Integrating Design into Undergraduate Honors Theses in a Computer Engineering Program: An Experiment

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Abstract*—ABET recognizes the practical component or design as a key ingredient of any successful engineering program and mandates its inclusion in every engineering curricula. However, many educators feel that the undergraduate (UG) engineering program should concentrate on the theories and principles and that the focus on engineering design takes the students away from the fundamental concepts. Also, many educators are deeply concerned that the current faculty reward structure in the US universities focus primarily on grants and publications which, in turn, tend to emphasize research in graduate programs over teaching in undergraduate programs. This paper is the result of a seven-year long experiment by the author that was initiated in 1989 as an attempt to integrate the tradition of undergraduate honors research at Brown University with the emerging ABET requirement of engineering design in the computer engineering program. The paper presents the philosophical principles, the underlying assumptions and goals of the experiment, and the character of the experiences learned at the conclusion of the experiment. The experiment involves a total of seventeen students between 1989 and 1995, all of whom successfully complete their honors thesis and most of the theses have been published in refereed conferences and journals. This paper explains the nature of the design inherent in a few of these problems and presents three projects in detail. Key experiences gained by the author include the realization that every student, regardless of their prior grades in the conventional courses, holds unlimited potential. This potential may be manifested in the form of high-quality research by encouraging independent and creative thoughts in the students, providing constant challenges, and a close one-on-one working relationship, and instilling in them trust and self-confidence. This experiment witnesses the development of an amazingly sincere motivation and superior commitment when the advisor demonstrates his/her genuine belief in their capabilities and expresses his/her gratitude to them for the value of their work and for the opportunity to collaborate.

***Index Terms*—Creativity, design, engineering curriculum, engineering education, honors thesis, nontraditional courses, open ended problems, undergraduate research.**

I. Introduction

According to Banios [1], the rapid advances in technology immediately following World War II caused educators in the United States to place greater emphasis on engineering science and theory. They reasoned that armed with the fundamentals, the engineering student would be better prepared to face the challenges. The cost, however, was the elimination of practical courses including manufacturing methods and design. Over the past two decades, the increasingly theoretical content of engineering programs coupled with the absence of the spirit of design and creativity discouraged many potential engineering students and many universities including Brown witnessed a decline in the number of engineering applicants. Supported by numerous industrial companies and engineering educators, ABET reintroduced design and mandated a minimum of 24 credits of design content in the four-year undergraduate engineering curriculum. Evidence of the timeliness and appropriateness of ABET's decision may be observed, retroactively, as recently as 1993, through the survey of the Brown engineering alumni [2]. The survey [2] reveals that, upon polling those who had graduated between 1983 and 1991, the alumni overwhelmingly state that their education would have been far more effective if they had access to independent study and research courses through which they could learn of the practical applications of the theory.

The renewed emphasis on design appeared to overshadow the importance of basic principles and fundamentals and some educators including Hoole [3] and Ravindra and Manor [4] have expressed serious concern. In the field of computer engineering, the author [5] had learned that when the scope of design is elaborated to include challenging and open-ended problems, many students demonstrate a high degree of creativity and report greater enthusiasm in the engineering program. In response to the criticism that the requirement of 24 design credits fosters "bean counting," is inflexible, and stifles innovation [23], ABET has revised its requirement, as reflected in the following excerpt from the annual report [6]:

a) "The engineering design component of a curriculum must include at least some of the following features: development of student creativity, use of open-ended problems, development and use of design methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact.
b) Courses that contain engineering design normally are taught at the upper-division level of the engineering program. Some portion of this requirement must be

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satisfied by at least one course which is primarily design, preferably at the senior level, and draws upon previous course-work in the relevant discipline."

Dutson *et al.* [6] report that in nearly every discipline of engineering, capstone design courses have been incorporated into universities throughout the United States. They note that a literature search reveals an excess of 100 papers on engineering design courses and conclude that engineering design is fast acquiring a firm grip. Smith [7] defines a capstone course to include research, conceptual design, process optimization, examination of alternative processes, economic analysis, and safety and environmental considerations. The value of the project is reflected by the extent that it approaches reality. Vajpayee [8] amplifies that the success of the senior design project must be measured by the quality of the work and the final report. Hodel and Baginski [9] report a successful senior project involving rocket flight testing where the students were required to analyze complex factors including stability, center of gravity, center of pressure, and engine thrust. Collier *et al.* [10] report that students entering the engineering design course, while enthusiastic, lack skills in dealing with uncertainty and in implementing a complex project. They introduce a sophomore-level design course, structured to simulate an engineering company, to expose the students to technical and ethical issues and to deal with limited resources and incomplete information. The mechanical engineering program at Purdue University [11] witnessed a major change with the integration of design throughout the curriculum. The core of the curriculum is reduced to achieve their primary goals—improve student skills in solving open-ended design problems, team work, and communications. The undergraduate electrical and computer engineering curriculum at Carnegie Mellon University is reported to be completely redesigned [12] with design, among others, constituting an integral factor.

The progress in the acceptance of engineering design appears to be eclipsed by a serious and practical concern raised by Fairweather and Paulson [13] in 1992. They argue that despite the National Science Foundation's sincere attempts to revitalize undergraduate engineering, an analysis of data from a national survey of faculties reveals that research and scholarship, not teaching, are the strongest predictors of compensation, and that time spent on teaching can be negatively related to compensation. The same concern is reiterated by Ernst [14] in 1995 who reports that conventional wisdom has become, increasingly, that the one role for faculty that counts is research—research that brings grants and results and publications. As a result, greater attention is focused on graduate study and research at the cost of undergraduate education. Coppula [33] stresses the need to integrate faculty research with teaching at the undergraduate level.

This paper presents an experiment at Brown University which, upon analysis and reflection, reveals an approach that fosters creativity and design and enhances the quality of undergraduate engineering education within the current faculty reward structure. The remainder of the paper is organized as follows. Section II presents the motivations, the experiment, and the results. Section III presents an analysis of the results and outlines the character of the lessons learned by the author. Finally, Section IV presents the conclusions.

II. The Honors Thesis Experiment

A. Motivating Factors

When the author had moved from Bell Labs to Brown University, like other junior faculty, he lacked immediate funds to support graduate students. In an attempt to build a research program, the author enlisted the collaboration of undergraduate students. The effort was greatly facilitated by the optional undergraduate honors thesis program, already in place in the Division of Engineering, which encouraged highly motivated and talented undergraduates to choose and work with a faculty on a research topic of mutual interest. The program was grounded in Brown's tradition of encouraging junior and seniors to participate in the research of a faculty member leading to "honors" following the successful defense of a dissertation. It received competitive internal funding from the undergraduate college within the university. Within the Division of Engineering, however, the key characteristics of the program were as follows. First, the number of students opting for honors research was very small, typically 1–2 out of a total of 120 students in any given year. Second, the honors work typically consisted of the student helping out the faculty member's graduate students by building a small hardware board or debugging a small hardware/software system. Honors students were neither given any serious projects nor were they expected to demonstrate creative excellence. Also, although the honors students were required to write and defend a dissertation, a standard to measure the quality of work was missing.

There were two additional factors that sustained the experiment and helped it evolve. The first was ABET's insistence on a minimum of 24 design credits in the undergraduate computer engineering curriculum. As a concentration advisor for the computer engineering students, the author hypothesized that a strong honors thesis could fulfill ABET's design requirement for a student. The hypothesis received strong internal support and external encouragement from Prof. M. Molen during his accreditation visit to Brown. Second, a growing number of undergraduate students felt increasingly stifled by the lack of creativity and the absence of *connection* between the real world and the traditional engineering courses. They discovered light in the independent study courses leading to a honors thesis. Proof of this growing sentiment is retroactively captured through the 1993 survey of the Brown engineering alumni [2]. The survey [2] reveals that, upon polling those who had graduated between 1983 and 1991, the alumni overwhelmingly state that their education would have been far more effective if they had access to independent study and research courses through which they could learn of the practical applications of the theory. They also cite that their peers from other institutions, especially state universities, are initially better prepared for the real world.

B. Principles and Assumptions Underlying The Experiment

The experiment is founded on the key belief that given the rapidly evolving sub-disciplines within computer engineering, especially computer architecture, software, distributed algorithms, and complex asynchronous systems, and that the standard textbooks are rapidly being outdated, independent study courses coupled with honors thesis research may be a pragmatic, effective, and exciting teaching paradigm even at the undergraduate level.

Another key belief underlying this experiment is that every undergraduate student holds unlimited potential for success. Even those junior and senior students whose grades fall short of A's and B's, but are hard working, enthusiastic, sincere, and possess a deep commitment to learning, are capable of participating in high-quality research and mastering the subject area. Thus, enthusiasm and sincerity are likely to constitute better indicators of success than the conventional metric—grades earned in the traditional courses.

The underlying philosophy of the experiment is initially developed by the author and then continuously refined through consultation with the honors advisees. The key components of the philosophy are elaborated subsequently.

First, every honors advisee is granted a wide degree of independence in selecting the research problem and investigating it. The individual is encouraged to freely challenge the advisor's thinking as well as the conventional knowledge encapsulated in the literature. The underlying belief is that independence fosters creativity and innovation. Total commitment to academic freedom is fundamental to the true advancement of knowledge. If the individual realizes that his/her views are respected, self confidence develops and a radically different thinking emerges. Criticisms are always constructive and the advisees must never be afraid to argue on any technical matter. Engle and Snellgrove [20] observe that creative individuals are generally independent in thought and action. Furthermore, some of the procedures that are known to promote creativity include the synthesis of a rich, stimulating, and unstructured environment, and encouraging spontaneity, originality, and free thinking in the individuals. In his address to the Indian National Science Academy, Esaki [21], 1973 Nobel Prize winner, advocates nurturing one's imagination, free spirit, and imagination to realize one's full potential.

Second, no student is turned away because of prior lack-luster grades. As a result, the participants in the experiment ranged from those with mostly B and C grades to straight A students to one individual whose highest score in every exam in every course earned the title of the best ever Brown engineering student. The scope of the experiment is broad and the results are, therefore, revealing and valuable.

Traditionally, team work and group projects are stressed. This paper adopts an alternate approach where each student is assigned a unique research project. The project is well defined, self contained, complex, and challenging. As a result, the honors advisee along with the advisor is solely responsible for any and all decisions relative to the problem including the plan of attack, the choice of algorithm, programming style, performance metrics, etc. The underlying belief is that, given sole responsibility of a project, a keen sense of responsibility and a personal commitment to the research is likely to develop in the individual, leading to success. The power of responsibility, according to Damon [18], is immense and he advocates its use to elicit ethics and morality in children as young as four years of age. Engle and Snellgrove [20] note that creative individuals view themselves as thorough and responsible individuals who dislike conforming to rules. A related belief is that one-on-one learning imparts to the advisee a sense that he/she is not merely a number but a valued and respected individual. The Office of the Senior Vice President and Provost at Arizona State University [15] terms this one-on-one learning paradigm, *asynchronous*. An underlying assumption, of course, is that the project is determined to be doable by the single individual within a reasonable time frame. Furthermore, under the one-on-one learning paradigm, the student is allowed a close-up view into the advisor's way of thinking. The underlying philosophy is probably not too distant from those of Plato, Rousseau, and the classic guru-disciple style of education in ancient India.

Fourth, trust between the advisor and the honors advisee is viewed central to the research project. Although the advisor and the student may work side-by-side trying to solve a problem, the advisor never looks over the shoulder of the advisee. There is never any unnecessary double checking or second guessing except when it is absolutely necessary to ensure scientific accuracy. The resulting environment provides ample freedom and room for growth. A comradery develops between them and the advisee realizes that the advisor considers him/her as his equal, a colleague, and a collaborator. Johnson [19] underscores the importance of trust by attributing the lack of trust in our institutions as a particularly perplexing systemic problem and the prime cause of the crisis in higher education.

Fifth, during the course of the research, the advisor continuously reminds himself of the privilege and honor of being selected to guide the advisee's research. At the same time, the advisor expresses gratitude to the advisee by first providing a sense of what the advisee may accomplish in the course of the research and its importance in the discipline, and then sincerely thanking for the advisee's efforts.

Sixth, the advisor and the advisee agree to abide by the philosophy of disinterested and dispassionate learning. While knowledge is truth—purely logical and impersonal, research is the pursuit of the truth. Ideas are absolute and belong to no individual. One should always view it a privilege when working with ideas. Conceivably, an individual, Y, through deep contemplation and effort may find errors in and propose modifications to an idea previously proposed by individual X. Under these circumstances, if X wrongly views this as personal attack, there is the danger of stifling the progress of research. Science evolves by accepting new ideas that are substantiated by the best evidence, relevant facts, and other proven ideas. In dispassionate learning, ideas are considered impersonal and the sharp razors of logic and experimentation are utilized to cut through the fluff and arrive at the truth. Learning is for the sake of learning and not to stroke one's ego. One must be indifferent to failures and successes for both reflect research progress. One must consider it a privilege to work with ideas and be fully aware that it may be disproved or superseded by others in the future. Thus, dispassionate learning will help keep the thinking process free from the cloud of personal ego, sustain one's ability to learn, and prevent the onset of complacency.

Seventh, the advisor and the advisee are both aware that it is the nature of research to take unpredictable turns. The direction of the project may change several times, throwing planned time lines out of sync. One should not be bewildered. Research is risk taking and one has to keep on trying—guess the truth, hypothesize, and perform objective evaluation. Where one knows for sure what one is doing, that is not research.

Eighth, a criteria for the selection of a research project is developed. An acceptable honors dissertation must satisfy three characteristics: 1) it is original research, 2) the underlying problem is intellectually challenging and the solution innovative, and 3) it significantly advances the state of the art of the discipline and/or benefits society. A measure utilized to assess the quality of the research is through its publication in a refereed conference or journal.

C. The Element of Design in the Research Projects

Given its experimental nature, design is a natural component of engineering research. In the experiment reported in this paper, all of the computer engineering research problems required new approaches to system design while a few of them involved, in addition, the design of new algorithms. This section explains the design component in a few of the research problems and presents a representative research effort in detail. In a project, the analysis of YADDES [24], one of the most complex distributed algorithms, required a complex software design to realize an implementation on a loosely-coupled parallel processor, Amstrong, consisting of 32 concurrent processors. Since each processor executed independently, any error could potentially lead to racing, and the literature on addressing this problem was virtually nil. Although, as a result of racing, erroneous results would be generated, when trace statements were inserted to determine the exact nature of the error, they would alter the relative timing between the executions in the different processors and the error would be masked. Upon removing the trace statements, the error would reappear. Another project required the design of a novel architecture to monitor the execution of YADDES on 32 concurrent processors of Armstrong through a single SUN workstation [25]. Since the speed of execution of the SUN workstation was an order of magnitude slower than the 32 concurrent processors, the direct exchange of data between them, utilizing the communication primitives built into Armstrong, would fail from buffer overflow. A new mechanism needed to be designed. The modeling of a large-scale broadband-ISDN network [26] on a network of 50+ SUN workstations, to verify the feasability of dynamic routing strategy and obtain Quality of Service measures utilizing over 3.2 million ATM cells, involved a major system design. This large-scale research effort was a first in the networking research community. In another project, the conception of a new, distributed approach to modeling the control of trains in a railway network [27] required the design, implementation, and performance measurement of a novel algorithm. The research project on the simultaneous visualization of a geographically-dispersed, complex system from multiple sites [28] required a radically new architecture for data acquisition and information processing. The project involving the development of an architecture [29] for a community care network required a new design strategy to collect patient data, forward it automatically to the primary care medical facility, and disseminate it to other facilities upon demand as well as the design of the underlying high-speed network.

1) Design of a Debugger for Loosely-Coupled Parallel Processors: The objective of this research project [30] was to design and develop a software tool to permit the debugging of asynchronous, distributed algorithms executing on Armstrong. Although, several parallel processors were available in the research community, none was accompanied by a debugger with the necessary capabilities and the literature on the design of such tools was virtually nil. The most advanced tool, POKER [31], was severely limited in that the user had to declare the variables of interest at compile time, the variables could only be of simple data types, and the user was permitted only to examine the variables, not modify them. The goal of this undergraduate research effort was to develop a state-of-the-art debugging tool that would permit the user to focus on any one of the 32 concurrent processors of Armstrong, read and modify the variables, complex data structures, records, and pointers, and control the execution of the asynchronous, distributed program.

Logically, such a debugging environment should support the following capabilities—1) the ability to control the progress of execution of any process, either by inserting breakpoints corresponding to any source code line or by stepping or tracing through the code at the source level and 2) the ability to display any variable, structure, or record of a temporarily suspended process.

The final design, termed Ddbx-LPP, consists of three distinct subparts—"Trace/breakpoint handler," "Monitor," and "Master debugger." The Trace/breakpoint handler is an assembly language routine, approximately four pages long, that resides in the Kernel. Ddbx-LPP takes advantage of the fact that each ARMSTRONG node is essentially a self contained unit. This fact permits the debugging system to be treated as a collection of uniprocessor programs and their monitors, executing concurrently. A Monitor process for each user process controls the behavior of the handler for the respective node. A single Master debugger process executes as the front end of the total environment. It accepts user requests to examine and modify variables and structures for each of the different processes and converts them into memory examine and modify requests that are relayed, via a common file server, to the appropriate Monitor process. The Master debugger runs under the X Window system on a Sun 3/60 workstation, that shares a common file server with ARMSTRONG. Fig. 1 describes the overall organization of Ddbx-LPP. Of the three components, the monitor process holds the greatest design challenge. For further details, the reader is referred to [30].

D. Results of the Experiment

Between 1989 and 1995, a total of seventeen students participated in the experiment. Except for a single individual who joined the program while in his sophomore year, all of the students started to work in their junior year. They continued their research through the senior year, writing an honors dissertation and defending it in front of a faculty committee. The author met with each student individually at least once a week to review the progress. The meeting times were scheduled based on mutual convenience and meeting times at odd hours were not uncommon. The duration of the meetings ranged from a few minutes when progress was slow to hours when strategies needed to be planned. Unscheduled

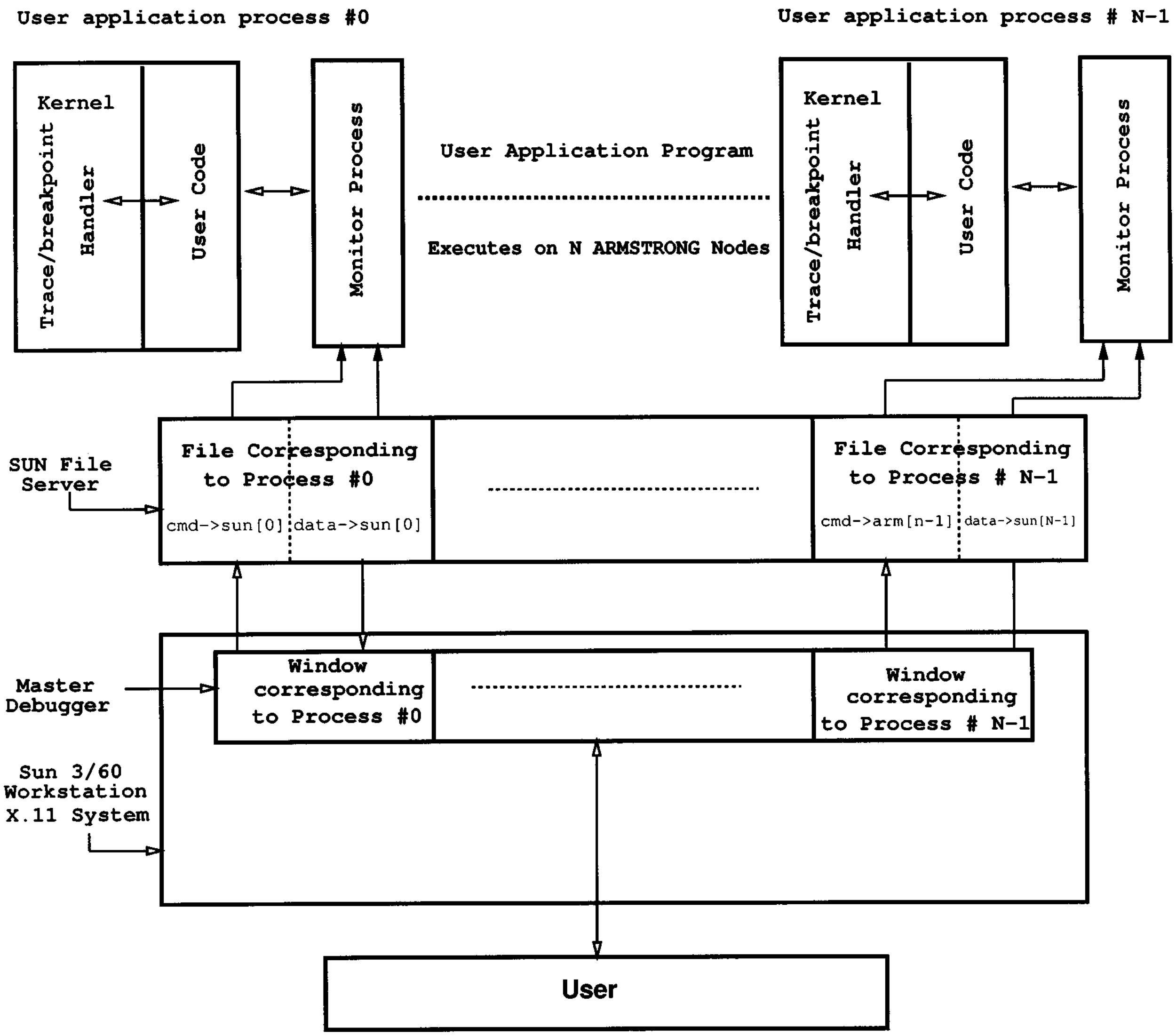

Fig. 1. Organization of the Ddbx-LPP.

meetings following an advisee's observation of an interesting result that needed immediate discussion with the advisor, were also common. Often, the advisor would work just as hard as the student, side-by-side, developing the algorithm, writing code, or debugging a system.

Every one of the honors advisees became self driven and progressively worked long hours on the project. Working weekends, staying up late nights to execute large simulations on the 65+ SUN workstation network, and spending more than 25 hours a week became a norm toward the later part of their effort. Not only did their research become the focal point, challenging, and exciting them, but they tried to understand the conventional courses from the point of view of depth rather than superficially memorizing formulas and using them to solve standard problems.

The quality of the research produced by the honors advisees was consistently high. Following an honors dissertation presentation early in the course of the experiment, a senior faculty had remarked that not only was it the best honors presentation that he had ever witnessed in his last ten years at Brown, but that it was extremely professional and of the highest research quality. Every one of the honors advisees produced either a journal paper or a conference paper or both. Between them, they had generated a total of 16 refereed journal papers and 11 refereed conference papers. Following graduation from Brown, the initial placements of the advisees were spectacular. Approximately 50% of them received scholarships for graduate study at the top five research universities. The remainder of the advisees secured high-paying, responsible positions in the top software, computer, and consulting companies and a few of them even climbed to managerial positions within two years of joining the company.

Virtually every one of the honors advisees felt that their experience was invaluable while a few went so far as to state that it was the single most valuable educational experience in their entire engineering program. One student acknowledged that everything that he needed to succeed at work—perseverance, creativity, originality, self-confidence, and faith in his own abilities, came from his experience with the honors thesis. Unlike the conventional courses that encourage regurgitation, the honors thesis had forced him to think and solve problems on his own and, in the process, imparting him a glimpse of what to expect in the real world. The honors advisees attributed their strong initial placement to the increased self-confidence, depth of knowledge, creativity, and ability to think freely, critically, and analytically. They acknowledged that their appreciation for continuous learning emanated directly from their honors thesis experience.

III. Analysis of the Experiment: Character of the Lessons Learned

Upon careful analysis of the results and reflection, the experiment yields revealing and subtle lessons. Perhaps the key lesson is the enormous influence that trust and faith in an advisee wields over his/her self-confidence and creativity. When the advisee is respected and treated as an equal, the individual's intellectual level appears to peak, the level of commitment and determination reaches a qualitatively different level, and the individual performs brilliantly. A similar outcome is predicted in the US Army Field Manual, FM 100-5 [16], Field Service Regulations, Operations, which states: "The commander who inspires his subordinates to speak with frankness, who never upbraids them for faulty opinions, who never ridicules them, who encourages them their personal confidences, has a hold over them that is difficult to shake . . ."

A second important lesson is the strength inherent in the belief that there is unlimited potential in every undergraduate student. The author acknowledges that the advisees have been responsible for introducing him to important problems in network modeling, transportation systems, and debuggers for asynchronous distributed systems, and for educating him in the innovative techniques needed to determine the input stimulus rate for testing the stable operation of a continuous asynchronous distributed system such as banking. Indeed, the Babylonian tablet with the inscription, "I learned much from my teacher, more from my colleagues, and most from my students," is true.

A third lesson is the value of enthusiasm, sincerity, and hard work as accurate predictors of an honors advisee's innovation in research, regardless of his/her conventional grades in the traditional courses. Conceivably, the cause of lack-luster grades may stem from the individual's lack of purpose and motivation and the perception of absence of relevance to the real world. When an individual expresses genuine interest in working one-on-one with an interested faculty on a research topic, he/she should be provided the opportunity for there is a high chance of success.

The fourth lesson is the undeniable value of nurturing a student and his/her research. The advisees demonstrate that they are capable of unprecedented achievements when someone cares for them, supports them, believes in them, provides them with challenging tasks, and thanks them for their efforts. Unspoiled by the fear of failure, they are never unwilling to try new approaches and their gratitude for the opportunity to do research with a faculty drives them to work harder and succeed. Contrary to popular belief that undergraduate students are disrespectful of academics, many young minds are highly spirited and are eager to learn and mature. Ratan [17] notes that many of the younger generation are more interested in the quality of life than money, keen on creating something of value, and are exhilarated by new challenges. According to Ratan, the younger generation says, "It's like, please let me do the job. There are so many young people who are so good at what they do. If you are asking me to do something, tell me why you need it and how it will be used, and I will figure out a way to do it faster." Not only does the author's personal experience corroborate Ratan's observation, it is truly rewarding and gratifying.

The final lesson is that, to achieve high-quality research, a unique research project must be assigned to every student, where the project is doable by a single individual within the given time frame. Unlike the conventional wisdom of team effort, the intense demand of the project, the open-ended nature of the problem, and the need to make frequent and long-term decisions, argues in favor of the one-on-one paradigm. Furthermore, the allocation of sole responsibility of a project to an advisee induces in him/her a qualitatively high level of commitment to succeed.

The value of regular and frequent meetings is two-fold. First, the advisees often have minor questions which, if left unclarified, may cause frustration and stall progress. In contrast, quick clarifications may require only modest effort and permit the advisee to progress faster. To foster depth of learning, the advisee is encouraged to address the major issues independently. While this may take time and frustrate the advisee, the advisor, while patient, must intervene just prior to the breaking point and never let the advisee cross the threshold. Second, the availability of the advisor will help the advisee realize that the advisor treats his/her effort and time with dignity.

Participation in the honors thesis should strictly remain an option to undergraduates. Any effort to mandate it will probably cause resentment and the basic objective of creativity may never be realized.

Despite strong similarities in their objectives, honors theses differ from senior capstone projects in several ways. First, honors theses are research oriented and require substantial effort, requiring one to start at the beginning of the junior year or even sooner. By their very nature, honors theses are individual student-centric. In contrast, generally, only seniors participate in the senior capstone project and work in teams. The author's recent experience while teaching "Intermediate Design: ECE300," to junior and senior engineering students at ASU, has been remarkable. Aimed at cultivating critical thinking, a total of 37 students were organized into eight groups and each group conceived, designed, and prototyped a practical project that is potentially patentable.

IV. Conclusions

This paper is the result of a seven-year long experiment at Brown University that was initiated in 1989 as an attempt to integrate the tradition of undergraduate honors research at Brown University with the emerging ABET requirement of engineering design in the computer engineering program. This paper has presented the philosophical principles, underlying assumptions and goals of the experiment, and the character of the experiences learned at the conclusion of the experiment. The experiment involved a total of 17 students between 1989 and 1995, all of whom successfully completed their honors thesis and, between them, generated a total of 16 refereed journal papers and 11 refereed conference papers. The students have been observed to emerge as self-confident and highly creative individuals, capable of critical and analytical thinking, and appreciative of the depth of knowledge. Following graduation from Brown, their initial placements were spectacular. Approximately 50% of them had received scholarships for graduate study at the top five research universities. The remainder of the advisees had secured high-paying, responsible positions in the top software, computer, and consulting companies. This paper has reported key experiences gained by the author which include the realization that every student, regardless of their prior grades in the conventional courses, holds unlimited potential. By encouraging independent and creative thoughts in them through constant challenges and a close one-on-one working relationship, this paper has noted that trust and self-confidence are instilled in the students. Furthermore, belief in their capabilities and gratitude for their efforts seems to induce a qualitatively different level of commitment and determination to succeed. Presently, the author is engaged in exploring the impact of extending the philosophy to the graduate level and in studying new metrics to measure teaching effectiveness in non traditional courses at the graduate level. The study is expected to provide insights into high-quality M.S. and Ph.D. programs.

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