



ENHANCING HIGH SCHOOL SCIENCE EDUCATION: *Evaluation of the UW-Milwaukee SEPA Project*

2011 – 2012

PREPARED BY

Barbara Goldberg
& Associates, LLC
CONSULTANTS



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EXECUTIVE SUMMARY

- *“Make sure that every MPS high school has the means to conduct this experiment, please!”*
- *“Welcome to the den of learning! I love Biology!”*
— 2011-2012 SEPA Students
- *“I loved that we got to ask questions to the creators of the modules; it felt very nice to be able to communicate with such pioneers.”*
– 2012 Student NIH Conference Participant
- *“I believe that this is a very valuable program because it engages students in real science activities. The students benefit from setting up the experiments, collecting the data, and interpreting the data on their own.”*
- *“Best thing I did the whole year.”* — SEPA Teachers

The UWM SEPA Program Model. The Science Education Partnership Award (SEPA) program, supported by the U. S. National Institutes of Health (NIH), is designed to improve science literacy throughout the nation through innovative educational programs. SEPA-supported projects create partnerships among biomedical and clinical researchers and K-12 teachers and schools, museums and science centers, media experts and other educational organizations.

This SEPA project – “Biology-Environmental Health Science Nexus: Inquiry, Content and Communication” – is an effort of the University of Wisconsin-Milwaukee (UWM) NIEHS Children’s Environmental Health Sciences Core Center.



The underlying goal of the SEPA program is to provide high school science students with multiple, integrated opportunities to conduct inquiry-based experiments that link biological concepts with environmental health issues. Specifically, students study the effects of various environmental agents on zebrafish embryo development, fathead minnow reproductive behavior and earthworm burrowing behavior. The project combines teacher professional development and student science experiences that reinforce student learning and are based on National Science Education Standards.

The project is designed to help high school science teachers to engage their students in doing classroom-based research with an environmental health focus. It seeks to provide high school teachers with the background, the experimental curriculum modules, and the educational tools to enrich their science courses with experiments, concepts, and information about environmental health. The project seeks to help students understand that substances harmful

to human health are found in both natural environments and environments altered by humans – and to understand the consequences of exposure to these substances.

Based on program statistics, results of pre-tests and post-tests, teacher and student feedback and other evaluation findings, this SEPA project is making available to teachers a well-received model for enhancing science education for high school students, through modules that emphasize inquiry-based learning and hands-on experiments related to environmental health science and is responsive to a critical educational void in high school science education through a project that meshes with the National Science Education Standards (NSES). Second year evaluation results indicate significant changes in knowledge and attitudes related to environmental health science.

The SEPA Evaluation. During the first year, the emphasis of the evaluation was formative; during this second program year and in subsequent years, the focus is on outcomes. Over the long term, the rationale for data collection is to fully document the extent to which the UWM SEPA program:

- Increases the ability of participating teachers to understand and utilize new inquiry-based science modules and curriculum;
- Enhances students’ success in inquiry-based learning related to life and environmental health science research, and
- Has sustained institutional impact on participating schools, as reflected in expanded inquiry-based science, greater enrollment in higher-level science courses, and other documented changes.

Sources of data utilized in this evaluation include: records maintained by project staff; program statistics and reports; curriculum materials; workshop evaluation forms; research conference teacher and student evaluation results; follow up teacher surveys; student pre- and post-test surveys; interviews with principals of participating schools; and observations, informal reports and anecdotal materials.

Teacher Participants. Twenty-two teachers, representing 20 different schools and having a wide range of teaching experience and background, attended the 2011 SEPA Summer Workshop. Ten

of the teachers were from MPS (Milwaukee Public Schools) schools, three from private schools, and the remaining nine from suburban public schools.

Of the 22 teachers who participated in the June 2011 workshop, 16 or almost three-quarters (73%) taught one or more of the modules at their school during the **2011-2012** school year. Fourteen taught the zebrafish module, three taught the fathead minnow module, and one taught the earthworm module.

Of the 16 teachers who had taught the module during the **2010-2011** school year:

- Three teachers attended the 2011 workshop as Year 2 participants;
- Three teachers were unable to attend the 2011 workshop, but intended to teach the zebrafish module again as repeating Year 1 teachers; and
- One teacher started the zebrafish module, but did not complete the module curriculum.

Student Participants. Teachers reached a total of 629 students through the SEPA modules during the first year of the program implementation. During the second year, teachers exposed 830 students to SEPA modules, an increase of 32% over Year 01. Teachers reported presenting the zebrafish module to a total of 460 Biology, AP Biology, IB Biology, Environmental Science, AP Environmental Science, Ecology, Anatomy, Physiology, and Chemistry students. The fathead minnow module was presented to 270 Biology, AP Biology, Anatomy, Physiology, and Environmental Science students. The earthworm module was presented to 100 AP Environmental Science students.¹ Modules were presented to students between October 2011 and May 2012.

Of the students involved with the SEPA module, 51% of the students were male and 49% were female. About two-thirds (66%) of the students reported they were white (non-Hispanic), 15% stated they were black or African-American, seven percent reported being of more than one race, and eight percent said they preferred not to answer the question. The remainder reported being of other races in numbers less than two percent. Nearly a quarter (22%) of the students stated they were Hispanic or Latino.

¹ An out-of-state teacher requested module materials and taught the earthworm module to approximately 20 students.

Key Accomplishments

During the 2011-2012 project year, significant progress was achieved with regard to the project's goals:

- A viable, innovative project continued and expanded; the project did what it was supposed to do:
 - An additional module, focusing on the fathead minnow, was added so that three modules were developed, refined and implemented.
 - 22 teachers were recruited and participated in the second summer workshop in June 2011.
 - The modules were taught during the 2011-2012 school year by 16 participating teachers, with support from Center scientists and SEPA staff.
 - The second research conference was held with greatly expanded participation from 11 schools.
 - A comprehensive evaluation was conducted.
 - Information about the program model was disseminated locally and nationally.
- The modules that were developed and implemented remained true to NSES standards and original project aims:
 - The modules include laboratory experiences that use live organisms in the classroom.
 - The modules offer authentic experiences that provide students and teachers with the opportunity to contribute to their design in each individual classroom.
 - The modules link basic life science content to contemporary biomedical and environmental health problems.
 - The modules' content are explicitly linked to a number of national standards for life science content.
 - The modules pre-suppose a support system that helps teachers bring and sustain the experiences in the classrooms.
- The model project established as part of the SEPA program at UW-Milwaukee is characterized by an emphasis on scientific inquiry and, also, by many best practices. For example, the UWM SEPA project model:

- Offers a rich environment where learners can acquire ideas, inquiry skills and positive attitudes toward science.
- Provides teachers with greater depth of content knowledge.
- Provides for structured classroom time that is spent on direct inquiry, where classroom laboratory experiences are made available to students.
- Offers ways for students to relate science to the world outside school, and to connect their investigations to their own lives and to the environment.
- Encourages collaborative group work where goals, observations, plans and problems are discussed and alternative methods may be suggested.
- Assesses for what was taught and offers feedback to students that emphasizes process and logic.
- Offers teachers opportunities to participate in extensive, in-depth professional development, with support from scientists.
- Over the course of the project year, 16 teachers at 15 different schools integrated the zebrafish, fathead minnow, and earthworm modules into their science curriculum, providing instruction and laboratory experiences to 830 high school students throughout the Milwaukee metropolitan area.
- Based on workshop feedback from the first year, presentation of the earthworm module during the second year workshop was improved; feedback from the second year workshop demonstrated higher levels of satisfaction with the earthworm module. During the first year, while teachers offered high ratings for most aspects of the workshop, there was significant dissatisfaction with one presenter and with the earthworm module itself. In response to this issue, several teachers were brought in to work with the co-principal investigator to refine the instruction manual. In addition, a key interactive video was developed to provide students with additional instructions.
- The project received high marks from participating teachers on several measures.

- Teachers reported being able to integrate the module into their curriculum, appreciated the opportunity to participate in the program, valued the support of the Center scientists, and felt that the scientific information in the module had been presented with clarity.



- All of the teachers felt that the zebrafish, fathead minnow and earthworm modules improved their students' scientific and analytical skills and, also, their students' environmental health science literacy.
- All (100%) of the teachers “strongly agreed” or “moderately agreed” that their students demonstrated an increased understanding of the relationship of toxicants to zebrafish embryo development; to lead exposure and fathead minnow reproduction; and to the effects of toxicants on earthworm burrowing behavior after exposure to the modules.
- Twelve (71%) of 17 module teachers responding to follow up surveys reported that their students were generally more interested in the module than in their standard life or environmental science curriculum.
- Eleven of 13 teachers of the zebrafish module, two of the three teachers of the fathead module, and the teacher of the earthworm module planned to use the SEPA modules again during the 2012-2013 school year.
- Teachers were able to document several ways in which the program had contributed to their professional development: All but one of the teachers reported gaining new understanding or skill in teaching high school science using an inquiry-based approach through presenting their module. Most (59%) reported using the program materials

and handouts “a great deal;” the remainder (41%) used SEPA resources “somewhat.” In addition, nearly three-quarters of the respondents shared handouts and materials with other teachers in their school: 18% “a great deal,” 29% “somewhat,” and 24% “a little.”

- Second year evaluation results indicate significant changes in knowledge and attitudes related to environmental health science for students who experienced the zebrafish, fathead minnow, and earthworm modules. Student respondents also reported satisfaction with all three modules. They reported enjoying the “hands-on” approach and said it was helpful to their learning. Regardless of the module they took part in, about three-quarters of the students felt that the module content and activities were appropriate for high school students.

With regard to specific modules:

ZEBRAFISH MODULE

- Results indicate that zebrafish module student opinions shifted significantly for four statements included in the survey from the time the pre-test was administered to the time of the post-test. At the time of the post-test, significantly more students agreed that: environmental agents acting upon fish act upon humans; that experiments with fish demonstrate how the environment affects humans; that a life form’s behavior evolves through adaptation to its environment; and that experimentation with fish might help make decisions about how the environment affects human health. In addition, zebrafish module students demonstrated increased knowledge about the specific toxicants effects on the organisms.
- As part of the pre-test/post-test survey, students were asked to indicate their interest in having a career in different areas of science. There was a statistically significant increase in the level of interest in having a career in environmental science.



- Student responses indicated a positive experience with the zebrafish module. For example, nearly three-quarters (73%) strongly or moderately agreed that, “After doing the zebrafish module, I have a better understanding of the effects of toxins on zebrafish and human embryo development.” Over 60% (63%) strongly or moderately agreed that, “I would like to do lab experiments like the zebrafish in future science classes.”

FATHEAD MINNOW MODULE

- Results indicate that fathead minnow student opinions shifted significantly for three statements included in the survey from the time the pre-test was administered to the time of the post-test. At the time of the post-test, significantly more students agreed that environmental agents acting upon fish act upon humans; that experiments with fish demonstrate how the environment affects humans; and that experimentation with fish might help make decisions about how the environment affects human health. Fathead minnow module students demonstrated increased knowledge about the effects of lead exposure on fish and on children.
- Student responses about the fathead minnow indicated a positive experience with the module. For example, 95% strongly or moderately agreed that, “After doing the fathead minnow module, I have a better understanding of the effects of toxins on fathead minnow reproductive behaviors.” Nearly 90% (89%) strongly or moderately agreed that, “Learning about the fathead minnow taught me things about the environment that I didn’t know before.” Almost two-thirds (65%) strongly or moderately agreed that, “I would like to do lab experiments like the fathead minnow in future science classes.”

EARTHWORM MODULE

- Results indicate that earthworm module student opinions shifted significantly towards preferred responses for four statements

included in the survey from the time the pre-test was administered to the time of the post-test. At the time of the post-test, significantly more earthworm module students agree: that environmental agents acting upon worms act upon humans; that experiments with worms demonstrate how the environment affects humans; that worms can become sick and even die if there is too much pollution in their environment; and that experimentation with earthworms might help make decisions about how the environment affects human health. Students who were taught the earthworm module demonstrated increased knowledge about factors impacting worm's burrowing behavior.

- Student responses about the earthworm module indicated a mostly positive experience. For example, about half (50%) strongly or moderately agreed that, “Learning about the earthworm taught me things about the environment that I didn't know before.”
- Participating teachers and students were pleased with the NIH Student Research Conference, which gave students the opportunity to present research papers and posters and to hear presentations from UWM faculty and students. Almost all (95%) of the student participants gave the conference an overall grade of “A” (51%) or “B” (44%). Student participants were pleased with the conference and felt it was well organized. Many students commented on what a “great experience” it was and how they were made to feel welcome and comfortable. Several students stated the conference had encouraged their interest in science. Conference participation increased from three schools during the first year to 11 participating schools during the second year. All the participating teachers “strongly agreed” (80%) or “moderately agreed” (20%) that “the conference was well organized” and that “the conference planners created an environment that was welcoming and comfortable for students.” Teachers appreciated the opportunity to showcase another communication method in science and reported some excitement among students.
- Based on surveys conducted with the school principals, satisfaction with the program among the principals who were aware of it was strong.

Three-quarters of the principals were aware of the program, would expand it to other classrooms and would recommend the program to other schools.

- The UWM SEPA program demonstrated a strong commitment to being a “learning organization” – one that uses information to change and improve what is learning on a continuous basis – and to dissemination of information about the program model. This was apparent in the ways in which teachers participated in the development of the modules and provided ongoing feedback to the program and the emphasis on continued refinement of curriculum materials and the laboratory experience. Part of the program model also included dissemination of information through presentations and other means. Presentations were given at the 2011 NIH SEPA Annual Conference, 2011 Midwest Zebrafish



Education Summit, the SETAC North America 32nd Annual Meeting, the March 2012 National Science Teachers Association Conference, and at the PEPH workshop entitled “Environmental Health Communication: Methods, Research and Training.”

Key Challenges

Key challenges during the second year included the following:

- Finding effective ways to inform teachers in a large metropolitan area of this available opportunity; as a corollary, identifying, recruiting and selecting sufficient numbers of teachers, while being mindful of the program's aim to engage students of color from various socioeconomic and ethnic backgrounds.

- Addressing the issues faced by teachers in carrying out the modules: (1) generating enough zebrafish embryos to carry out the experiments; and (2) ensuring that teachers know how to complete each step of the module procedures outlined in the manual. There were two primary issues for teachers in utilizing the modules in their classrooms. The first issue was unexpected: Almost all of the teachers experienced difficulty in generating enough zebrafish embryos with consistency utilizing homemade aquaria located in their classroom laboratories. As a result, during the first year, the SEPA staff had to invest extensive time harvesting embryos at the NIEHS Core Center and repeatedly delivering embryo supplies to the participating teachers. Secondly, although detailed procedures were presented during the summer workshop and were also outlined in the module instruction manual, sometimes teachers missed key steps (e.g., proper dilution of solutions), leading to poor results. With additional funding, the program was able to address this issue by: (1) purchasing a MEPS unit – stand-alone system for the continuous production of eggs - to be set up at the UWM NIEHS Core Center facility; and (2) creating videos, with companion hard copy materials, that detail the proper procedures for carrying out the zebrafish, fathead minnow and earthworm experiments.
- Ensuring that all the teachers who participate in the workshop also utilize the modules in their classroom. During the first year of the project, four of the 13 participants in the workshop did not carry out a module. During the second year, six of the original 22 participants did not carry out any of the three modules: zebrafish, fathead minnow, or earthworm, and one instructor started the module but did not complete it. Follow up surveys with teachers who did not utilize the module in their classroom indicated institutional and/or school barriers that challenged teachers from continuing with the project.
- Following up with teachers who have “graduated” from the summer workshop phase of the program but may still use the modules in their classrooms in subsequent years.
- Ensuring that the modules are adaptable for several different levels of students. Participating students were enrolled in AP Biology classes, IB

Biology classes, Biology classes, and classes for students with special needs.

- Continuing to increase the number of students who attend the Research Conference, write research papers and present posters. While there was a high level of enthusiasm among those who attended and participated in the first and second Research Conference, several teachers chose not to. Given the Conference’s success in its initial years, it may be that enrollment will improve dramatically in subsequent years, given a clearer understanding on the part of teachers of what is required and what can be gained by their students.
- Making sure that school principals are aware and supportive of the program. While some principals had a level of awareness about the SEPA program, some did not. As the program matures, it has the opportunity to fully maximize the program’s effect at participating schools by better informing principals and other school administrators.
- Determining the optimal size of the program and its best rate of growth. As the program continues to expand, the principal investigators and others engaged with the program will have to determine the optimal size of the program and its staff and its best rate of growth to ensure that the much-valued technical assistance and personal attention provided to teachers can continue at a high level.

Recommendations. The recommendations listed below are drawn from program records, observations, teacher survey results, student feedback, and other evaluation findings.

- Stay true to the program model – a model that builds upon past UWM SEPA programming, emphasizes inquiry-based learning, draws on and contributes to best practices in science education, and meshes with the National Science Education Standards.
- Continue to call upon teachers to contribute to the refinement of the modules and to be active participants in strengthening the modules and the experience for their students. This interactive process, whereby scientists propose the experiments, master teacher-writers convert the experiments into text and instructions, teachers and students engage with the modules and report back on their findings, and SEPA staff add their observations, can serve as a model for other SEPA

projects seeking to involve teachers in a meaningful way in curriculum development.

- Develop and implement a careful teacher recruitment and selection process to ensure that the SEPA program is reaching schools with a high number of students who are students of color and/or first generation college prospects. Explore the possibility of working with the Milwaukee Public Schools in this effort.
- Continue to explore the possibility of offering “mini-workshops” on topics such as skyping and use of available Internet resources.
- Continue to view the Research Conference as the capstone for student and teacher participants in the program. Build upon the successes of the first two years of the Research Conference by emphasizing its value and utilizing the past year’s testimonials. Find additional ways to encourage networking and interaction among students from different schools. Continue the inclusion of UWM faculty, staff and programs in the day’s events, through the keynote speaker, poster presentations and informational booths.
- Continue to nurture a long term commitment to the SEPA program among teachers who attend the workshop. Conduct a focus group

with teachers to identify strategies to ensure their involvement for multiple years. Conduct an “exit interview” with teachers who choose not to remain with the program.

- Expand efforts to have an institutional impact at participating schools by:
 - Building awareness among the administration by presenting the program to principals and their science department chairs;
 - Inviting the principals and department chairs to the Research Conference to help build support for the program;
 - Encouraging past participants to continue and to invite any colleagues they feel would be interested.
 - Exploring opportunities through wikispace, skyping, and other means to encourage interactions among students from different schools, particularly urban, suburban, and exurban schools.
- Continue to seek out opportunities for dissemination on aspects of the program model, including the modules, but also the Research Conference, through presentations, posters, articles and online opportunities.