Part II: External Evaluator's Report

A) NSF Gk-12 Programmatic and Project Goals

1) Goals and Measures

Fellows' Goals	**Measures**
Enhanced understanding of one's own research subject area	Presentation skills protocol & number of presentations made
Its societal & global contexts	Presentation skills protocol & number of presentations made
Improved communication skills	Presentation skills protocol & number of presentations made
Improved leadership skills	Presentation skills protocol & number of presentations made
Experience working on teams	Summer program survey, exit survey
Enhanced teaching capabilities	Direct observation of teaching inquiry-based lessons

Teachers' Goals	**Measures**
Professional development in STEM content	Summer program content tests
Professional development in hands-on science activities	Student Watershed Watch training and implementation observations
**Establish long-lasting professional relationships with the Environmental Science Learning Community	Teachers' record of collaborative activities.

Students' Goals	**Measures**
Energize students to pursue STEM careers	Attitude towards science survey
**Increase participation in hands-on environmental research	Items will be added to Student Survey to explore amount of hands-on research students have experienced over the previous year.
**Increase participation in SWW and science fairs	SWW & science fair participation numbers
**Increase interest in science and science-related careers	Student Science Interest Survey

University/Community Goals	**Measures**
Create strong and enduring partnerships with K-12 schools.	Participation of local schools in LEC sponsored poster session
Transform graduate programs	Feedback from graduate advisors & fellows
Enhance the impact of graduate education on society	Combination of all outcomes

Indicates project only goal

2) Explanation of Measures and Instruments

Evaluation of the project continued the in-depth case study design used in previous years:

Fellow data was gathered using four instruments—a performance assessment was used for direct observations of the fellows as they presented their research to a variety of audiences (mostly high school students) throughout the year, an exit interview for fellows graduating from the program, fellow content knowledge gain was measured during the summer program using a pretest/posttest of relevant content, and a teamwork survey was completed that assessed the fellows' perceptions of the GK-12 team.

Teacher gains were also measured using the content test developed by the faculty teaching in the summer institute and the teamwork survey. Teachers also completed the Science Teacher Ideological Preference Scale in April to examine preferences for inquiry vs. non-inquiry teaching practices and changes over time and teachers also completed a project exit survey.

Project effects on students were again examined using our Student Attitudes Towards Science instrument following a pretest/posttest design. Detailed information about this survey was provided in the 2012 Annual Report. Because data on the posttest is collected after the deadline for the report, findings from 2012 are provided in this report. 2013 findings will be reported in the final report.

B) Summary of Findings during 2012-2013

1) Fellows: During the past year, fellows made 54 research presentations (including 12 synergistic activities) and published 12 scholarly articles. Once again, fellows presented their research to local high school science classes and were observed by the evaluator to assess fellow presentation skills when working with the general public. Categories on the observation rubric include "proficient", "developing", and "needs attention". Overall scores placed all fellows in the *proficient* category with one fellow having a bit of difficulty with organization (some members of audience had trouble following the presentation and there was no conclusion), one fellow with delivery (a lot of "ums" and "ahs"), and one fellow with audio-visual aids (some of the slides contained quite a bit of text).

The summer program was presented in two parts—the Water Quality course for new fellows and teachers during week 1 and the Environmental Sensor Network course during the second week. Five of the eight fellows attended the Water Quality course. They all felt that they had a clear understanding of what to expect in the course, felt the course had a balance between lecture and field/lab activities, and found the course to be challenging but not beyond their ability to master the content. The fellows practiced Student Watershed Watch data collection at a local creek. All felt confident that after the practice they could effectively assist their teacher's students in the data collection in the fall. Most of the fellows agreed that they learned new content about the physical factors lab, microbiology, fish biology, stream ecology, and algae and zooplankton during the summer. One fellow felt that little new content was learned.

Content mastery was measured through a pretest/posttest of the Environmental Sensor Network course. Fellows realized a statistically significant gain in content knowledge (pretest = 6.8 on 10 point test; posttest = 9.2; $t < 0.001$). We also examined effect sizes (large—1.60) and the Cohen

U3 which indicates where a fellow who scored in the 50th percentile on the pretest would fall on the posttest. Based upon fellow scores, the posttest percentile for someone scoring in the 50th percentile on the pretest is projected to be the 94th percentile.

All eight fellows attended the second week. Reactions to the Environmental Sensor Network course were mixed—six felt they had a clear understanding of course expectations and two were undecided; five felt there was a balance between lecture and field experience and two strongly disagreed with this; but they all felt the subject matter to be challenging yet not beyond their comprehension. As a group, the fellows indicated they learned new content in the areas of eddy covariance towers, remote sensing, measuring components of energy, measuring water flux, and making sense of data. There were two field trips associated with this course and the fellows felt both trips augmented work done in the classroom. Fellows specifically noted that the trips allowed them to see real applications of what they were learning in the classroom thereby making it more relevant and assisting in their comprehension and they noted that the trips spurred ideas about things they might do in the high school classrooms. All of the fellows found the summer program to be useful and looked forward to incorporating what they learned into their work at the schools in the fall. Finally, fellows were asked to provide an example of something they learned over the summer that they would incorporate into the high school classroom. All of the examples were thoughtful and appropriate. When asked to summarize what they took away from the experience, one fellow noted: **"While I did pick up a lot of new scientific knowledge throughout the summer courses, I think more importantly it helped me more as a potential future educator in terms of what works and does not work in the class room. Working with the teachers was definitely the highlight of the courses."**

As opposed to last year, fellows did not indicate any changes they would make to the experience to make it more meaningful. Last year, homework and written assignments were an issue. Fellows viewed the assignments as busy work and did not feel they contributed to the summer experience. Fellows this summer did not mention any shortcomings.

Because this is the last year of the project, all fellows completed the exit survey. Seven fellows completed this survey. Three fellows indicated they hope to enter a PhD program next fall, one was looking for a postdoc or research position, and the remaining three were seeking employment (areas included wetlands, policy, and teaching in a community college). While four of fellows felt that the GK-12 experience did not influence their plans for the future, two offered that the experience reinforced their plans while one indicated that the experience has actually caused him/her to consider obtaining a Masters degree in Education with the expectation of teaching in high school eventually. Six of the seven felt that their involvement with GK-12 has improved their ability to share their research with a variety of audiences and noted was the ability to gauge the comprehension level of the audience and tailor or simplify their research so that it can be understood by the novice. To do so, the fellows simplified the data reported, added more explanatory and interesting pictures/photos, and allowed students in particular to interact in the presentation. They all agreed that the public has much to gain from interacting with scientists including gaining a clearer picture of the role science plays in their lives. By sharing research with the public, the fellows felt the scientist can improve his/her ability to keep research in touch with its role in society. One fellow noted, "In some ways I feel like scientists have really failed society by separating themselves as they have."

The fellows agreed that the typical undergraduate science classroom is more effective if it includes interactive teaching that had less lecture and more hands-on student work. One fellow took this a step further to suggest that college science courses could benefit from better high school preparation: "The way to improve this is by better preparing K-12 students for college. That way professors can spend more time on furthering a class' knowledge, and less time on basics like, basic math, spelling, proper English, etc." They also agreed that to recruit more scientists, science needs to be taught in an interesting fashion at earlier ages than high school. They felt students need to realize early that science is relevant and fun.

Through their classroom experiences the fellows identified challenges science teachers face including the fact that many students are taking science because it is required and have little interest in the subject. They learned that teachers need to be flexible and creative to engage students in learning. The GK-12 experience has had positive effects on the fellows with regard to their ability to communicate their science, their understanding of how the educational track fits together (k-college), and the way in which they view their work as scientists. One fellow provided the following summary:

> The GK-12 program has been a unique experience that has helped mold me into the scientist that I am today. Teaching at the high school level after a year of being a teaching assistant for the University put the state education system into context for me. I will use communication skills I developed throughout the duration of this fellowship to my advantage when relating with other individuals in my industry, and when teaching the general public about environmental science concepts. I will also advocate for always trying to push the envelope for better k-12 science education.

We also conducted follow up with fellows from previous years (19) to see where they are today. Eleven are employed, two are pursuing employment, and the other six are still working on their advanced degrees. Places of employment include:

- Hydrogeologist with Hull & Associates Inc. in Cincinnati
- Defended thesis Jan 2011, Biologist US Fish and Wildlife Service
- Research Assistant Professor, Environmental Remidation & Restoration Lab, LEC
- USGS Sandusky Office
- Illinois State Geological Survey
- PhD Candidate & Research Coordinator, Stone Lab
- Geosystems Specialist at BHE Environmental, Cincinnati, OH
- Instructor, DES
- Postdoctoral Researcher Ohio State University
- Ford Motor Company
- Defended PhD Oct 2011, postdoctoral research associate, USDA Agricultural Research

2) Teachers: During the summer, one teacher took the Water Quality course (the other seven took it previously) and all eight took the Environmental Sensor Network course. As with the fellows, teachers showed a statistically significant gain in content over the summer with similar

pretest and posttest mean scores—6.68 and 8.68 respectively ($p < 0.001$). The effect size was large (2.01) and the Cohen U3 projected the posttest score to fall in the 97th percentile. In general, teacher reactions to the summer program mirrored that of the fellows. When asked what stood out for them, many teachers indicated that the ability to actually use equipment was a bonus and they all ended the summer program with many ideas of activities and experiments they can bring to their classrooms. This summer received the highest rating from both fellows and teachers.

In April 2012, teachers completed the Science Teacher Ideological Preference Scale. In 2010, five teachers completed this survey that examines teachers' preferences for inquiry versus non-inquiry instructional practices. The average ratio of inquiry to non-inquiry practices was 2.59:1. In 2011, some teachers left and new ones were added and the 2011 surveys were completed anonymously making it impossible to measure change within the teacher. In 2012, however, teacher responses were tracked so change over time can be examined when they retook the survey in 2013. All eight teachers completed the survey in 2012 and the preference for inquiry over non-inquiry techniques was 1.94:1. Both years teachers had a strong preference for inquiry-based teaching strategies. In 2010, teachers had the most difficulty agreeing with "students should have a major role in making decisions about what are the best means for learning the concepts in the material being studied." In 2012, however, teachers had more difficulty agreeing with "students should figure out on his or her own the important concepts of the materials being studied rather than receiving them directly from the teacher." Both items are concerned with allowing students more control over their learning. Taking into consideration the change in the sample, no conclusions can be made as to change over time; however, both years the teachers had a higher preference for inquiry-based instructional strategies.

In March 2013 the teachers completed the STIPS one last time. This time the preference for inquiry instructional practices increased to a ratio of 2.52:1 over non-inquiry practice. Responses on the instrument suggest that the teachers believe that science should be taught in context, students should be free to identify his or her own relevant questions when conducting lab experiments and students should have a major role in deciding the best means for pursuing answers to these questions. Their agreement with non-inquiry instructional strategies focused on lab activities. In general, the teachers did not believe that students should be free to explore lab activities but rather should follow a prescribed process. This could be due to the limited amount of class time and the need to maintain safety measures although no conclusion can be drawn without follow up.

This year we also asked the teachers to complete an exit survey that asked them to reflect upon their experience in the UT LEC GK-12 program. Seven teachers completed the survey at the time of this report. Of the seven, three had been with the program since its inception and the remaining participated for four years, three years, and one year. The following provides the questions asked and the teachers' responses:

Has your experience as a GK-12 fellow had any influence on the way you teach science? Please explain how or why not:

- GK-12 program has significantly enhanced my teaching by giving me a broader understanding of the nature of research based science as well as an expanded repertoire of lab skills and knowledge that allow me to better engage my students.

- Yes, it has helped me be more aware and incorporate more of the community resources of the University into my classroom.
- Yes. The interaction with the fellow within the classroom has enabled an acquisition of a deeper understanding of research and how to incorporate it into the classroom.
- Yes. GK has brought resources, methods, and valuable, practical real-world examples and experiences. The collaborations and mutual goals/expectations have allowed this learning community to develop and evolve.
- Absolutely, having an "expert" in certain fields can enable you, the teacher, to go into much more detail on certain topics.
- I've become more "hands-on" activity oriented
- Yes. It has helped me realize the importance of bringing in real-life situations and experiences into the classroom.

Have you learned anything about integrating advanced research into the high school classroom?

- Yes, although many advanced research projects are too complicated or costly to incorporate into the classroom having the GK-12 collaboration has allowed my students access to techniques and equipment we would not normally have.
- Yes, but I do still find it difficult to work with a broad range of student abilities while trying to integrate advanced research into the classroom. I think it will be difficult without the support of a fellow in the room.
- Yes-addressed in question #1. This has been the most valuable part of the program. I will continue many of the strategies that I have learned while working with my fellows.
- Yes- The fellows' experiences and insights are extremely valuable and provide a different perspective to students that they really appreciate. It also provides an avenue for mentoring and first-hand experience for students. This was by no way a one way flow of learning. All involved gained valuable insight, knowledge, and experience.
- Yes, research on "up- to- date" topics are important in teaching high school in the 21st century.
- We done some. The students are aware there are opportunities for any ambitious, motivated student
- I have learned that integrating advanced research into the classroom is challenging, but can be done if introduced at a basic level with real-life examples.

What do you believe the general public can learn or gain from interactions with scientists about their research?

- The general public can gain a better appreciation for how decisions they make impact our world. The general public also needs to better understand the scientific process so that they can be better interpreters of the mass print media.
- I believe that the general public has a great interest in what is being studied by researchers. Dependent on a personal interest and the research topic, I thing that universities need to do a much better job at reaching out to the public in a "friendly", non-intimating manner to share this information.
- The public can see science as more accessible and having more impact on their everyday lives.

- Yes- It helps to break stereotypes and allows young people to see their inner scientist. It removes barriers separating the "general public" from the scientific world and allows "scientists" to be seen for who they are: people.
- That a “scientist” is not like the stereotype pictured on TV or in the movies. These individuals are everyday people.
- It's a good opportunity to gain knowledge from an expert rather than relying a local gossip.
- I believe that the general public would learn more about the world they live in and develop a better understanding of the work scientists do. I also believe they would benefit by having more knowledge to understand real-life situations around them.

By sharing their research, teachers felt scientists could gain a clearer understanding of how research is perceived by the public. The teachers agreed that programs like NSF GK-12 are effective ways to recruit more students to studying science in college because it allows students to interact with scientists who do not fit the stereotype. Adding fellows to the high school classroom allowed the teachers to include authentic assessment, introduce new science topics not typically covered, and demonstrate the latest in scientific inquiry. The fellows also sparked student interest in science by providing a real look at what a scientist is and does. Finally, the teachers were asked to add any other comments they would like to make concerning the project. Their responses were as follows:

- I would like to see every science teacher and classroom be able to have a partnership like I did with GK-12. Science changes to quickly to rely on college instruction and textbooks. The real science advancements are happening every day and teachers need to be a part of the progress. The GK-12 program has made me a better teacher and given my students experiences that they will have with them for life. Even students who will never pursue a vocation in science will be better citizens as a result of their involvement in GK-12.
- My GK-12 experience has been outstanding! Sometime challenging and demanding but overall one of the highlights of my teaching.
- Great experience! I am glad I was involved!
- On a positive note, this has been hands-down the best PD experience I have had the pleasure of participating in. One can easily see the impact it has in the classroom. I would like to say THANK YOU to Dr. Carol Stepien, all of the Co-PI's, the fellows that I have not had the chance to work with, and ESPECIALLY to those poor souls, Amanda, Nate, and Karen for putting up with my adolescent approach to life. You all have made a tremendous impact upon myself and my students. For this I am most appreciative. On a less positive note, I am very disappointed that an organization such as NSF would not recognize and understand that this type of experience IS a priority and just what kind of impact it has upon the future of science in America. Our GK program did exactly what it intended to do: build a learning community and make the connections between high school, higher ed, AND the "real world". In an ideal world educational institutions would automatically make these connections and make funding these a priority but with staff and budget cuts, these sorts of programs can easily be eliminated. We need more collaboration not less. More people in classrooms, not fewer. EDUCATION IS NOT ONE PATH, IT IS THE ONLY PATH to continue the advancement of our society.

- This program helped me to reinvent my teaching style.
- I'm sorry the program is finished. It's been a very rewarding experience
- Overall, the experience has been positive and helpful in getting the students learn about science.

3) Teamwork: This year the Teamwork Survery (8 fellows and 7 teachers) was again administered to provide a measure of the degree to which the fellows and teachers operated as a team and found value and mutual respect in the partnership. The instrument examines two levels of teamwork—that between the teacher and the fellow and the teamwork experienced on the project level or whole group working together. Individual teamwork assessments scored high (average 22.13 points out of a possible 24) and responses to items reflected mutual respect and open communication between the teachers and their fellows. Project teamwork scored just as well with an average of 18 points out of a possible 20. Both teachers and fellows felt the project provided resources and support, the faculty and project staff were helpful, and working as a group (such as the meetings at the University of Toledo Lake Erie Center) to be rewarding and helpful particularly in the development and refinement of lessons. This assessment is higher than the previous year indicating that changes in the group meetings have improved the team experience.

4) Students: Each fall and spring students in the teachers classes are surveyed using the project-developed Student Attitude about Science survey. During previous years, data was used to verify reliability and establish scales within the survey. A factor analysis revealed two scales: usefulness to society and personal interest in science. Responses to statements in the survey were based upon a 4-point ordinal (ranking level of agreement) scale. Once data was collected, the pretest was analyzed using Rasch modeling to convert the ordinal scores to interval scores so that parametric comparisons could be made. The pretest also provided item anchors so that comparisons between testing could be normalized.

Because of the odd reporting dates for this project, 2011-12 student data will be reported (2012-13 data will not be collected until April 2013 and will be included in the project final report). Pretest (August 2011) consisted of 455 students in the participating teacher/fellow classrooms. The posttest was administered in April 2012 to a smaller sample of 145 (one classroom per teacher; for the pretest several teachers surveyed more than one class). An F-test for equal variances showed the variances to be unequal so comparisons on the two scales were performed using a t-test assuming unequal variances. Results showed that there was no statistically significant change in attitude towards the students' personal interest in science as a result of having the UT LEC GK-12 fellow in the classroom ($t = 1.35$; $p = 0.09$). **However, the effect of having a fellow in the classroom did statistically significantly increase the students' perception of the value or usefulness of science to society** ($t = 5.38$; $p < 0.001$). It is expected that this effect stems not only from the fellow in the classroom but also from both the teachers' greater understanding of practical/research applications of science as well as the presentations of research fellows made in many of the classrooms.

During the 2012-13 academic year, 10 students participated in science fairs. Eight earned"excellent" scores and the other two earned "superior" scores. Among those with "excellent" ratings, one won the Geology Award and one won the Outstanding Physics Award. Three student projects qualified for the state competition.

5) University faculty & sustainability: The University has agreed to sponsor three fellows to work in high school classrooms after the completion of this NSF funded project. This commitment illustrates the effects the UT LEC GK-12 program has had on the University. Previous years' findings suggested that in general faculty preferred research graduate assistants and unless graduate students were specifically assigned to work with K-12 classrooms, they did not place much value in that experience (feeling that advanced research experiences were more meaningful). That the University has pledged to sponsor these positions shows commitment to maintaining connections with K-12 education and the value the University administration and faculty place upon this relationship.

The UT LEC GK-12 project continues to reach its goals for fellows, teachers, students, and higher education.

C) Conclusions

Findings from this final year to the project illustrate the growth the project has experienced. Goals were met and formative assessment found little to correct. Triangulation of objective measures like presentation observations and student outcomes with self-reported data and reflections revealed that not only did all participants find the project to be meaningful but it did indeed meet its goals and objectives and in some cases surpassed them. Of course the lasting effects the UT LEC GK-12 project will have on all who benefitted from it will not be realized for years. In the meantime, assumptions can be made that the project has indeed positively affected the way in which the high school science teachers teach science, the way their students learn and view science, and the way in which the fellows view science education and their role and responsibilities as scientists in education and society.

Prepared by Gale A. Mentzer, PhD
UT LEC GK-12 Project Evaluator