DEVELOPMENT OF AN EDUCATIONAL PARTNERSHIP FOR ENHANCEMENT OF A COMPUTER RISK ASSESSMENT MODEL

K. Topper
K. Castleton
J. Buck
J. Droppo, Jr.

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Pacific Northwest Laboratory
Richland, Washington 99352

(a) Mesa State College, Grand Junction, Colorado

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Abstract

The Multimedia Environmental Pollutant Assessment System (MEPAS) is a computer program which evaluates exposure pathways for chemical and radioactive releases according to their potential human health impacts. MEPAS simulates the exposure pathways through standard source-to-receptor transport principles using a multimedia approach (air, groundwater, overland flow, soil, surface water) in conjunction with specific chemical exposure considerations. This model was originally developed by Pacific Northwest Laboratory (PNL) to prioritize environmental concerns at potentially contaminated U.S. Department of Energy (DOE) sites. Currently MEPAS is being used to evaluate a range of environmental problems which are not restricted to DOE sites. A partnership was developed between PNL and Mesa State College during 1991. This partnership involves the use of undergraduate students, faculty, and PNL personnel to complete enhancements to MEPAS. This has led to major refinements to the original MEPAS shell for DOE in a very cost-effective manner. PNL was awarded a 1993 Federal Laboratory Consortium Award and Mesa State College was awarded an Environmental Restoration and Waste Management Distinguished Faculty Award from DOE in 1993 as a result of this collaboration. The college has benefited through the use of MEPAS within laboratories and through the applied experience gained by the students. Development of this partnership will be presented with the goal of allowing other DOE facilities to replicate this program. It is specifically recommended that DOE establish funded programs which support this type of a relationship on an ongoing basis. Additionally, specific enhancements to MEPAS will be presented through computer display of the program.
Introduction

Multimedia Pollutant Assessment System Computer Program

The Multimedia Environmental Pollutant Assessment System (MEPAS) is a human health risk computational model (Multimedia in this context refers to multiple environmental transport and exposure media.)\(^1\)\(^2\) MEPAS takes the nontraditional approach of integrating all major exposure pathways into a single public health computational tool. MEPAS employs an integrated, physics-based approach that couples source, contaminant release, migration and fate for environmental media (groundwater, surface water, air), with exposure routes (inhalation, ingestion, dermal contact, external dose) and risk/health consequences for radiological and non-radiological carcinogens and non-carcinogens (Figure 1).

![MEPAS Overall Structure Diagram](image-url)
Throughout MEPAS' development and subsequent application, PNL has subjected the methodology to thorough external evaluation. Extensive review by the scientific community has fostered and confirmed the validity and usability of MEPAS. Some of the evaluations and applications of MEPAS are:

**Major Applications**

- DOE Environmental Survey (1987-90)
- Hanford single-shell tank analyte prioritization for characterization (1987-90)
- State of Washington Risk-Based Standards (1990)
- University of Indiana, University of Washington, Washington State University, Mesa State College (Colorado) use MEPAS as teaching tool (1991-1994)
- Office of Management and Budget Pilot Study (performed by ORNL) (1991)
- Hanford 100-area study groundwater plume risk maps (1992)
- Fate/transport modeling at Eielson Air Force Base (1992-93)
- DOE Programmatic Environmental Impact Statement (1992-93)

**Major Evaluations**

- DOE selects MEPAS for environmental survey (1986)
- EPA testing of RAPS/MEPAS for prioritization (1987)
- National Academy of Sciences reviews MEPAS (1989)
- Idaho National Engineering Laboratory selects MEPAS for risk screening (1989)
- Health and Welfare, Canada selects MEPAS for use after reviewing 22 multimedia models
- Oak Ridge National Laboratory (ORNL) selects MEPAS for DOE's Programmatic Environmental Impact Statement (1992)

MEPAS' versatility and sound technical basis make it applicable for a wide variety of risk estimation applications, which has resulted in its extensive use by PNL, DOE, universities, state governments and private firms for a variety of risk estimation problems.

Mesa State College

Mesa State College (MSC), located within the western slope of Colorado, provides liberal arts and sciences undergraduate education to approximately 4500 students annually. An Associate of Applied Science degree entitled Environmental Restoration Engineering Technology (ERET) was implemented the fall of 1990. This program was intended to address the immediate need of creating technologists who could efficiently resolve the complicated environmental problems which our industrialized nation has created. The ERET degree was initiated by strong interest from the Grand Junction Projects Department of Energy (GIPO DOE) Office and its prime contractor, RUST Geotech.

It was recognized during the development and implementation of the A.A.S. degree that there was an equally critical need for a baccalaureate degree in this general area of study. A Bachelor of
Science degree in Environmental Restoration and Waste Management (ERWM) was initiated for the 1993-94 academic year. The ERWM program is an interdisciplinary based degree which develops an understanding of natural science, mathematics, and communication skills coupled with environmental courses which integrate the support courses in an applied manner. The enrollments within the two degrees were approximately 130 students the fall of 1994.

This relationship with the GIPO DOE office facilitated establishment of several other industry and governmental partnerships. The result has been a quality educational program which is responsive to work-force needs.

**Educational Partnership Addresses Specific DOE Needs**

**PNL/MSC Addressing Cooperative Objectives**

MEPAS 1.0 was created to estimate risk at DOE site to enable DOE to prioritize the cleanup problems. The tool’s most important feature is that it was to apply to many installations and many different sites. The approach chosen by the MEPAS team was unique in the sense that they started with the data that was commonly available at the installation and then created the models to use the data. To make the models general enough for wide spread use semi-analytical approaches were chosen over finite element, this is because the data required for a finite element model is very site specific. The structure of the package was designed (Figure 1) and experts in specific fields were used to write the actual models.

The MEPAS 2.3 user interface was written to ease the burden of entering data into text files that are read by the MEPAS models directly. MEPAS 2.3 UI was written in Clipper for dBase III. This interface did ease the burden of data entry but had many drawbacks. Specifically the interface was limited to the MS-DOS operating system and the database structure was spread across many files making sharing of MEPAS data and input difficult if not impossible.

In 1990 MSC began working on enhancements of environmental software to be used for educational purposes on equipment donated from NCR/AT&T. Coincidently Dr. Karl Topper, an environmental professor at MSC, had worked with Dr. Gene Whelan during their doctorate studies. Dr. Whelan was one of the primary developers of the RAPS/MEPAS methodology. This relationship led to an agreement whereby students at MSC would work on programming enhancements of MEPAS and use of MEPAS for educational purposes while PNL would have the rights to the newly developed software. Initially the college funded several students to begin this work. However, this arrangement was unsatisfactory due to limited funds. PNL arranged for summer appointments through the DOE Student Research Associate Program administered by the Northwest College and University Association for Science (NORCUS: This program is now administered by the Associated Western Universities (AWU)). Further funding augmentation was obtained through a DOE Environmental Restoration and Waste Management Distinguished Faculty Award presented to Dr. Topper in 1993. Unfortunately, this two-year award was shortened to one year due to elimination of this valuable program by DOE.
Specific MEPAS Enhancements

Since the MEPAS models were developed as stand-alone models not all of the MEPAS package needed to be modified, only the user interface. During the summer of 1992 PNL assigned five MSC students to tackle the task of the MEPAS UI conversion. At the beginning of the appointment, the students spent a week with the staff at PNL designing a new MEPAS user interface. The remainder of the work was completed at MSC under the direction of Dr. Topper and in coordination with PNL personnel. The new interface used pull-down menus and dialog box methods which reflected commonly available computer software. In addition the design optimized the data handling so that all of the user input would be in one file, making it trivial to share data with other MEPAS users. The new and improved MEPAS UI made converting the units of input values easier for the software developers as well. The new MEPAS package was completed during the summer and was named MEPAS 3.0.

In 1993 Oak Ridge used MEPAS 3.0 to do a risk analysis of the Savannah River Site and validated the usefulness of this undergraduate student product. As a result of this collaboration PNL received a more user-friendly (Figure 2), more flexible software package and decided to employ one of the students as a staff member. For this joint effort, the MEPAS team received a Federal Laboratory Consortium award for Technology Transfer in 1993.

The new data handling for MEPAS 3.0 made many new products possible. One task that is often difficult for environmental models is a sensitivity or uncertainty analysis of the models. Both require the user to change multiple parameters many times to see the effect of the input changes. The sensitivity analyses allows the modeler to evaluate the degree of accuracy required within the input parameters. MEPAS 3.0's new data handling facilitated development of the sensitivity/uncertainty analysis routine because all that need be modified is the one input file generated by the new MEPAS 3.0.

![Figure 2](image-url)
Four MSC students were selected to start work on developing a MEPAS sensitivity shell during the summer of 1993. The result of this work has been a stand-alone package that can do sensitivity/uncertainty analysis on the MEPAS models as well as on other models which conform to the data format that MEPAS 3.0 uses. This package used some of the same parts as the MEPAS 3.0 interface so that a user feels like they are running one application.

The MEPAS Sensitivity/Uncertainty Analysis Module is now maintained by PNL staff with the aid of the original MSC developers. It has been used to compute the uncertainty in the Hanford Remedial Action Environmental Impact Statement as well as a poster session on ecological risk estimates, which used a model other than the MEPAS models.

Computational models often produce and analyze large amounts of numerical data which makes it difficult to visualize. This problem, along with the need to produce useful results to decision makers, has now focused the attention of the MSC and PNL partnership on the process of producing report ready charts and tables from MEPAS 3.0 results. This task required the designers to understand MEPAS and be able to work with the same tools that have been used in the past. Once again this task of design and implementation of a Graphics Display user interface for MEPAS was passed to MSC.

During the spring of 1994 three MSC students began working on the Graphics Display for MEPAS. This is the most ambitious task that has been taken on by MSC because it requires the students to develop parts of a much larger application. The MEPAS Graphics Display is not entirely completed yet but significant accomplishments have been realized. MEPAS is no longer a single program of models, it is a collection of tools that allow the user to do a thorough job of estimating risk for contaminants from waste sites. MEPAS allows the user to calculate, graph and assigned a probability distribution to all parts of the calculation (Figure 3). The majority of the tools in the toolbox have been produced by the MSC and PNL partnership in a very cost-effective manner.

**Lessons Learned and Project Benefits**

This relationship between PNL and MSC has resulted in a truly symbiotic partnership in which each organization has realized significant benefits. We hope that other DOE facilities and contractors will seek similar partnerships. There are many reasons why there may be some initial reluctance to initiate such activities, but the benefits have far outweighed any inconveniences. The following highlight a few of these benefits:

- **Efficient, effective development of enhancements to MEPAS which has resulted in greatly improved usability and flexibility.**

  Using the undergraduate students with faculty and PNL supervision has allowed development and implementation of ideas which might never otherwise be accomplished because of the enthusiastic expertise the students bring to the project along with the extremely low cost of this approach.

- **Enhancement of the technology transfer mission of DOE through MEPAS improvements and educational use.**
Figure 3

- Enhancement of the undergraduate student experience through working on a "real" project.
- National recognition for the on-going benefits of this project.

This project has also had some constraints which had to be addressed. However, each one of these constraints were readily overcome with sufficient attention. The first touchy issue was protection of rights to the software developed within the project. Yes, the lawyers on both sides had to become involved to help produce a legally acceptable document. The next major issue has been project funding. This has been addressed through the use of student research appointments within the AWU infrastructure and by the DOE research faculty award. Using this approach requires careful attention to deadlines in terms of submitted paperwork. Given that the AWU funding only addresses direct student wages, other means of funding must be sought for this to be a sustainable project. We have signed an MOU which administratively supports the idea that MSC and PNL may seek joint proposals to help seek such augmentation funds in a more stable manner. This is an area which we will be actively seeking as the efficiency of this program is unmatched within the DOE system.
Another point in terms of "lessons learned" is that there needs to be a strong commitment and responsive communication between the partners. We have used a combination of computer communications (Internet) to send computer files/messages and telephone conferences for group discussions. However, there is a need to directly fund the supervising staff so that they have the dedicated time to be responsive as needs arise. This leads back to the previously discussed need for on-going funding which is dedicated to this type of program. Thus, it is our recommendation that DOE and its contractors re-evaluate some of their funding priorities to include development of similar partnerships. There needs to be competitive programs which specifically target undergraduate colleges to develop similar projects. The costs are extremely insignificant relative to the benefits.

References


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