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Chapter 1 : Conclusions and Future Directions - Freshman Monroe Scholars Summer Research Projects

Conclusions and future directions PETER PETROS (*) Conclusions The aim of Part 2 was to directly challenge the Theory Clinical results from Studies

DBER can be a field of study within any academic discipline, in the sciences and beyond. However, because this study focused on education research in a select set of science and engineering disciplinesâ€"physics, chemistry, engineering, biological sciences, the geosciences, and astronomyâ€"this report uses the term DBER to refer only to these disciplines. The previous chapters have described the current status of DBER; synthesized peer-reviewed, empirical research on undergraduate teaching and learning in the sciences and engineering; and examined the extent to which this research currently influences undergraduate science and engineering instruction. By presenting conclusions and recommendations that draw on the key findings and directions for future research from previous chapters, we describe here the intellectual and material resources that are required to further develop DBER. The conclusions are grouped into four areas: Translating DBER findings into practice 4. At present, DBER is a collection of related research fields rather than a single, unified field. The term DBER is best thought of as an overarching term that refers to a set of distinct fields that have emerged over several decades across multiple disciplines. The individual fields of DBER share the overall goal of improving learning and teaching in a discipline through the use of findings from empirical research. The National Academies Press. However, each field is tightly coupled to its parent discipline, which gives rise to differences across the fields of DBER, such as in the history of development, professional pathways for researchers, and emphasis of research. As described in Chapter 2 , the fields of DBER share some common milestones in their development that reflect the larger context of science and education. Yet the developmental trajectories of the DBER fields differ. Physics education research was established earliest, followed by chemistry education research and then engineering education research. Biology, the geosciences, and astronomy education research have emerged more recently. The fields that emerged later appear to have benefitted from building on and borrowing from the more established fields in DBER, especially from physics education research. The parent disciplines for each field differ in terms of how readily they have embraced research in education, and the availability of venues for publishing research. Chapter 2 describes how such differences continue to shape the way research is conducted in each field of DBER and the paths that scholars can follow to gain expertise in DBER. The fields of DBER have made notable progress in establishing venues for publishing and in gaining recognition from their parent disciplines. However DBER scholars still face challenges in identifying pathways for training and professional recognition. Each DBER field has one or more professional organizations that support education research through policy statements, publication venues, and conferences. As discussed in Chapter 2 , many of these professional homes are sections of larger disciplinary professional societies. Some tension exists between publication venues intended to share research findings among researchers and venues intended to inform instructors of the findings of DBER that might be useful in their classrooms. Pathways to establish interdisciplinary research such as DBER are not straightforward. Tenure and promotion committees may not take into account the time and energy necessary to become acculturated into a new field, which poses particular challenges for nontenured DBER faculty. In a different vein, institutions and disciplinary departments do not always recognize the distinction between education specialists whose primary focus is on teaching and DBER scholars who conduct research on teaching and learning. As a result, expectations for DBER faculty regarding teaching, research, and service can sometimes be imbalanced see Chapter 2. Page Share Cite Suggested Citation: DBER encompasses a range of research goals and emphases that span the continuum from basic research that provides insights into fundamental learning processes to applied research on effective designs for instruction carried out in actual classrooms. Although an overarching goal of DBER is to improve undergraduate learning and teaching, individual studies do not always have a directly applied component. Instead, as in other areas of science, the DBER that is synthesized in Chapters 4 through 7 includes a blend of studies with immediate application in the classroom and those that explore more basic questions. Basic research in DBER might examine why students hold particular understandings, beliefs, and ideas some of them incorrect or why one instructional intervention is more effective than another. High-quality DBER combines expert knowledge of a science or engineering discipline, of learning and teaching in that discipline, and of the science of learning and teaching more generally. A long-term goal of DBER is to understand how people learn science and engineering in order to improve learning and teaching. Research that advances this goal must be grounded in an understanding of what it means to develop expertise in a discipline and the challenges inherent in developing that expertise. At the same time, individual studies must be informed by a working knowledge of existing findings related to learning and teaching in a discipline, and more broadly, an understanding of the methods that are appropriate for investigating human thinking, motivation, and learning. These methods are often drawn not from the parent science or engineering discipline, but from disciplines in the behavioral and social sciences such as psychology, sociology, anthropology, and education. Bringing together the diverse expertise required poses a challenge that can be met in a variety of ways. As described in Chapter 2 , individual researchers can begin to develop the necessary expertise through well-crafted graduate and postdoctoral programs. The required integration of expertise can also be accomplished through collaborations that range from two individuals in different disciplines e. Many DBER scholars, their disciplinary colleagues, professional societies, and funding agencies are motivated by the need to reform science and engineering education in ways that are informed by DBER findings. And, as in any discipline, DBER scholars strive for high-quality research. Education research centers, funding programs, and some journals blend both of these goals. Clearly articulating the distinction between discipline-based education research and the application of DBER findingsâ€”and embracing the value of bothâ€”is important for ensuring continued advancement of the research, promoting improvement in undergraduate education, and enhancing synergies between these efforts. In all disciplines, undergraduate students have incorrect ideas and beliefs about fundamental concepts. Students have particular difficulties with concepts that involve very large or very small temporal or spatial scales, in part because they lack an experiential basis from which to develop an understanding about these concepts. Across all disciplines, the education community needs a better understanding of those that pose the biggest challenges to learning at the undergraduate level, how they arise, and how to help students align them with scientific explanations. Undergraduate science and engineering learning, like all learning, occurs against the backdrop of prior knowledge. Students at all levels, from preschool through college, enter instruction with various commonsense, but incorrect, interpretations of scientific and engineering concepts, as well as personal beliefs that can affect their learning. DBER studies have identified a wide range of incorrect ideas and beliefs related to such fundamental concepts as electricity, magnetism, the nature of matter, phase changes, evolution, and deep time. The most productive lines of research involve concepts that are central to the discipline and focus on incorrect understandings that are widely held Page Share Cite Suggested Citation: By drawing on expert knowledge of which concepts are central to a discipline and expert understanding of those concepts, DBER offers a unique contribution to this research. DBER scholars in engineering, biology, the geosciences, and astronomy are beginning to identify incorrect ideas and beliefs to determine which concepts are more difficult to learn than others. This research often is coupled with instructional techniques that are targeted at eliminating a specific erroneous belief. In physics and chemistry, some DBER scholars have begun exploring whether some classes of misconceptions are connected by a common underlying cognitive structure. Identifying such common structures may facilitate the development of instructional strategies that address large classes of misconceptions, rather than addressing them one at a time. As novices in a domain, students are challenged by important aspects of the domain that can seem easy or obvious to experts, such as complex problem solving and domain-specific representations like graphs, models, and simulations. These challenges pose serious impediments to learning in science and engineering, especially if instructors are not aware of them. The ability to solve complex problems is central to science and engineering. Problem solving has been extensively studied in cognitive science, physics education research, chemistry education research, and engineering education research. It is an emerging area of study in biology education research and geoscience education research. A considerable amount of cognitive science and discipline-based education research addresses well-defined quantitative problems. Except in engineering and chemistry, considerably less research exists on ill-defined, open-ended, or context-rich problems, which are more characteristic of what scientists and engineers encounter in their professional lives. Chapter 5 shows that across the disciplines, students have difficulty with all aspects of problem solving and they approach problem solving differently than experts. Equations, graphical displays, diagrams, and other representations feature prominently in problem solving and other scientific and engineering activities. The disciplines differ in terms of how problems are specified and the conventions for representation, and many of these representations are Page Share Cite Suggested Citation: To flourish in science and engineering courses and careers, students must become fluent with the discipline-specific approaches and representations used by experts in the field. Students begin this process as novices, and, with targeted assistance, can move toward expert-like understanding. Along the way, how students create, use, and interpret representations can provide insight into their understanding of important concepts in a discipline. Although equations, graphical displays, and other representations may seem easy to understand for undergraduate faculty who are domain experts, the research discussed in Chapter 5 shows that students have difficulty extracting information from these representations and constructing appropriate representations from existing information, regardless of discipline. For example, in chemistry, students have difficulty constructing particulate-level diagrams of chemical and physical phenomena. Students also have difficulty understanding the commonality of the underlying structure across different representations of the same phenomenon, such as imagining the three-dimensional distribution of earthquake epicenters when given a map showing earthquake depth and magnitude using both colors and symbols. Improving undergraduate science and engineering education involves integrating proven strategies for general instruction with strategies designed to explicitly target challenges that are unique to science and engineering or to a specific discipline. As discussed in Chapter 6 , a considerable amount of DBER examines instruction that is based on established learning theories and principles. Consistent with research from cognitive science, educational psychology, and science education, DBER indicates that involving students actively in the learning process can enhance learning more effectively than traditional instructional methods, such as lecturing by a professor. Exemplary methods include making lectures more interactive, having students work in groups, incorporating authentic problems and activities, and promoting metacognition. These strategies are not discipline-specific, and range in scope and complexity from slight modifications of instructional practiceâ€”such as beginning a lecture with a challenging question for students to keep in mindâ€"to completely redesigning the learning space. Overall, DBER does not yet provide evidence about the relative effectiveness of various student-centered strategies or whether any of these strategies are differentially effective for learning certain types of content. The findings and the gaps in current understanding discussed in Chapter 6 suggest that effective instruction includes a range of well-implemented, research-based approaches. Similarly, Chapter 5 discusses specific instructional strategies that have been shown to help students create, use, and interpret graphical representations. The use of learning technology in itself does not improve learning outcomes. Rather, how technology is used matters more. Chapter 7 shows that evidence on the efficacy of widely used technologies such as animations and personal response systems clickers is mixed. Clickers are small handheld devices that allow students to send information typically their response to a multiple choice question provided by the instructor to a receiver, which tabulates the classroom results and displays the information to the instructor. The most compelling evidence on their use shows that learning gains are associated only with applications that challenge students conceptually and incorporate socially mediated learning techniques, such as having students work and be assessed collaboratively. Taken together, this research demonstrates that how technology is used matters more than simply using technology. For technology to be effective, instructors must be aware of the conditions that support the effective use of technology and incorporate it into their lessons with clear learning goals in mind. Across all disciplines and all topics of inquiry in DBER, relatively few studies explore whether or how learning and responses to different instructional approaches vary by key characteristics of students such as gender, ethnicity, and socioeconomic status. As a result, current knowledge of similarities and differences among student populations is severely limited. With few exceptions, DBER has not examined variation across different populations of students, such as those with different demographic characteristics or ability levels. Similarly, very little DBER conducted in the context of introductory courses distinguishes among outcomes for majors versus nonmajors. The relative lack of attention to group or individual differences reflects, in part, the foci of DBER to date. Early DBER has studied major trends in learning and teaching before undertaking explorations of subgroups.

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Chapter 2 : 9 Conclusion and Future Directions - Oxford Scholarship

12Â° CONCLUSIONS AND DIRECTIONS FOR FUTURE WORK We see the major contributions of this monograph to be: PART I: (i) Introduction of a very simple ~s~del of database systems and the.

For each case study, the committee illustrated how its framework could be applied; it defined the specific decision options to be compared and developed a risk-attribute table to characterize the public-health consequences of the alternative decisions; and it provided a discussion of how the risk characterization could be used to support the specific decision options being compared. General conclusions and suggestions for future directions are provided at the end of the chapter. The decision focus of the framework, specifying and comparing the outcomes of specific decisions, did not come naturally to committee members who had more detailed scientific expertise related to FDA products and product categories. They were initially inclined to look more broadly at the effects of the product being considered, and some iteration and detailed discussion were necessary to narrow the focus of discussion to the comparison of specific options. For example, in discussions about the evaluation and comparison of the risks associated with various food products Chapter 4 , the committee was initially tempted to include a discussion of the health benefits of each food product as Page Share Cite Suggested Citation: The National Academies Press. After focusing on the decisions that the comparison might be used to support that is, allocation of food-inspection resources , the committee determined that the focus should be on the risks and, more specifically, on the risks that could be averted by improved or more rigorous inspections. The committee notes, however, that the targeting-decision case study did not explicitly compare the health consequences of the current inspection processes with those of changes in the inspections; if that decision were to be evaluated, additional steps would be necessary. The decision analysts on the committee were able to focus the subject-matter experts on a relatively constrained decision context, to identify the sequence of information needs, and to assist the subject-matter experts in making judgments about the array of possible effects on the basis of sparse data. The decision analysts, of course, could not provide the specialized and detailed knowledge necessary to identify and recognize the most relevant data for a specific decision context. The committee was hampered in one case study the effects of potential melamine contamination of infant formula by the lack of detailed subject-matter expertise among the committee members; as a result, the committee had much less confidence in the estimates of the risk attributes of the case study than in the estimates of the other three case studies. In all case studies, the discussions and interactions between committee members with different backgrounds and expertise were critical for the use of the risk-characterization framework. On the basis of its experience, the committee concludes that FDA will benefit from including multiple stakeholders in its decision-making process, from defining decisions to gathering information and ultimately formulating conclusions. Just as shared decision-making Charles et al. Defining the Decision Context The committee found that it was critical in each case to define the decision options to be evaluated and compared clearly, so that appropriate risk information for the decision-making process could be obtained. In all cases, decision-analytic structuring was used to organize thinking about the decision context. Analytic reasoning and basic structuring tools, such as influence diagrams see, for example, Figure , were used to identify the various factors that needed to be considered to develop estimates of the public-health consequences of the alternative decision options. For mitigation-selection decisions, as illustrated with the vaccine-withdrawal case study in Chapter 3 , defining clear and distinct decision options to be compared was straightforward. Although the example was deliberately chosen to be a simple comparison of a yes-no variety, it would have been easy to Page Share Cite Suggested Citation: For targeting decisions, as illustrated with the evaluation of three food categories in Chapter 4 and the evaluation of melamine testing in Chapter 6 , defining the decision context and the options to be compared was more complex. In fact, the food case study focused on comparing the health consequences associated with consumption of the different food categories but stopped short of evaluating different resource allocations. The evaluation and comparison presented in Chapter 4 could be used to support a risk ranking or could be used as one input into a targeting decision. For example, if FDA were deciding where to target additional food-safety inspection resources, understanding the public-health consequences as characterized in Chapter 4 would be an important input. As described in Chapter 2 , for targeting decisions, the options or alternatives theoretically available to FDA are vast; virtually any amount of a resource could be allocated to the identified products or product categories and is constrained only by the total resources available. However, before substantial time and effort are invested, the many options possible need to be narrowed judiciously, and such narrowing will necessarily involve input from FDA management in addition to the technical staff. Finally, strategic-investment decisions, as illustrated by the evaluation of enhanced surveillance of medical implants in Chapter 5 , proved the most difficult to formulate and evaluate with the framework. In theory, defining the options for this case studyâ€"current surveillance compared with enhanced surveillanceâ€"was simple. In practice, however, the committee members had to speculate about the details of what an enhanced surveillance program would entail to enable them to estimate its effects. That proved to be a difficult task and one that clearly had substantial effect on the estimates derived. As described by FDA Bertoni , strategic-investment decisions are typically long-term capacity-building investments. Characterizing the Public-Health Consequences of Each Option For each case study, various tools were used to develop the estimates necessary to characterize the public-health consequences and populate the attribute tables shown in each case study. In some cases, the quantities of interest could be estimated directly from available data; for others, several stepsâ€"some with considerable uncertaintyâ€"were required to generate estimates. In simple cases, exploratory descriptive statistics and bounding analysis were used. For example, estimates of the number of people exposed to the risk of foodborne illness caused by pathogens in leafy greens required an estimate of the number of people who consume leafy greens in a year, which could be based on readily available information on food consumption. In more complex cases, a series of estimates and relatively complex calculations were used to derive estimates for the attribute table. For example, estimating the number of deaths that might occur Page Share Cite Suggested Citation: To develop the final estimate, the committee had to identify and structure the various factors and their relationships, estimate each of the critical factors by using a combination of descriptive histories, bounding analyses, and judgment , and calculate the resulting numbers in this case, using Monte Carlo simulation methods. The risk-characterization framework provides guidance on the estimates that are necessary to compare decision options but not on how those estimates are to be developed. In working through the case studies, the committee encountered several challenges that FDA will also face in applying this framework. Some of the challenges are discussed below. Challenges in Finding and Interpreting Data The success of the proposed risk-characterization framework depends on the ability to populate the attribute table. Common challenges among all case studies were finding and interpreting data to support the required estimates. In the vaccine-withdrawal case study described in Chapter 3 , for example, determining the excess risk of intussusception attributable to the vaccine was difficult; there were few data on the background rate of intussusceptions and little information on whether the rotavirus infection might cause intussusceptions in some cases. There was also speculation at the time that the cases of intussusceptions occurring after vaccination would have happened anyway: For the food case study described in Chapter 4 , there were several data challenges. The industry segment is so large and diverse that information on volumes, producers, and distribution is not readily available. The committee chose a simple measure of the size of the exposed population the number who consume any of the product over the course of a year partly because more detailed data about annual consumption and consumption quantities were not readily available. An additional complication for many food categories is the lack of morbidity and mortality data. Although information exists on the estimated number of illnesses, deaths, and hospitalizations because of foodborne pathogens generally, no direct data exist on the attribution of those illnesses to specific commodities. The committee used other sources of data and made a number of assumptions to support estimates of the attribution of the illnesses to the specific food categories. In the melamine case study described in Chapter 6 , the committee was severely hampered by lack of data. Regardless, the committee was able to estimate attribute values by using the available data, assumptions, and judgments and to produce a table that would have been helpful for decision-making. The case study on strategic-investment decisions described in Chapter 5 highlighted some additional challenges. Although lack of data is clearly a problem, inaccuracies in the available data are barriers to accurate evaluations and make it difficult to identify newly emerging risks. Furthermore, when data are difficult to obtain because they are in multiple locations and in inconsistent formats, developing the required estimates is again hampered. Thus, having data in a format that will support decision-making is clearly advantageous. For example, in the case study on strategic-investment decisions, the committee observed that a simple count of adverse event reports in the databases MAUDE and MDR databases does not yield a suitable estimate for determining the probability of an adverse event. There is potential for both over-reporting and under-reporting in the information contained in those databases, and there is no information on the total number of devices implanted. Furthermore, it is unclear in the reported data whether an adverse health effect suffered by a patient who has a medical device is a result of the device or is a result of some cause unrelated to the device. In some case studies, the committee did not have much direct information; in others, a large variety of data were available. In all cases, assumptions were necessary about how to interpret the data to complete the risk-attribute table. Those challenges arose partly from the fact that the specifics of the enhanced surveillance system had to be hypothesized, and it was not clear precisely what new information would be attained or how it might be used. As discussed in that case study, for example, it is clear that better information would reduce uncertainty in the estimated number of adverse health effects which would reduce the range between the 5th and 95th percentiles , but it is not possible to estimate what the new range would be before collecting the information. Some type of expert judgment is always required in evaluating and comparing the potential outcomes of different decisions. Within the risk-characterization framework, decision options are to be evaluated and compared on the basis of whatever type, quantity, and quality of data are available when the decision must be made. That flexibility allows risk information to be considered by decision-makers for any risk-relevant decisions even if detailed quantitative risk analyses are not available. The framework provides a structured way to document the data and the associated expert judgments clearly; as the framework is used more extensively, some of the analyses and data sources used for earlier studies can be leveraged to make related studies less burdensome, although some new data and new expert judgments will probably be required. Using the Risk Characterization to Support Decision-Making The risk-attribute table provides a succinct comparison of the decision options that were evaluated and should be useful to decision-makers interested in understanding the key differences in the public-health consequences of those options. The comparisons alone, however, are not likely to provide all the decision-relevant information that decision-makers and policy-makers need to consider, nor are they intended to do so. The focus of the framework is to enable a comparison of the potential public-health outcomes of different decisions and to provide a common language for discussing those consequences within FDA. The committee concludes that such risk information is relevant to many FDA decisions and that clear characterization of the consequences will lead to more consistent consideration of those issues. As discussed in Chapter 2 , however, the committee clearly recognizes that many other factors must be considered by FDA in its risk-management decisions. The case studies illustrate that careful examination of the attribute table may lead to clear conclusions about the relative public-health consequences of different options, as in the mitigation-selection case study in which one option dominated the other. That will not always be the case; the summary table may simply highlight that one option is better on some attributes but worse on other attributes than the alternative, as in the comparison of food categories. In the latter case, the FDA may ultimately want to consider more formal approaches for weighing the tradeoffs among the different risk attributes to determine which option, on balance, would be preferred in terms of public-health consequences alone, as discussed in Chapter 2. Extending the Framework to Estimate the Value of Information When scientists conclude that more or better information is necessary and time and resources are available to obtain that information, the risk-characterization framework can be used to highlight what type of additional information on public-health consequences would be most useful by using the decision-analytic concept of the value of information. As discussed in Chapter 2 , new information is valuable only if it has the potential to change decisions and thus potentially improve outcomes Clemen Two of the case studies provide some insight into the potential value of information: The former focused specifically on evaluating and comparing the public-health consequences of two levels of information collection the current system vs an enhanced system. The latter included discussion of an extension of the case study to one in which alternative decisions would be explicitly included in the evaluation. In the context of the decision-relevant value of an enhanced postmarket-surveillance system, many changes in decisions may result from the gathered enhanced information, including possible device recalls, revised guidelines for patient selection or patient monitoring, and different device designs. If decisions to take different actions lead to different health outcomes or lead to other decision-relevant aspects, such as operational efficiencies, public perception and trust of FDA, or political support for FDA activities , the enhanced system will have delivered information of value. The committee found that framing the evaluation in a decision context was more straightforward and created an evaluation that would be more relevant for decision-making than simply conducting a risk ranking of products or product categories. The committee found that a risk-characterization framework could be developed with a relatively small number of attributes that are applicable within and among FDA programs. Those attributes can provide FDA with a common vocabulary for discussing risk-related decisions across centers and can be used as the basis of a consistent approach for including risk components in decision-making. There is a learning process for developing and refining the attributes, and comfort with the risk-attribute vocabulary grows over time. On the basis of its experience in developing the case studies, the committee found that it is possible to characterize decision options by using the risk attributes and that they could be estimated by using existing data and expert judgment. The judgments that were required were not always easy, and committee members were not always comfortable in making them, but in the end the committee concluded that the case studies would provide useful, relevant, and sufficiently accurate information to be of use to a decision-maker. FDA should consider using the concepts defined by the risk-characterization framework and particularly the risk attributes defined in the present report as a common language for discussing risk-related aspects of various decisions. In risk-related decisions, considering the outcomes of alternative decisions in terms of the attributes identified in the present report will begin to establish consistency in risk vocabulary throughout the agency and will build a base of understanding that will enable more detailed use of the approach for evaluating and comparing decision options in the future. As FDA begins to use the risk attributes and risk comparisons, such as those illustrated in the case studies for comparing decision options, it may find that some aspects of the method need to be modified. In its interactions with FDA, the committee came to recognize that in many cases the agency has a substantial amount of data but that the data are not collected, organized, or accessible in a format that is useful for supporting risk-based decision-making. More focus on developing and implementing structured decision processes that are based on clearly defined risk attributes and metrics will allow the agency to improve its approaches and mechanisms for collecting information. The committee emphasizes that simply collecting more data is not necessarily the best use of resources; collecting more relevant data and organizing them so that they are useful for decision-making is the key. The committee acknowledges that new data-collection approaches and efforts will require information management and technology support. The committee recognizes that precise predictions of the outcomes of different decisions based on the risk attributes may be difficult to develop. Data may be lacking, and scientists may be uncomfortable in making or even unwilling to make the necessary judgments to estimate the risk attributes. However, the committee emphasizes that decisions in which risk information could be valuable are made regularly and recommends that FDA use internal or external experts who are trained in and comfortable with decision analysis, risk assess- Page Share Cite Suggested Citation: The committee recognizes that FDA will need specific expertise, training, and staffing to implement the proposed risk-characterization framework consistently.

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Chapter 3 : Conclusions and future directions

9 Conclusions and Future Directions AnÂ´Ä±bal Ollero and IvÂ´an Maza Robotics, Vision and Control Group, University of Seville, Camino de los Descubrimientos s/n, Seville (Spain).

Conclusions and Future Directions August 23, by sehartzell As the summer is drawing to a close, I felt inclined to discuss the conclusions I reached with my Monroe project, reflect on several unanswered questions, and propose future directions for my research. Much of my research this summer was based on the premise that a better public understanding of the science behind environmental issues would lead to a better understanding of the issues themselves, and better preparation on the part of the public to make important policy decisions. For one thing, understanding basic concepts of climate, biodiversity, fossil fuel formation, and other topics aids in developing an understanding of the environmental issues they concern. A conclusion I reached from the freshman seminar course that inspired this project Beyond Petroleum as Fuel, taught by Professor Hinkle is that an understanding of the process of science is also critically important. Realizing that research is inherently slow-moving and replete with dead ends can help overcome, for example, the misconception that alternative sources of energy will materialize without political support. Through my research this summer, I uncovered another of the various roles that science plays in public understanding of environmental issues. As I concluded in my last post, the framework used to communicate scientific information to a non-technical readership may be even more important than the information itself. With any research project, flaws are most clearly recognized in the aftermath. The greatest weakness in my project, which opens up a fertile path for future research, is that I chose the books I read for a specific reason: I was interested in the topics they discussed. I am left with the nagging awareness that popular books on environmental issues will appeal mostly to those who are already interested in the topics they discuss. Since voting and, hence, policy decisions are made by a much wider subsection of the population, effective communication of environmental information must reach more than a specific interest group. Crafting a public environmental consciousness will require a widespread appraisal of all communication channels. Addressing the question of where most people get their information on environmental issues would be a good starting point for the continuation of this research project. If the answer to this question turns out to include news sources, a problem arises related to journalistic ethics. Can news sources incorporate the second premise? Should they do so, or is it their responsibility to remain wholly objective? When opinions are given in traditional news sources, both sides are, ideally, represented equally. Future research could investigate the most effective way to popularizes sources of information that are free to explore the second premise, and involve citizens in ethical discussions that incorporate a greater variety of viewpoints. A personal objective for this project was to improve my own writing. As a writer, I should also strive for an increased awareness of the first vs. While ethical judgments are powerful, I should keep them clearly separated from any scientific evidence I cite, to avoid compromising the integrity of the discipline. I thoroughly enjoyed my Monroe research experience this summer, and I am excited to explore new avenues as I continue my research of this topic.

Chapter 4 : Writing in Science

9 Conclusions and Future Directions In this book, memory optimization techniques were proposed to transform an application such that it efï¬•ciently utilizes the memory hierarchy of the underlying system.

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Clinical results from Studies appeared to validate these assumptions. Accurate diagnosis of structural damage The first step in understanding causation is the appreciation that all structures work together inextricably as a system.