, including learning new methods, analysis procedures and/or skills, and (vi) dissemination of the results in both written and oral forms. The development of these skills has the indirect effect of increasing student confidence, improving critical thinking and problem-solving abilities, and enhancing both verbal and written communication skills. In addition to providing a meaningful research experience, the site includes a variety of enrichment and professional development activities that allows students to better appreciate the inherent complexities of urban engineering and to explore the broader social and political implications of their work. Enrichment activities include an ethics workshop, a seminar series on urbanism, a reading group, and field trips focused on urban policy and managing the urban infrastructure.

Assessment Strategy & Design

Prior to program implementation, a framework was developed to provide a language for discussing and evaluating program activities. The framework was based on the logic model and included three key ideas based on the tenets of backward design (McTighe and Wiggins 2004): desired results, assessment evidence, and an action plan. Figure 1 shows the logic model developed for the evaluation of the *Engineering Cities* REU Site. Specifically, the framework identified:

- Inputs – those resources dedicated to or consumed by the program;
- Activities – what the program does with the inputs to fulfill its mission;
- Constraints – limitations or restrictions inhibiting program processes;
- Outputs – the direct products of program activities; and,
- Outcomes – the benefits for participants during and after participation in program activities.

From this framework, a data collection matrix was created that consisted of a) specific questions to guide the evaluation process, b) information source, c) assessment instrument, d) method of analysis, and d) a time-frame for when information is to be collected and analyzed.

Assessment data was generated through specialized data collection efforts. The evaluator interviewed the program directors, reviewed project documents and administered a survey to both faculty and student participants. The survey comprised both quantitative and open-

Inputs →	Activities	Constraints	Outputs →	Outcomes
Resources dedicated to or consumed by the program	What the program does with the inputs to fulfill its mission	Limitations or restrictions inhibiting program processes	The direct products of program activities	Benefits for participants during and after program activities
Examples	*Examples*	*Examples*	*Examples*	*Examples*
• Funding • Drexel staff & staff time • Drexel faculty & graduate student mentors time • 10 REU participants selected annually • Faculty mentors from participants' home institutions	• Recruit/select REU participants; • Development of key learning and working skills • Networking • Field trips • Ethics education • Poster session	• Funders' requirements • Time	• REU students "learn by doing" • REU students' application of technical/scientific expertise • Conduct cutting edge research at a major research institution • Amount of lab assignments produced • Number of participants served • Number of conference presentations submitted and approved • Number of article publications submitted and approved • Broad project dissemination via: (1) presentations & publications; (2) presentations by participants at home institutions; and (3) dedicated REU website	***REU students:*** • Research and technical writing skills • Enhanced communication and collaborative skills • Increase in graduate education and/or research careers in engineering fields • Broaden pool of future engineers and scientists • Maintain US global leadership position in STEM fields • Increase in confidence and self-esteem

Figure 1: Logic Model For Engineering Cities REU

ended questions designed to look at the overall program experience. The interviews were used to discern the goals and objectives of the program and to articulate both the enduring understandings the students were intended to develop and the essential questions that would be presented to the students. Survey results revealed attitudes and understandings among participants. Specific qualitative data were collected via open-ended student participant survey questions and informal interviews.

In determining how to measure the program's educational efficacy, the following questions were considered:

- What exactly does the program want its participants to understand and/or be able to do?
- How are such understandings identified and developed?
- How is progress gauged and how are the program directors provided with relevant feedback?

The evaluation design should flow from the research questions and the conceptual framework surrounding those questions (Marshall and Rossman 1999). The design must clearly delineate the data collection and analysis approaches proposed to answer the evaluation questions listed above. The design must also include specific details regarding proposed instrumentation and data sources, and their relation to tasks and timelines, as well as information about how each methodology and data source will address the evaluation questions, and the analytical procedures that will be used. When multiple sources of data are used, the potential for bias is reduced and there is a greater opportunity for a balanced picture of the program. The evaluation team can further reduce bias by balancing stakeholder information with program documentation and input from primary sources wherever possible. This strategy has been documented as a means to enhance validity (Silverman et al. 1990). In this evaluation, both qualitative and quantitative data were collected from a variety of sources.

The data were analyzed to reveal both the summative and formative components. Student participants were administered both an entrance and an exit survey and faculty mentors were administered an exit survey. The purpose of the surveys was to provide formative data regarding opinions concerning different program elements and participant experiences in the program to determine program efficacy and make improvements if necessary. The purpose of the student entrance survey was to provide formative data to the program regarding students' opinions about different program elements. The purpose of the exit survey was to gather information about faculty and student experiences in the program for the purposes of future improvement and determination of program efficacy.

The surveys were paper-based and used a Likert scale of 1-5 with 5 being the highest. Survey questions and results are presented in Appendices 1 through 3. The survey method was chosen for several reasons. Most importantly, the standardized questions make measurement more precise by enforcing uniform definitions upon the participants. Standardization ensures that similar data can be collected from groups and then interpreted comparatively (between-group study). In addition, there is usually a high reliability that is easy to obtain by presenting all subjects with a standardized stimulus; thus, observer subjectivity is greatly eliminated (Corrigan, Dorey, & Swanhart, 2008). Surveys can also provide specific information about the values, opinions, and behaviors of respondents. An additional value of the survey method as a qualitative research tool consists of the validity of the information received; obtained data is taken as correct and believable vis-a-vis opinions and experiences reported (Chen 2005; Creswell 2003; Marshell & Rossman 1999; Silverman et al. 1990; Worthen et al. 1997). The major disadvantage of the survey method is that small groups of individuals cannot be taken as representative. However, given the context of the program, a random control trial or even a quasi-experimental design was not possible.

The statistics software SPSS, version 17.0, was utilized to provide descriptive, inferential statistics. Analysis of qualitative data is a complex process of bringing order, structure, and interpretation to the mass of collected data (Marshall & Rossman 1999). Information derived was analyzed thematically (Aronson 1994; Creswell 2003; Taylor & Bogdan 1984).

Data Collection & Results

Student Surveys

The objective of the entrance survey (see Appendix 1) was to gather students' opinions at the beginning of the program and to better understand their priorities upon entering the program in order to provide data for formative decision-making. Additional survey tools were used at the conclusion of the ten-week program to collect data about students' attitudes and opinions regarding aspects or products of their experience with the REU program (see Appendix 2). These surveys posed questions about student opinions about program characteristics, their interactions with the REU staff and faculty and other REU students, what they learned from the REU program, and their intended actions as a product of their experience in the REU program.

Faculty Surveys

Faculty participants were surveyed only at the end of the program. These surveys, included as Appendix 3, were designed to collect faculty opinions about their interactions with students, research performed during the program, satisfaction, and general attitudes and opinions about themselves in relation to the program. More specifically, the surveys were subdivided into sections pertaining to (i) faculty's interactions with students after completion of the REU program, (ii) selection criteria used by REU faculty to select students into the program, (iii) faculty's perceptions of students' program activities, (iv) faculty's perceptions of students' research activities, attitudes, opinions, and recommendations relevant to the REU program, and (v) reports of publications and presentations made as a product of the REU program mentorships.

Informal Interviews

The program directors and staff held informal conversations with the student participants and faculty mentors throughout the program. These conversations were not recorded, but the results were used as a means of triangulating the survey results.

Results of Student Surveys and Interviews

Student survey results are tabulated in Appendices 1 and 2. Students entering the REU program in 2008 were most interested in understanding the overall research project and how their work would contribute to it, becoming familiar with relevant scientific literature, understanding the practical applications, having opportunities to co-author and publish a scientific paper, learning more about professional organizations/networking/career opportunities, and developing methodological, technical, and instrumentation skills. They were somewhat less interested in being able to get "results," developing skills in research writing, and learning more about the publishing process in engineering.

Exit surveys for this group indicated that students generally found REU faculty, staff, and graduate students to be helpful. A majority of students reported feeling like part of the intellectual effort rather than an assistant. Eighty-nine percent reported feeling comfortable approaching faculty with questions about their research. Overall, students rated their research experiences positively. They expressed the most benefits related to the direction and practical applications of their research, the development of their skills on how to present scientific presentations, increasing comfort and familiarity with the scientific literature, and the relationship of research to scientific knowledge. Unfortunately, half of the students did not have the opportunity to co-author or publish a paper and they felt that this inhibited their learning about the publishing process in engineering. While the mean of 1.8 on a 5-point scale indicates that the research projects did not stimulate participant curiosity and enthusiasm about research in engineering, it should be noted that 67% agreed or strongly agreed that, in fact, the projects did.

Informal conversations with students and program staff, as a means toward triangulation, confirm survey data that reported the vast majority of students (67%) believing that the REU experience would help in their decision about future career plans. Eight of nine students expressed enthusiasm about pursuing an engineering graduate degree. Nearly all students would advise a friend to apply for the program.

Results of Faculty Surveys

A majority of faculty participating in the program in 2008 reported some type of contact with students after the REU program. Fifty-seven percent interacted with students via email. Forty-two percent of faculty continued their relationships with students by working or planning with the REU student on research. Only one faculty member talked to or communicated with REU students post-program about career and/or graduate school options.

Faculty most predominantly used students' grade point average, appropriate technical background, and research interests to guide participant selection. Less frequently used selection criteria were whether the student was from a college without a graduate or strong research program, or the student's level of research experience. Faculty also relied on ability to work independently, letters of intent, and good communication skills as additional sources of information guiding student selection.

Of the activities included, students were most often involved in the collection and analysis of data and preparing and delivering final written reports or oral presentations. Students were somewhat less likely to be involved in the project design or go on a research field trip. Faculty were of the opinion that students understood how their work contributed to the big picture and that they gained increasing independence over the course of the summer.

All faculty felt that REU student work benefited their research efforts to varies degrees and that research is a good experience for undergraduates regardless of their career decisions, with 85% of them strongly agreeing. Faculty most often felt that open and regular communication between mentor and student, providing sound technical advice, and making the student feel like an integral part of the research team were important or most important in producing a high quality research experience. Faculty considered student involvement in project design and a close relationship between research and coursework as either least important or somewhat important.

All REU faculty believed that involving undergraduates in their research enables them to expand the avenues of investigation they can pursue, and reported receiving a lot of personal satisfaction from working with undergraduates doing research. Fifty-seven percent reported that their work lends itself to undergraduate participation. Interestingly, despite these findings, only one faculty member cited their own positive experiences doing undergraduate research as a motivating factor in their mentorship. Faculty, overall, were somewhat or very satisfied with the experience as a whole.

Overall, ten peer-reviewed articles that included REU students as co-authors were prepared or planned during the course of the program. Eleven more articles were built on students' work but did not have their names. Student work has been or will be a part of eight conference presentations, posters sessions, and/or future proposals.

Interpretation & Discussion of Data

As part of triangulating the data, REU program efficacy can be framed by summarizing student perceptions of the REU program in three areas: faculty, research experiences, and future orientation/ program results. Overall, students had positive perceptions of their faculty experiences; however, three students expressed difficulties with the disposition and frequency of contact with their faculty members. This finding runs contrary to faculty expression of the importance of regular communication between mentor and student. This translated into these students not feeling a part of the team, not feeling comfortable asking questions, and not developing a mentor relationship with these particular faculty. These experiences also run contrary to the accomplishment of several of the program objectives. To address this, in future years, feedback interviews are recommended to be held two or three weeks into the REU in order to determine how things are going for each of the students. This will allow appropriate adjustments to be made if any issues are raised.

While most students reported positive research experiences, as stated previously, many did not have the opportunity to co-author, publish, or learn more about publishing a scientific paper. This is an interesting finding as this desire was rated somewhat highly among the needs and references of the students at the start of the program. One-third of the student respondents felt that the program did not stimulate curiosity and enthusiasm about research in engineering. This finding is not conducive to the accomplishment of one of the program's primary objectives—motivating students to pursue advanced degrees in engineering.

A small majority of students rated the REU program positively on project results and their future orientation upon exit, while 88%of the students expressed enthusiasm regarding the pursuit of an advanced degree in engineering. Several student respondents (45%) were not fully convinced that they would be interested in continuing work on their REU project. These are important findings as one of the REU program's biggest objectives is motivating students to pursue advanced degrees in engineering. Forty percent of the students were ambivalent or negative regarding the extent to which they were able to get "results" during their summer project. In future years, faculty need to be better equipped to define exactly what "results" means with each student at the beginning of the summer, and then work towards those objectives for each student during the program. When implemented, this change will be reflected in the tools used to assess participant learning/performance outcomes, quality of activities, contextual factors such as identification of barriers that constrain activities, and the area of facilitator/mentor skills and practices.

While the evaluation was not modeled on the "ideal", it was able to inform program staff of ways to improve the program, as well as ways to improve the assessment since the latter was not fully capturing what staff felt was needed. For example, several changes were implemented in response to the data: (i) faculty will be better educated on the characteristics of a mentoring relationship prior to the beginning of the program, (ii) a portion of the program curriculum will be modified to allow students to participate in the publishing process, and (iii) effort will be made to better pair students with projects involving topics that they are enthusiastic about.

Conclusion

Program assessment and evaluation are important components in determining whether an undergraduate research initiative is achieving its broader goals and, additionally, for generating data needed to modify and improve the program. This paper discussed the critical features of program evaluation by first presenting the necessary components in an ideal, comprehensive evaluation along with a case study involving the design, application, and interpretation of an assessment plan for the REU program *Engineering Cities*. Understanding and undergoing the evaluation process provides critical data about the REU program, and perhaps most importantly, provides information that will be used to modify and improve the program in future years.

NSF grantees are naturally concerned that their programs produce meaningful results, but they often fail to take evaluation seriously. As illustrated in the case study, evaluation provides valuable information on the effectiveness of an initiative. At the same time, the process itself can build the capacity of program directors, leaving them with specific skills, or at least an understanding or appreciation of evaluation, to help monitor their work long after the evaluation is complete. As evidenced in the case study example, the evaluative experience taught not only program staff what not to do, but the evaluator, too.

When evaluation is an ongoing process rather than a one-time, required event, interest is kept alive and self-reflection is fostered. Both are critical for continued development and improvement. When program directors are aligned with evaluators as co-learners, mistakes can be avoided and at the same time, previously planned strategic steps can be reassessed. Stakeholders move from talking about issues/concerns to taking action. Thus, the value of evaluation, again as illustrated in the case study presented, rests in the notion that program or project directors are often so involved in the day-to-day challenges of their work that they seldom step back and critically examine their objectives and methods. The result is that quality can decline. Evaluation, therefore, is an effective means for monitoring and promoting good practice, if, and only if, the findings are put into practice.

Overall, it was determined that the *Engineering Cities* program is largely meeting its goals; however, certain areas requiring improvement were indentified. Assessment will continue to be used to document the impact of the modifications on the program outcomes.

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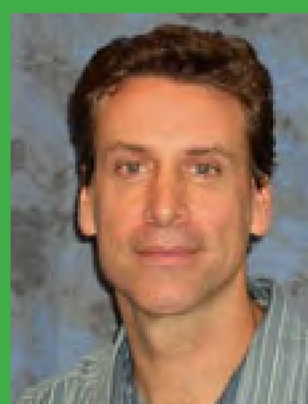

APPENDIX 1: STUDENT INTERESTS UPON ENTRANCE INTO REU PROGRAM

Item	Low 1	2	3	4	High 5	Mean
The opportunity for close interaction with faculty.	-	1	1	5	2	2.25
Developing a sense of how research contributes to scientific knowledge.	-	-	1	4	4	3
Understanding the overall research project and how my work will contribute to its success.	-	-	-	4	5	4.5
The opportunity to become familiar with the relevant scientific literature for my research project.	-	-	-	6	3	4.5
Being able to get "results" during the summer project.	-	1	4	2	2	2.25
Feeling as though I am part of an intellectual effort and not just a technical assistant.	-	-	2	4	3	3
Developing a mentor relationship with faculty/graduate students on whom I can call for guidance in the future.	-	1	1	5	2	2.25
Understanding the practical applications of my research.	-	-	-	3	6	4.5
The opportunity to learn more about other faculty and student projects in addition to my own.	-	-	4	3	2	3
Developing my methodological, technical, and instrumentation skills.	-	1		3	5	3
Learning how to design an experiment.	-	1	2	2	4	2.25
The opportunity for intellectual discussions about research ethics and practice.	-	-	2	4	3	3
Developing skills in how to do a scientific presentation.	-		1	5	2	2.67
Developing skills in how to write up research results.	-	1	2	5	1	2.25
The opportunity to co-author and publish a scientific paper.	-	-	2	2	5	3
Learning more about the publishing process in engineering.	-	2	2	1	4	2.25
Learning more about professional organizations, networking, and career opportunities.	-	-	-	4	5	4.5
Quality of research facilities at Drexel University.	-	-	4	2	2	2.67
Developing relationships and enjoying camaraderie with other REU participants.	-	-	1	2	6	3
Making contacts and connections that I expect will pay off in the future.	-	-	2	4	3	3

APPENDIX 2: STUDENT PERCEPTIONS UPON EXIT FROM REU PROGRAM

Item	Low 1	2	3	4	High 5	Mean
I developed a mentor relationship with faculty on whom I can call for guidance in the future	1	1	-	3	4	2.25
I made many contacts and connections that I expect will pay off in the future	1	1	1	4	2	1.8
I was pleased with the quality of my interaction with my faculty mentor.	-	-	4	2	3	3
I was treated like one of the team and my research seemed valued	-	-	2	2	5	3
Faculty offered encouragement and feedback on my work	-	-	1	1	7	3
I received the appropriate amount of guidance from faculty and mentors	-	2	1	-	6	3
I felt comfortable approaching faculty with questions about my research	-	1	-	-	8	4.5
I had the opportunity for close interaction with faculty	-	-	1	5	3	3
I felt as though I was a part of the intellectual effort and not just an assistant	-	-	3	2	4	3
I met regularly with my research mentor and/or other faculty for progress and problem solving discussions	-	-	2	4	3	3
I had the opportunity to learn more about other faculty and student projects in addition to my own	-	1	4	1	3	2.25
I was very interested in my research project.	-	-	3	1	5	3
I am clear on where the research that I have contributed to is headed and what it is trying to be accomplished.	-	-	1	2	6	3
I gained valuable experience in methodology, technique, and instrumentation.	-	2	2	5	3	3
I have a sense of accomplishment with my activities for the research project.	-	1	1	2	5	2.25
I developed a sense of how our research contributes to scientific knowledge.	-	1	1	2	5	2.25
I understand the overall research project and how my work will contribute to its success.	-	-	-	3	6	4.5
I became familiar with the relevant scientific literature for my research project.	-	-	2	3	4	3
I understand the practical applications of my research.			1	1	7	3
I learned how to design an experiment.	-	1	2	4	2	2.25
I had the opportunity for intellectual discussions about the ethics of research and practice.	-	2	1	2	4	2.25
I developed skills on how to present a scientific presentation/poster.				2	7	4.5
I had the opportunity to co-author and publish a scientific paper.	4	-	1	2	1	2
I learned more about the publishing process in engineering.	3	1		2	2	2
I did real research work rather than following a text book or lab manual.	-	-	2	1	6	3
My particular role in the overall research of the lab was interesting, meaningful and worthwhile.	-	2	1	4	2	2.25
I am enthusiastic about continuing a graduate degree in engineering	-	1	-	5	3	3
I would be interested in continuing to work on my project	-	2	2	-	5	3
I was able to get "results" during the summer project.	1	1	1	3	3	1.8
The experience I had will help in my decision about future career plans	-	1	2	-	6	3
Based on my REU experience, I would encourage friends to apply to this REU next year.	1	-	1	1	6	2.25

APPENDIX 3: FACULTY MENTOR EXIT SURVEY RESULTS

Item	Not at all	A small amount	A moderate amount	A lot	Mean
How much did the REU student work benefit YOUR research efforts?	-	2	3	2	2.3
Item	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Mean**
Research experiences are more valuable for students who will pursue research or teaching careers than for those who will not.	-	2	5	-	3.5
Research is a good experience for undergraduates, regardless of their decisions about career or advanced degrees.	-	-	1	6	3.5
Rate each of the following factors on their importance in producing a high-quality research experience.	**Not Important**	**Somewhat Important**	**Important**	**Extremely Important**	**Mean**
Open and regular communication between mentor and student	-	1	-	6	3.5
Providing sound technical advice	-	2	4	1	2.3
Making the students feel that s/he is an integral part of the project team	-	-	3	4	3.5
Carefully planned experiments that yield expected results	-	4	1	2	2.3
Student independence	1	4	5	-	3
Close relationship between research and coursework	4	2	1	-	2.3
Student involvement in project design	1	4	2	-	2.3

Check all of the statements with which you agree:	Responses
Involving undergraduates in my research enables me to expand the avenues of investigation that I can pursue.	6
I get a lot of personal satisfaction working with undergraduates doing research.	6
My work lends itself well to undergraduate participation.	4
My own positive experiences doing undergraduate research help motivate me to be a mentor.	3
Mentoring undergraduates is viewed favorably in my department's tenure/promotion review process.	1

	Very dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Very satisfied	Mean
How satisfied were you with the experience as a whole?	-	-	2	5	3.5

Item	Developed	Planned
How many research publications in peer reviewed journals did you prepare or are planning on preparing that included REU students as co-authors?	3	7
How many research publications in peer reviewed journals did you prepare or are planning on preparing that built on REU student work to some extent, but the students were NOT go-authors	3	8
How many conference presentations or posters did you develop or are planning on developing that include(-d) REU students as co-authors?	3	9
How many conference presentations or posters did you develop or are planning on developing that build on REU student work to some extent, but the students were NOT co-authors?	1	7
How many proposals did you write or are planning on writing that build on REU student work (perhaps including their work as preliminary data, etc):	1	7