Problem-Based Education (PROBE): Learning for a Lifetime of Change

Buck F. Brown, Sr., Buck F. Brown, Jr.
Rose-Hulman Institute of Technology

ABSTRACT

Education in the United States is at a pivotal juncture. U.S. citizens must compete in a demanding global society, but our educational systems are struggling with outdated approaches and stagnant budgets. The "knowledge explosion" of the past 20 to 30 years has provided technological, engineering, and science education with a singularly difficult challenge. The traditional answer to this "knowledge explosion" has been to pack more "essential facts" into the curricula. Careful consideration of this issue suggests that an information-laden society requires resourceful skills, insights, and abilities; hence, educational innovation must focus less on facts and more on problem-solving and inquiry-based learning. The Wabash Valley Educational Alliance[1], supported by the National Science Foundation (DUE-9553705), has implemented an important educational vision and established a permanent cooperative effort within the Wabash Valley (west central Indiana) to meet this need.

This paper describes how this project addresses instructional methods that impact the education of students of technology, science, mathematics, and engineering in two-year and four-year institutions as well as those in grades 6 through 12. It outlines an educational approach and announces the WVEA effort to produce new curricula materials including problems and examples; provide a "living" video series of applications; and create a national, refereed, electronic database for sharing problem-based materials and experiences.

I. INTRODUCTION

The Problem-Based Education (PROBE) project grew out of the need to address both pedagogical and curricula reform at multiple levels within learning institutions in the Wabash Valley. The WVEA recognized a singularly important goal for all of its students--the ability to deal with change in modern and future work environments. In order to address this goal, the WVEA began a quest to find key factors in new teaching methodologies. Concurrently, the Alliance began pursuing ways in which it might address broader, curricula reform issues. During this process, it became evident that by modifying new and revolutionary (ideas in learning theory)practices in medical school education, it might be possible to simultaneously address both change in teaching methodologies and curricula reform. In fact, it seemed that these revolutionary practices might lend themselves well to multiple educational settings, levels and content areas. Therefore, the WVEA proposed that by adopting the PROBE project, faculty from virtually all of its institutions could participate in a cooperative venture to further pedagogical

[1] The Wabash Valley Educational Alliance includes Indiana State University, IVY TECH State College—Terre Haute, Purdue University Cooperative Extension Service—Vigo County, Rose-Hulman Institute of Technology, Saint Mary-of-the-Woods College, Vigo County Public Schools, and Vincennes University.

reform in engineering, technology, mathematics, and science education. A proposal written to the Advanced Technological Education program of NSF was subsequently funded for three years, starting in September of 1995.

This paper describes the basic tenants of problem-based education and the educational theory behind it. Next, it provides some ideas about how it might be implemented at multiple levels and content settings. Finally, the paper presents a description of future developments expected as part of the PROBE project and describes how others are invited to participate in the project through a national, refereed publication and world-wide web database development.

II. PROBLEM-BASED EDUCATION

Problem-based education concentrates learning around "real-world" problems similar to those encountered by practitioners in the field. It closely resembles an interdisciplinary work environment and is fundamentally different from traditional approaches because the problem is encountered **FIRST** in the learning process. The "problem" provides both the impetus and context for learning and skill acquisition. This suggests that it is actually an educational approach rather than merely a teaching technique.

Curricula and institution-wide restructuring through problem-based education generally occurs from the inside-out. Instead of having restructuring imposed upon them, faculty and instructional staff first work to revise and restructure courses to incorporate a problem-based approach. As students progress, the types, scope, and complexity of the problems used may be expanded to encompass interdisciplinary topics. These can be utilized to extend student problem-solving skills, increase their interdisciplinary thinking and emphasize the importance of communication and cooperation.

Dewey [1], Piaget [2], Brunner [3] and others have contributed to the foundations of this method as an outgrowth of cognitive and later, constructivist learning theory dealing with the problem-solving process. Problem-based learning has modern origins in medical education. In particular, Barrows and Tamblyn [4] in the mid 1970's began exploring its use at McMaster University as part of the medical school's curriculum. Within more recent times, Harvard Medical School completely revised its pre-clinical curriculum from a lecture-based approach to a problem-based format [5].

Problem-based education has a growing number of supporters from a variety of disciplines, learning settings and levels. [6] For instance, the problem-based approach has been gaining popularity in the areas of administration, optometry, history, law, and, most recently, mathematics, science and engineering. [7] At the same time it embodies the standards set forth by elementary and secondary professional educational organizations such as the National Council of Teachers of Mathematics. In each of the aforementioned fields, great strides have been made in helping students become critical thinkers and problem solvers. [8] There is significant potential for its further refinement and widespread application at all levels of technically-oriented educational programs.

While the problem-based approach to learning and instruction can become quite complex, it is, in fact, the way most people learn outside a school setting. A simple example of this would be learning how to use a word processing program. Few people really "learn" how to use a word processor by sitting with the manual and memorizing each useful function first and then trying to apply the use of those functions to accomplishing a task later. Instead, what actually occurs is that the task or "problem" arises first. The task may be simply to write a letter. As one begins the task it is apparent that there are certain functions that must be learned. Those functions (i.e. setting margins, numbering pages, setting justification, formatting a page, etc.) are learned ONLY in the context of the task of writing a letter. In fact, the letter task provides the reason for learning these functions and understanding how they operate together.

In a way similar to the word processing example, "problems" in any discipline are generated by the instructor of a course. These "problems" or tasks provide both incentive and reason for learning certain facts, concepts, and procedures necessary to the solution. It is only within the context of that solution that these facts, concepts and procedures really make sense and are found to be truly useful. In a traditional class, these facts, concepts, and procedures are normally taught first in an isolated way with students expected to put them together in order to solve problems. Often this leads to fragmented learning and problem-solving capabilities that are not really integrated.

In problem-based learning the teacher's role changes quite dramatically from that in a traditional learning situation. [See Table 1] The teacher must guide the students in the problem-solving process, directing them through questioning techniques. The amount of guidance and structure provided by the teacher should be directly proportional to the amount of experience the students have had with the basic skills necessary to solve the problem as well as their experience in problem-solving.

The teacher must act as guide and cognitive model for the students as they learn to think about the information that is available in the problem and how to go about beginning to find its solution. Since the solution is complex and involves multiple procedures, this task should be spread over a number of weeks. Students are usually encouraged to work in groups to share their ideas and to help each other make wise decisions about the direction their inquiries should take.

During the problem-solving process, the teacher may find that the students are searching for a particular procedure or method that is necessary to a solution of the problem. When some or all of the students have deemed it necessary to learn such a procedure, the teacher may also act as information resource and find this to be the optimal time to demonstrate the particular procedure.

As students progress, the types, scope and complexity of the problems may be expanded to encompass interdisciplinary topics. These can be utilized to extend student problem-solving skills, increase their interdisciplinary thinking and emphasize the importance of communication and cooperation. The attendant increase in complexity for faculty participants must be carefully addressed. Strategies for "cooperative" problem-based instruction are an important added consideration that must be developed.

Problem-based instruction promotes learning that results from the process of working toward the understanding or resolution of a problem [9]. Learning, then, occurs as much as possible within a complex environment - one which reflects the environment in which the student will ultimately be working. This not only means working with complex problems that involve many content and procedural elements, but problems which involve solutions most effectively found by teams who can build on each other's knowledge. It requires the use of the latest techniques, information, and technology-based tools. This not only approximates the work world, but also allows students to gain insight into the thinking processes of others--gleaning that which they can accommodate to their own problem-solving process. The learning which results from the problem-based approach has several important benefits which are listed in Table 2.

Problem-based learning's widespread applicability provides an excellent vehicle for educational innovation in a classroom setting with traditional students or for use with non-traditional and remote instruction. It is greatly enhanced by technology-based resources, including electronic collaboration, and is a dynamic means for responding to changes in principles and practice.

PBL concentrates on recent additions to our expanding knowledge base, is well suited to a rigid class structure where required, and provides a stimulating learning environment akin to that of the workplace. Most importantly, it promotes the team-oriented, problem-solving skills that are necessary for life-long learning in support of productive careers and satisfying lives. Its successful use by Wabash Valley Educational Alliance post-secondary institutions can be seen as a national model for the broad application of this powerful learning experience.

III. Making Problem-Based Education Work

Making the transition from a traditional, lecture-type class format to a problem-based format is fairly complex for both faculty and students. We have found that certain courses lend themselves better to that transition than others. In particular, if one of the stated goals of the course is to teach problem-solving skills, then it is likely that a problem-based approach will yield significant benefits. If, however, the major goals and/or objectives of the course are focused on having the students memorize rules and/or standardized procedures, then it may not be an appropriate educational method. It is important for any faculty member to determine up front what the major goals and objectives of the course will be. This will always provide guidance as to the educational method which will yield greatest benefits.

Over the course of this PROBE project, to date, we have found several “elements” which, when incorporated into teaching, tend to make problem-based education most effective. It is important to realize that each course and class setting is unique; therefore, each person will have to tailor the methods described to his/her own unique situation. It is also important to understand that many of these elements MUST be performed simultaneously in order to be successful. The elements should not be thought of as “steps” but as belonging to the whole of the instructional and learning process. Nevertheless, the seven “elements” necessary to make problem-based

1. Problems are designed to emulate "real-world problems.
2. Problems used are complex and cover multiple objectives.
3. The problem or task is introduced FIRST, before any learning occurs.
4. Learning of procedures, facts, and concepts occurs within the context of finding a solution to the problem.
5. Specific procedures or algorithms are learned as needed.
6. Additional structure for learning is proportional to the experience level of the learner.
7. Much of the structure for learning is provided through in-depth questioning by the instructor.
8. Students using this process usually work in cooperative or collaborative groups to gain multiple perspectives on possible solutions.

Table 1: Critical Attributes of Problem-Based Education

1. Since learning occurs in an environment similar to that in which the students will work, the problem-solving skills they learn will be more easily transferable to that work environment.
2. Students no longer learn facts, skills and concepts as separate entities, but instead see how these can be interconnected to solve real problems.
3. Students develop their own unique problem-solving skills which allow them to reason through ambiguous situations in which solutions are not easily obtained.
4. Students are more easily able to evaluate their own solutions to problems to determine their "reasonableness."
5. Students are better able to coordinate their thought processes with others from different disciplines.

Table 2: Critical Attributes of Problem-Based Learning

education a success include: (A) establishing an environment of trust; (B) designing and developing the problem; (C) implementing the problem; (D) establishing structure; (E) researching the problem; (F) allowing students to develop solutions; and, (G) evaluating.

A. Establishing an Environment of Trust

This first element cannot possibly be overstated. The teacher must establish rules of engagement in the class from the beginning. The instructor must continually work on maintaining that environment. This allows students to pose ideas and/or solutions without the fear of being told "no." It is important, then, that the teacher refrain from using that word as much as possible. While this may seem trivial or trite, students have been socialized for years within a system that gave them immediate feedback as to the correctness of their answers. This system rarely allowed the student to decide for himself/herself whether or not a correct conclusion had been drawn from the given data or information. Yet, students must learn how to evaluate their own solutions in order to become effective problem solvers. Faculty must remember that students need to practice their problem-solving skills as much as they need to learn subject-specific content knowledge.

Not only must the teacher change his/her "no" behavior, but other students must change as well. It must not only be "okay" to pose flawed solutions, it should be encouraged as long as the student has carefully considered that solution and is willing to evaluate it with helpful input from other students and/or the teacher. Here, the teacher's role changes from giver of information to facilitator of the problem-solving process. Generally this facilitation takes the form of questioning so that a student comes to understand his/her thinking process and then determines the correctness of the posed solution. This is a very difficult technique for most faculty to employ. It is so much easier to immediately evaluate the solution for the student and quickly state what is wrong. Again, this does not allow the student to develop his/her own strategies for determining the "reasonableness" of a solution.

B. Designing and Developing the Problem

Through the PROBE project, we have found that by far the most time consuming and difficult part of true problem-based instruction is developing a "good" problem. Without such a problem, much of the rest of the instruction will be of little value. A "good" problem has several distinctive characteristics: (1) the problem must be as authentic as possible; (2) it must be complex(ill-defined) and cover multiple learning objectives; (3) it must have multiple solutions which may be equally valid; and finally, (4) it must have established boundaries so that its solution takes a "reasonable" amount of time.

Authenticity refers to the way in which the problem emulates a problem found in industry or other authentic work settings. Whenever possible, the problem should actually be derived from those settings. Generally, contrived problems are perceived by students as "busy" work that have no real application in the world of work. The goal in the problem-based classroom is to <u>approximate</u> true industry or work conditions. Most industrial problems are so complex as to pose impossible time requirements on students, therefore it is incumbent upon the problem designer to maintain the essence of an authentic problem while making it solvable in a realistic educational time frame.

While authenticity of a problem is important, it is also important that stated goals and/or content objectives of the course are accomplished. The problem, then, should be developed in such a way as to "cover" the same number of course objectives that would normally be covered in the given time frame. That is, if you expect to take 3 weeks solving a problem, then that problem should cover 3 week's worth of objectives that would normally be taught in a traditional course. This allows students to develop problem-solving skills without missing any of the basic set of objectives they would get from a traditional course in the same subject area.

Whenever possible the problem should be ill-structured and/or ill-defined. This is normally the case with authentic problems. An ill-structured problem is one that requires students to make assumptions and set boundaries. These assumptions and boundary conditions should be listed and become part of the problem solution. Students may need to even further define the problem as their knowledge and abilities grow.

Most of the time, a "good" problem should allow individual students or groups of students to reach differing solutions which are equally valid. Many students have difficulty in understanding that there may not be one "right" solution for a given problem. One of the special characteristics of problem-based education is that it encourages students to develop their own unique solution and ideas about solving a problem. This does not mean that they shouldn't incorporate many standard and well established ideas about solving a particular problem. It simply means that within the context of solving the given problem, students may apply what they learn in multiple ways to reach a valid solution. The instructor should encourage multiple as well as unique solutions to the various aspects of the problem. The instructor should also encourage each student to clearly identify the thought processes necessary to justify the solution. No solution should ever be taken without explanation.

Establishing "reasonable" time limitations for any problem can be a bit tricky. Most of us work in educational settings which tend to have specific requirements and unique limitations. In the PROBE project, the length of time given students for problem-based learning has varied from as little as two weeks to a full semester and on to a full year, incorporating 3 quarter long courses. Faculty must decide for themselves how long they wish to spend in the problem-solving process.

C. Implementing the Problem

In order to successfully implement problem-based education, the facilitator must first introduce it to the learners. Most learners will be resistant, at first, to any new teaching/learning approach. Most learners have grown accustomed to very specific instructional structures and have developed appropriate skills to fit within those structures. When presenting this new approach to students, the instructor must find ways to explain the "why" of problem-based learning. It is crucial that students have some idea about what is to be expected of them in this new structure. It is vital to the students that they understand how and when they will be evaluated in this structure. The facilitator should be able to answer those questions reasonably well. The facilitator should be able to explain how long the problem-based portion of the course will last, share specific strategies which will ensure that students are successful, express specific evaluation criteria and provide examples from previous problem-based learning setting when possible.

The actual implementation of problem-based education always begins with the problem. The problem must come FIRST in the instructional process. It is the problem which provides the reason for learning, but more importantly the problem defines the context in which learning will occur. The context in which learning occurs then defines what is to be learned and how it will be learned. This first step in implementing problem-based learning is exactly the **reverse** of most traditional teaching methods in engineering and technical courses. Traditional teaching techniques generally call for the presentation of concepts, skills and procedures first before they are applied to a more complex problem. In problem-based education, the problem drives what is learned. Again, all concepts, skills and procedures are learned within the context of solving the problem.

D. Establishing Structure

The type of structure that a facilitator establishes for the problem-based instruction will determine what the facilitator will do and what the students will do throughout the course of solving the problem. The amount of structure imposed on the process should be inversely proportional to the amount of experience the students have with the subject matter and with problem-solving in general. The amount of structure imposed should also be inversely proportional to the amount of experience the facilitator has with the related teaching methods. In other words, if the facilitator has been using cooperative group work for some time, then it is appropriate to incorporate the use of cooperative groups in problem-based instruction. If, however, the facilitator has little or no experience using cooperative groups, then he/she should implement only one of the new methods at a time. We suggest using cooperative groups first before trying problem-based instruction. The remainder of this paper assumes the incorporation of cooperative learning within problem-based education, but it is clear that this is not required.

There are a number of different types of structure that the facilitator may use to guide the students through the problem-solving process. These include traditional lectures, individual help sessions, facilitated cooperative group work, tutored cooperative group work and cognitive modeling. The latter three of these relate to the research cycle which should be incorporated in combination with the structure. However, any of the five structures listed may be used alone or in combination. The research cycle is described later in this article.

Traditional lectures provide a great deal of structure, but may allow students to move into the problem-based method gradually. Using this type of structure, the facilitator presents the problem first and then proceeds with traditional lectures over the course of the given problem-based learning period. These lectures should be aimed at the solution of the problem and should allow for class time to answer questions pertaining to the solution of the problem. With this type of structure, students tend to be more interested in the lectures and realize that the problem validates the need for learning specific concepts presented in the lectures.

Individual help sessions may be used in conjunction with traditional lectures, especially if the students are required to solve the problem on their own. In this case, the facilitator makes time for students to work specifically on the solution of the problem. The facilitator must take great care to understand the student's perspective on the problem solution. This is particularly the case when a student is developing a solution which is valid, but markedly different from the way in which the facilitator would solve the problem. In order to best understand a student's perspective the facilitator must take advantage of "why," "what," and "how" questions. The facilitator should force the student to explain not only what was done, but how the student reached particular conclusions. The facilitator's role here is to guide the student into understanding his/her own thought processes and to determine the validity of those thought processes for himself/herself.

The other three structures listed above will be described with the "research cycle" which really becomes the heart of problem-based learning in its truest form. The structure provided simply determines how students will go through researching the problem.

E. Researching the Problem - The "Research Cycle"

In most instances, the second crucial part of problem-based education is the "research cycle." The research cycle is usually conducted immediately after the problem is presented. The research cycle should become an integral part of the problem-solving process. Problem-based education works best when the students perform the "research cycle" carefully and multiple times during the problem-solving process. The "research cycle" consists of four main parts: (1) generating hypotheses; (2) determining what the students know; (3) determining what the students need to know; and (4) developing an action plan.

Most of us when faced with a problem, no matter how complex, immediately want to jump to an answer. Students are no different. Most students' initial response is to try to formulate a solution, even if it's trivial or ill-conceived. In most cases, this initial solution formulation should be encouraged. One should allow the students to spend some time in thinking about what the solution might be, or at least what the solution might look like. All of this should be recorded for later use and revision.

After students have exhausted their initial efforts at solving the problem, they should be guided into thinking about what they know at that particular moment, about the problem that might help them solve it. This should almost be a brainstorming session. Anything that seems pertinent should be recorded. These activities support what students rarely do--take the time and effort to decide what they know about the problem.

Next, the students should be required to examine what they do not know or better, what they need to know about the problem. This is often a little more difficult than listing what they know, but with some help, students usually are able to make a good listing of some of the things they need to know in order to solve the problem. This should and will change over time. However, this first list of needs allows the students to generate an action plan for starting the problem solution.

The action plan should include a specific listing of everything that the students need to know about the problem. With each of the listed "needs" the students should specify where that information can be found. If the students are working in cooperative groups, then each group should specify who is responsible for finding certain information and designate a time frame for finding it. The facilitator should have an excellent grasp of campus resources available, as well as possible industry or other resources which might be usable by the students. This may be a time when the facilitator should even suggest possible alternatives for resource gathering and provide any needed guidance in the gathering process. During the implementation of the PROBE project, it has been noted that students often need a real incentive for taking the action plan seriously. One incentive used has been to evaluate group work and written action plans. Students should be required to stay in the research cycle long enough to develop an action plan which might look something like an industry plan for solving the same problem.

Both facilitated and tutored groups work well in combination with the research cycle. In either case the groups are asked to develop group hypotheses and conclude with group action plans. In the case of facilitated groups, the instructor acts as the facilitator for each group, joining the cooperative groups and providing input when necessary to help the students push their thinking in the research cycle. It is almost a necessity that facilitated group work be done during class time. In order to make group work most effective, class time should be provided whenever possible. The instructor should facilitate group processes by asking questions and suggesting answers only when absolutely necessary.

Likewise, the tutor for a group should act in the same way. Tutors for groups usually come from students who have already had the course or are upper-level students. It is extremely important that the tutors learn their role as facilitator and not as answer giver. This may take some special training which must be provided before problem-based education is undertaken. Tutored groups work well when the tutor truly facilitates the problem-solving process. Tutored groups are typical in medical school versions of problem-based education.

After students have developed an action plan, they must carry it out. If the students are working in groups, they have provided a time frame for finding certain information. At the time frame provided, they should return to the group and share the information found. At this point, the research cycle should be repeated. Students should update and test hypotheses while reformulating action plans. This may be repeated as often as necessary, depending upon the time frame for problem solution. It may be that during the formulation of action plans, the facilitator notices that many groups or individuals are interested in learning information which would normally be part of a lecture. The facilitator could suggest that time be taken for that lecture which would become a resource for all interested groups.

Cognitive modeling can be utilized at any point during the problem-based experience; however, it is often most effective when used at the beginning. One of the purposes of problem-based education is to help novices become more like expert problem-solvers in a particular content domain. One way to help this come to fruition is for the expert (the facilitator) to model the problem-solving process. This can be done by utilizing an example problem which would be fairly similar in complexity to the problem the students will be working. The teacher should spend time going through the research cycle with the students utilizing this example problem. The facilitator should work to express what he/she is thinking throughout the process of developing the research cycle. This provides an enormous insight into how an expert thinks about a complex problem. Simultaneously, it provides a key model for what will be expected from the students when they progress through the research cycle and ultimately develop an action plan.

F. Allowing Students to Develop Solutions

Whether the students are developing their problem solutions independently or as part of a group, they should be encouraged to try new ideas and propose imaginative solutions. That does not mean that any outrageous solution is acceptable. However, each may have a unique way of looking at the solution to the problem. If the solution path is valid, then the student should be encouraged to follow it, even if it is not necessarily the most efficient solution (except in cases where efficiency is the goal of the problem solution).

At some point during the problem-solving process, it almost always becomes apparent that the students as a whole have a gap in their understanding. This gap is caused by the fact that students simply don't know, they don't know. This becomes a critical point for problem-based education, but if handled carefully, can become a very powerful experience. There are a number of ways of dealing with this point, but the most direct is simply to express to the students the gap which has appeared and to use a lecture or other resource designed to fill that gap. In other teaching vernacular, this time is often known as a "teachable moment." After the gap is filled, it often becomes an "ahah" experience. Sometimes students wonder why the facilitator has been "holding out on them." Yet, if what is taught is timed correctly, the level of understanding is immensely greater than it would be if the subject had been presented earlier. Understanding is directly related to the problem and therefore is enhanced though the context.

G. Evaluation

Evaluation should have at least two components in problem-based education. The facilitator should employ on-going assessment of both individual problem-solving and group/class problem-solving. One of the advantages of problem-based education is that the facilitator should know where each student falls along a continuum of understanding of content and problem-solving abilities. Later, more formal evaluation techniques should, then, basically confirm that which the facilitator already knows.

Formal evaluation of problem-based learning can be done in a multitude of ways. These range from the traditional content-oriented tests to mini-problem-solving activities. There is absolutely no reason why the same tests used in traditional class settings could not be used with problem-based education. These generally do a good job of showing content knowledge, but often don't provide much information about higher level problem-solving skills. However, tests for such skills may be unnecessary if the process and product of the problem-solving activity is also evaluated.

One critical item in evaluation with a problem-based approach involves frequency. This mostly applies to formal evaluation, since informal evaluation is on-going. Still, if one problem takes multiple weeks or a semester to resolve, it may be necessary to find formal ways to evaluate progress. These may take the form of requiring intermediate action plans to be submitted for grading. It is even possible to used content-oriented tests before the resolution of the problem solution.

If the instructor is using groups, it is important to take advantage of group evaluation techniques. These can range from group grades to group incentives on formal evaluations. There are many cooperative group evaluation techniques which should be explored by anyone interested in using a combination of cooperative group techniques and problem-based education.

IV. PROBLEM-BASED EDUCATION IS IMPORTANT - YOUR HELP IS NEEDED!

The obvious benefits accrued from problem-based education are not without a price. Significant planning and effort are required to effect success through problem-based instruction. Paramount to this is the need for high-quality, realistic problems with accompanying resource materials. The PROBE Project is presently developing problems and materials in technology, engineering, mathematics, and science education.   These resource materials include video of various classes in transition from more conventional lecture/laboratory formats to that of problem-based instruction. Our intentions are to make these materials available to others for direct use, modification as may be appropriate, or simply as models for materials development and application. Based on project experience to date, the availability of such materials is instrumental in speeding the application of problem-based approaches. Of course, having high-quality problem-based educational materials that fit even very limited needs and applications of such diverse disciplines requires a major effort, if it can be accomplished at all. However, even where the developed problems are inappropriate for direct use, their consideration and review can be of tremendous benefit to those who have serious aspirations in the problem-based educational arena.

The PROBE Project is committed to becoming one of the enabling forces in problem-based education in technology, engineering, mathematics and science education where possible. To this end project plans go beyond the mere development of problems and materials to:

1. Develop a World Wide Web Site dedicated to the distribution of high-quality information and materials database relating to problem-based education within these disciplines and linking to other sites offering networking advantages;
2. Solicit submissions and act as a coordinator for those who are willing to develop and share problem-based educational materials;
3. Develop a peer review process for the evaluation of problem-based learning database materials submissions;
4. Facilitate on-line information exchange among those within technology, engineering, mathematics and science education who have problem-based learning interests;
5. Publicize the availability of the database and individual/institutional participants; and,
6. Perpetuate the development and use of problem-based education within technology, engineering, mathematics, and science.

Clearly, these cannot succeed without the enthusiastic support of this educational community. Our hypothesis is that there are many who are interested in using and developing problem-based education within their programs. By offering peer review, publicity, informational exchange and distribution services, we hope to promote the quality, use, and standing of participant educational products.

You, the reader, are important to the success of problem-based education within technology, engineering, mathematics and science! We seek your input and association with this effort.

We are looking for:
1. Volunteers to serve on a Web Site Advisory Committee;
2. Experienced and inexperienced individuals willing to serve as peer reviewers;
3. Problem and materials developers; and,
4. Interested faculty from all areas willing to share ideas and problem-based educational techniques.

It's easy to become a part of this activity. You may contact either author via our Web site - www.Rose-Hulman.edu/~PROBE: email: Buck.Brown@Rose-Hulman.edu or Buck.BrownJR@Rose-Hulman.edu: FAX 1-812-877-8102; or simply call 1-(800) 248-7448. This is a standing offer but we hope you will contact us as soon as possible!

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Buck F. Brown, Sr. served 13 years as Professor and Head of the Electrical and Computer Engineering Department at Rose-Hulman Institute of Technology. He also served as Program Director for the National Science Foundation's

Instrumentation and Laboratory Improvement Program. He is currently Dean for Research and Graduate Studies at Rose-Hulman where he uses problem-based methods in conducting a year-long research seminar.

Buck F. Brown, Jr. is the PROBE Project Director. He is experienced in conducting problem-based education workshops and has worked closely with WVEA members in implementing problem-based education within their classes. He has a B.S. and M.S. in education with special emphasis and experience in mathematics and multimedia educational methods. He is currently a Ph.D. candidate at Indiana University in Instructional Systems Technology.