AC 2007-2556: NEW PROGRAMS IN MECHANICAL ENGINEERING AND "THE ENGINEER OF 2020"

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New Program in Mechanical Engineering
and "The Engineer of 2020"

Abstract
Development of the new Mechanical Engineering program has been described in detail, in reference to two recent reports of the National Academy of Engineering, commonly known as "*The Engineer of 2020*". Various aspects of a curriculum design, as well as program implementation, are discussed in the context of the NAE findings and recommendations with regard to future engineering education. Presented first is a brief overview of published NAE reports, their findings and relevant recommendations. The second part presents the new Mechanical Engineering program and discusses the relevant impact of *"The Engineer of 2020"* on program objectives, particularly as it relates to curricular requirements. In addition, some aspects of the recruitment implementation plan are also discussed in the paper. Lessons learned from the entire process conclude the paper.

1. Introduction

Central Connecticut State University's School of Technology has recently faced an unprecedented challenge — but also a unique opportunity — in curriculum development. The school was charged with establishing a brand new (and the first) full engineering program in its academic offer. The faculty and administration started building an engineering program virtually from scratch. One must note, however, that implementing major components toward a future engineering program had been underway for many years. The university already has in place fully qualified engineering, math and science faculty, technical and computer laboratories, established linkages with industry — as well as data gleaned from previous feasibility studies on engineering at CCSU. All of this was the result of a well developed strategic plan and consequent strategic management. At the moment of expanding its academic offer to include engineering, the school had four engineering technology majors, three technology majors, and also programs in technology education and applied sciences.

As always is the case with new academic disciplines, implementation of the new mechanical engineering program was a tremendous challenge, both in terms of logistics and resources, but foremost in regard to curriculum and program mission.

Along with brand new program development, we realized a great opportunity to join and implement current and NAE validated recommendations on future engineering education. Unlike existing programs, which are subject to natural inertia hindering subsequent program modification, we faced an unrestricted curriculum playing field. The circumstances can be compared to the implementation of upgraded technological systems. In technologically advanced countries, any upgrade (or new generation system) is implemented at a relatively slow pace since they have to prove their superiority and advantage (in various aspects) over the old system. At the same time, many previously underdeveloped countries took advantage of that situation and quickly implemented the most recent, more reliable and significantly improved generation of technical systems. That same kind of opportunity was before us, when we started our project.

2. "The Engineer of 2020" – aspirations, attributes, findings, and recommendations

In 2001 the National Academy of Engineering established a steering committee to develop a vision for engineering and the role of engineers in the modern society of the future. From the beginning, the committee was charged with revising current engineering education according to their predictions of how the discipline will need to evolve to face the challenges of the future technological revolution of the new communication age (vs. past industrial age). While there is apparent common understanding and agreement that the future prosperity of humankind will predominantly depend on technological innovations and inventions, it is quite a challenge to make recommendations as to how to educate engineers for that future. One assumption seemed to be obvious — that engineers are expected to be proactive and lead-the-way as opposed to being reactive in the society of the 21st century. The National Academy of Engineering undertook this important project and, as a result, the first NAE Report *"The Engineer 2020; Visions of Engineering in the New Century"* was made public in 2004 [1]. This report was primarily focused on a vision of engineering as a profession and its role in society in the first quarter of the 21st century. Following that first report, the NAE undertook the initiative to examine current engineering education and offer recommendations with regards to anticipated and necessary changes in engineering education of the future. The goal was to draw some conclusions on the findings of the first report, which identified major challenges that engineers will face in 2020. Consequently, in late 2005 the NAE published its second report "*Educating the Engineer of 2020; Adapting Engineering Education to the New Century*" [2]. Both reports are essentially focused and based on undergrad education, however in many places the reports tackle graduate education problems as well as post-grad issues related to the discipline. Obviously, both reports became invaluable references for all kind of engineering issues we face now and will need to deal with in the foreseeable future. Similarly, when developing the first engineering program at Central Connecticut State University, we analyzed numerous state-wide and national reports and data but the NAE report was clearly a very helpful reference source in the final development of our curriculum.

The first NAE Report *"The Engineer 2020; Visions of Engineering in the New Century"* identifies the role of the future engineer in technically developed modern societies. However, in order to solve future problems, engineers will need to acquire much more advanced core knowledge as well as technical skills. Given the rapidly changing nature of modern technology, preparation for Engineering will extend to interdisciplinary education and clearly require, more than ever before, commitment to self- and continuing- education. In the broad context of societal, cultural, economic and geopolitical issues, as well as the current trends in information technologies, nano-scale biomedical-, material- and medical sciences, the report defines major aspirations for engineering in the first decades of the 21st century. The aspirations can be considered a sort of "mission and vision" for the engineering profession of the future. These visions created a broad foundation for the next steps in the NAE project and are presented in Table 1.

Table 1. Aspirations for Engineering in 2020 [1]

Role and perception of engineering in the society	✧ Public awareness of the engineering profession's impact on the society as a whole ✧ Public appreciation of the continuity between past and future roles of engineering in the modern society's development. ✧ Sensitivity to societal- economical- and human aspects by the engineering profession.
Evolution of engineering beyond traditional boundaries	✧ Cross – and multi- disciplinary cooperation and new emerging disciplines ✧ Increased leadership of engineering profession as a result of the growing role of technology in the modern society ✧ Underrepresented talents in engineering
Environmental and global aspects of engineering	✧ Wisdom and responsibility in using global resources ✧ Geopolitical implications of engineering work
Engineering education challenges and responsibilities	✧ Visionary engineering education in anticipation of various future challenges ✧ Appreciation for diversity in engineering education including recruitment of diverse talent

When studying the report, it is interesting how various "definitions of engineering" attempt to describe the same features in different ways:

"Engineering is problem recognition, formulation, and solution" [1]
"Engineering is a profoundly creative process…" [1]
"….engineering is a design under constraints" [1]
"Engineering is not just an applied science" [1]

The concluding part of the "*The Engineer of 2020*" report discusses the desired attributes of future engineers. Although the key attributes constitute very helpful recommendations for currently offered program modifications, their primary influence is toward new program development. In the long run, these attributes (or at least some of them) will certainly be adapted into professional as well as state and regional accreditation standards. Table 2 summarizes the key attributes and presents some possible means of implementation. The table was developed at the early stage of our discussions and is presented only as an illustration of the curriculum development process.

Table 2. Key Attributes of Future Engineering Graduates and Possible Ways of Implementation

Key attributes [1] **"*The Engineer of 2020*"**	**Suggested but not limited to possible means of achieving the desired attributes**
Strong analytical skills	Science and mathematics with focus on applications involving analytical objectives of several technical courses, which would develop strong reasoning skills rather than memorization
Practical ingenuity	Accountable laboratory requirements – well coordinated laboratories and lectures. Application oriented projects – Perhaps all capstone projects should be local industry-driven and applicable (that would require excellent connections with local industry)
Creativity	Include principles of research as a 1-2 credit subject (not only capstone research project), possibly following the applied sciences format and experience in undergrad research. Special course(s) on innovations and inventions.
Communication skills	Team work and individual presentations of reports and papers (publishing the capstone/special projects in a typical format for engineering papers)
Business and management	Including the technology management faculty in developing suitable courses in lean management to enhance not only the "manufacturing" component of the curriculum but also contribute to management skills development. Accounting.
Leadership	Regular seminars on engineering topics and presentations by invited speakers from industry, business and academia. Special course on leadership or topics in selected courses.
High ethical standard and professionalism	Course on ethics for engineers and professionals or/and ethical topics in selected courses
Flexibility, agility, resilience, dynamism	Curriculum cannot be too narrow and only specialization oriented. That would limit general engineering skills, necessary to adapt and adjust in the future.
Lifelong learners	Several mandatory self-study projects during four years, requiring intensive research and professional literature study in the library (not just websites).

It has to be pointed out here that at the moment of curriculum development and our program application for state licensure, the second report "*Educating the Engineers of 2020*"[2] had not yet been published and was unavailable. Thus we utilized the above listed recommendations on key attributes of future engineers in shaping our final curriculum and program requirements. We found the attributes very useful and applicable.

The second report "*Educating the Engineers of 2020*"[2] presented fourteen recommendations for engineering education, which are summarized in the table below.

Table 3. Recommendations for Engineering Education in the New Century[2]

1	Four year undergraduate engineering degrees should be recognized only as "pre-engineering" degrees;
2	Masters' "professional" engineering programs should be the integral part of engineering education and as such they should require professional accreditation (ABET);
3	Flexibility in developing innovative curriculum content (and its delivery) should be vigorously encouraged by strong promotion of outcomes-based accreditation standards;
4	Principles of engineering (design, simulation, modeling, prototyping and testing) should be incorporated into the curriculum as early as the first semesters;
5	Research in engineering education needs to be recognized as valuable and appropriate scholarly activity for engineering faculty in their promotion and tenure evaluations;
6	Universities should adopt or modify hiring standards for engineers to require some level of professional experience, provide professional development support and, in general, focus on other ways to close the gap between engineering practice and engineering education;
7	The life-long learning in accelerating engineering disciplines must be strongly promoted in both the curriculum and by offering recognized "post-graduate, executive" degrees;
8	Both undergraduate and graduate programs require involvement in interdisciplinary learning and research;
9	Case-studies in classroom practice should include both success stories and failures. Students need to learn from engineering mistakes;
10	Four-year institutions have to initiate and implement articulation agreements on credit transfer from two-year colleges;
11	U.S. institutions have to promote and reward the pursuit of M.S. and Ph.D. degrees among domestic engineering students;
12	Engineering schools need to be actively involved in promoting engineering education at the K-12 level;
13	Nationally coordinated efforts have to be undertaken to specifically promote engineering education but also more general technological literacy in the society;
14	Nationally supported projects (NSF, ASEE, etc.) have to promote collecting, analyzing and disseminating data on engineering students and, in particular, on negative and positive factors affecting student success, diversity and demographic trends, available jobs, etc.

When analyzing the preceding fourteen recommendations, one has to immediately recognize that the recommendations are obviously not homogeneous. They are very different in terms of their importance, implementation level, magnitude of possible impact on future engineering education, and even possibility of ever being implemented. For instance the first recommendation, although reasonable and relatively simple, seems to be possible only by bringing all majors stakeholders to the same table and developing a brand new, nationally recognized system of engineering education supported by professional licensing standards and industrial promotion criteria for practicing engineers. On the other hand, various other recommendations such as: 4, 5, 6, 8, 9, 10 and 12 can and should be implemented directly at a university/school level, as we attempted to do when developing our new engineering program.

3. New program in Mechanical Engineering – curriculum and implementation

Mechanical Engineering program development overview

When we started our engineering program development, it was not totally unknown territory into which we were heading. The involved faculty all had engineering Ph.D. credentials and, in many cases, previous industrial as well as teaching experience in engineering programs. Our mathematics and science departments were very supportive and already offering all kinds of advanced, engineering level supporting courses. Industrial Advisory Boards and industrial partners were in place and extremely helpful and supportive in our endeavor. Long term special articulation agreements with community colleges had been in place for many years and working well for engineering technology and technology majors. There was even an existing engineering science credit transfer option from community colleges at our disposal, which could be easily adopted. We had a great deal of experience in undergrad research projects, capstone projects, lab experimentation and extracurricular student/faculty research. Last but not least, we had already learned quite extensive lessons in implementation of outcomes-assessment based accreditation standards by TAC of ABET and other accreditation boards such as ACCE, NAIT, and NCATE. Nevertheless, the new engineering program development was quite a challenge both in terms of curriculum development and justification at the state level when applying for licensure from the State Department of Higher Education.

Curriculum development and "*The Engineer of 2020*" key attributes

Mechanical engineering is probably the most diverse of the engineering fields, encompassing many specialties such as mechanical design, energy, control systems and dynamics, aerospace, biomedical sciences, manufacturing, and material sciences (Fig. 1). The envisioned mechanical engineering program is initially focused on two major specializations, namely: manufacturing and aerospace engineering. These specializations were based on local industry needs.

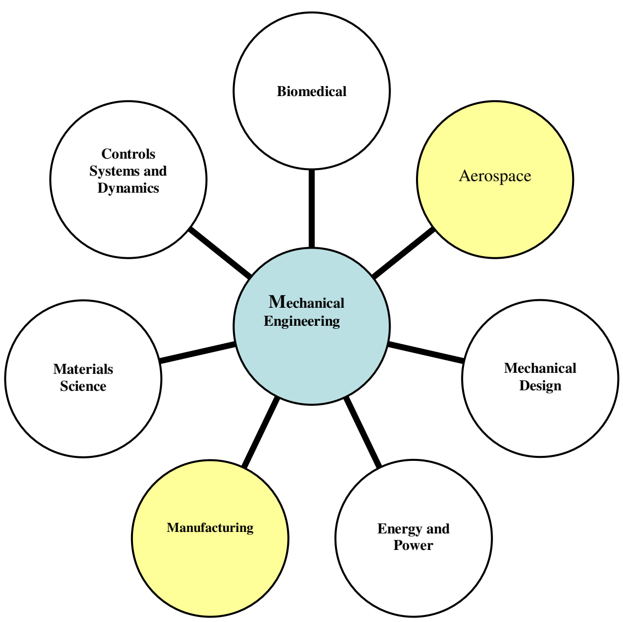


Fig. 1. Mechanical engineering specializations.

In the development of the curriculum and specific courses, we have used the NAE "*The Engineering of 2020; Vision of Engineering in the New Century*" [1] report as a guide and reference. The course objectives were compared with the key attributes of future engineering graduates and a relevant road map has been developed. The relationship between the key attributes and course objectives is illustrated in Fig. 3. Since most of the courses were developed specifically for this program we had a unique opportunity to tailor the courses and their objectives in order to meet the desired attributes of a future engineer.

The Bachelor of Science in Mechanical Engineering is a program of study requiring 127-135 credits of undergraduate work that culminates in a two-term senior project capstone requirement completed through oral and written reports. A flowchart indicating the prerequisite structure and laboratory component is presented in Fig. 2.

Within the program students may opt for general mechanical engineering electives or an appropriate sequence of courses to specialize in Manufacturing or Aerospace. The required coursework can be grouped into four categories: General Education, Major Requirements, Electives or Specialization Requirements, and Additional Requirements. Curriculum sheet is presented in the Appendix. The proposed course sequence of 129 credits is the requirement for the typical B.S. in Mechanical Engineering student; 135 credits are required for the student not meeting the University Language requirement. A transfer student is required to meet 127 credits. Although a degree of flexibility exists, the semester-by-semester listing of courses (Fig. 2) satisfies the rigorous prerequisite structure and allows students to graduate within four years.

Laboratory Component (*Analytical skills, practical ingenuity….*)

The Mechanical Engineering program lecture/laboratory courses consist of two separate segments, i.e., two semester hours of lecture plus two semester hours of laboratory. The lecture carries two credits, while the two hours per week of laboratory carries one credit.

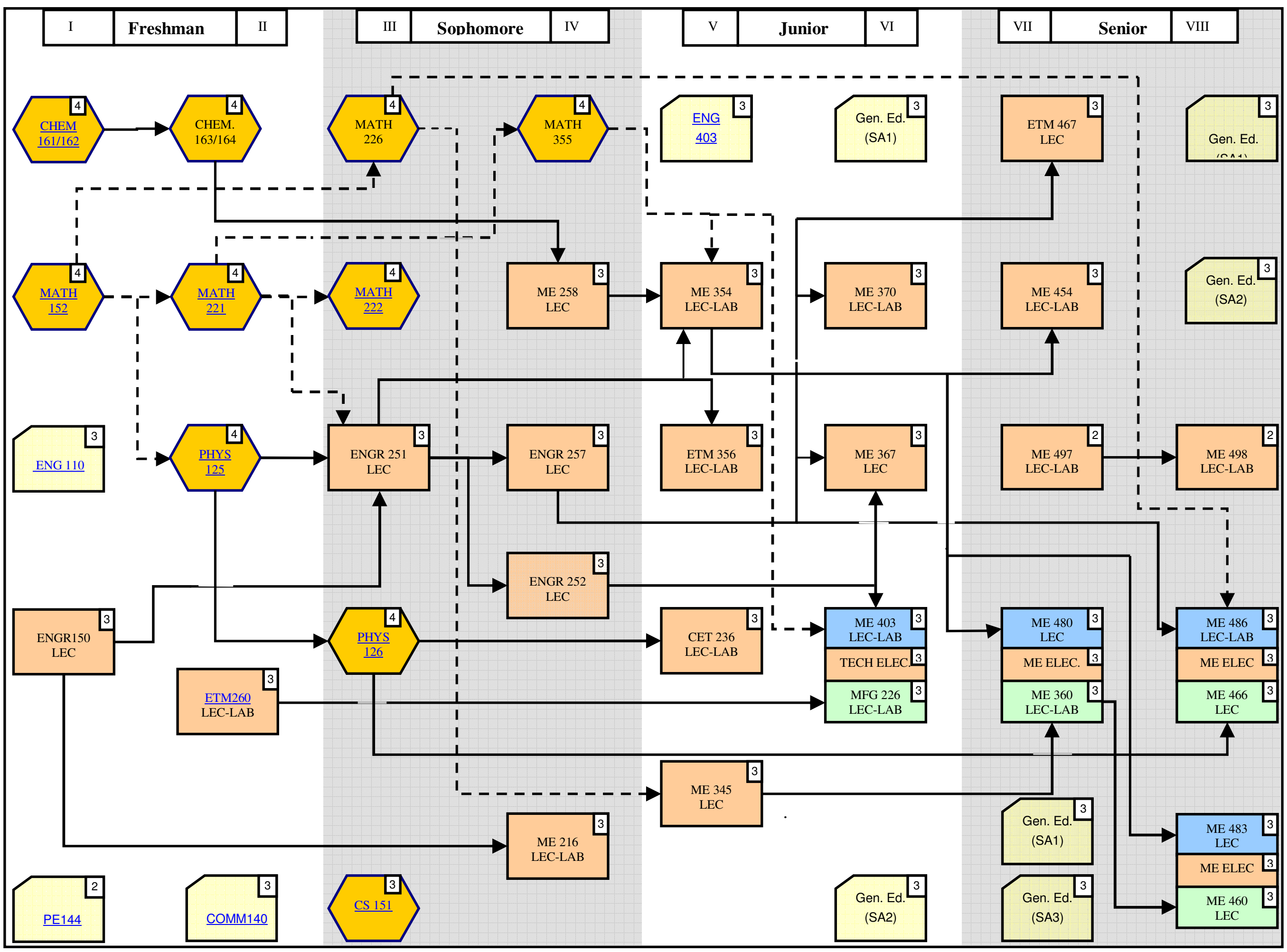


Fig. 2. Mechanical Engineering program flow chart.

Forty-four (44%) percent of the engineering courses required in the program have an "application oriented feature" or laboratory component. The courses offered by the department that contain a laboratory component are ME 216 Manufacturing Engineering Processes, ME 354 Fluid Mechanics, ME 360 Manufacturing Operations Analysis & Simulation, ME 370 Instrumentation, ME 454 Heat Transfer, ME 486 Aerospace Structures & Materials, ME 497 Senior Project I: Research, ME 498 Senior Project II: Design Project, ETM 260 CAD/CAM/CIM, ETM 356 Materials Analysis; and MFG 226 Principles of Computer Numerical Control and CET 236 Electrical Circuits.

Two-Term Senior Capstone Project(*Analytical skills, Ingenuity, Creativity…….)*
This two-term senior project capstone is intended to be a team design experience that integrates overall studies in the major. Departmental experiences with a single senior project course reveal that students are often quite rushed to deliver suitable substance for capstone oral and written reports. To strengthen the design exposure and "hands-on" aspect of the education offered through the capstone assignment, this program will require a two-term senior capstone sequence of ME 497 followed by ME 498 each bearing two credit hours (Fig. 3).

The first course, ME 497- "Senior Project I: Research", is intended to provide students with an opportunity to expand their skills in searching for information and literature to ultimately formulate the introduction and work statements found in any meritorious work. Students will work in teams in an environment representing an industrial setting. Teams propose and begin development of designs for projects that have a practical character, tied or connected to real engineering projects from local industries. Teamwork and oral and written communication skills will be emphasized. The follow-up course, ME 498 - "Senior Project II: Design Project", is intended to provide student design teams with an opportunity to finalize their capstone projects through oral and written presentation. Final design analysis must satisfy requirements and show sound engineering judgment. Computer simulation and prototype development are expected. Assessment Rubrics will be used to evaluate the quality of the senior project.

Proof of 400 Hours Professional Experience (*Communication, Business, Ethics, Flexibility…*)
Professional experience is an extremely valuable asset for students when they seek permanent employment. In fact, some employers require it for hiring. The requirement of 400 hours in a professional setting will ultimately deliver a more marketable graduate from the CCSU's Mechanical Engineering Program. It is intended that this requirement can be met through cooperative work assignments in industry coordinated through CCSU's Career Services and Cooperative Education Office, or through one or more summer positions arranged directly with local industries. The program advisor and the cooperative education coordinator will verify the student's completion of the professional experience. This can be checked off on the student's transcript in a similar manner as the university foreign language, first year experience, and international requirements.

	Strong analytical skills	Practical ingenuity	Creativity	Communication skills	Business and management	Leadership	High ethical standard and professionalism	Flexibility, agility, resilience, dynamism	Lifelong learners	Broad education, global citizens
ENGR 150	✓			✓		✓	✓		✓	✓
ETM 260		✓	✓	✓	✓					✓
ENGR 251	✓	✓		✓						
ME 258	✓	✓	✓	✓					✓	
ENGR 257	✓	✓		✓						
ENGR 252	✓	✓		✓						
ME 216		✓	✓	✓	✓		✓			
ME 354	✓	✓		✓		✓				
ETM 356	✓	✓		✓				✓		
CET 236	✓							✓		
ME 345	✓	✓	✓	✓	✓	✓			✓	
ME 370	✓	✓		✓		✓		✓		
ME 367	✓	✓	✓	✓		✓		✓	✓	
ME 403	✓	✓		✓					✓	
MFG 226		✓			✓			✓		
TECH. EL.								✓		
ETM 467	✓	✓	✓						✓	
ME 454	✓	✓								
ME 497	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ME 480	✓	✓	✓	✓		✓		✓	✓	
ME 360	✓	✓		✓	✓	✓		✓	✓	
ME EL.								✓		
ME 498	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ME 466	✓	✓	✓	✓	✓	✓		✓	✓	
ME 486	✓	✓	✓	✓					✓	
ME EL.								✓		
ME 483	✓	✓	✓	✓					✓	
ME EL.								✓		
ME 460	✓	✓	✓	✓	✓	✓		✓	✓	
Math & Comp	✓									✓
Chem & Phys	✓	✓								✓
ENG 110			✓	✓						✓
ENG 403				✓						✓
COMM 140			✓	✓						✓
Gen. Ed.										✓

Fig. 3. The key attributes of "*The Engineer of 2020*" vs. course objectives.

4. Recruitment for engineering - reaching out to talented, underrepresented population

<u>National and Connecticut workforce needs</u>
The (NSF) Science and Engineering Indicators report of 2004 outlines the changing conditions of engineering capacity in the US [5]. The report highlights three areas of uncertainty in the continuous expansion of innovation and economic growth: 1) the effects that adjustments in national security policy due to the September 11 attacks will have over the workforce in the US; 2) the uncertain path of economic growth worldwide; and 3) the continuous globalization of labor markets on the US knowledge-based economy. The NSF report shows a decrease in the recruitment of foreign scientists and engineers. Compounding this workforce challenge is the fact that a large portion of the US scientists and engineers at all levels of preparation are entering retirement age. The creation of necessary talent for engineering innovation represents an important challenge in the US.

Along with other states, Connecticut faces the realities of a global economy, rapid technological changes and shifting state demographics. A Battelle Memorial Institute study commissioned by the Governor's Office of Workforce Competitiveness [6] found that Connecticut employs 1.7 percent of the engineering workers in the nation, but generates only 0.8 percent of the engineering graduates in the nation…as Connecticut's economy continues to grow in the direction of a "knowledge economy".

All indications are that Connecticut is poised to expand its share of the knowledge economy. Industries in CT are increasingly relying on well educated, high tech workers. The Connecticut Department of Labor recognizes that "strategies should be put into place to ensure that it has the workforce to sustain that economy. CT needs to continue efforts to hire and keep graduates of the State public and private colleges in Connecticut jobs and to attract additional skilled workers from other states [7].

The DOL [7] report compared a number of graduates in CT with a number of annual openings for each occupation. Engineering/Sciences/Technology occupations were listed as number one with the best opportunities for employment. Among these occupations Mechanical Engineering (including Aerospace and related specializations) was ranked number one with 511 annual job openings (including related disciplines) and only 268 graduates. That indicates that if all graduates decided to stay in CT, only 50% of the openings would be filled. However, an additional factor is that the majority of CT graduates leave the state upon graduation, which makes this shortage even worse [7]. The chart in Fig. 4 illustrates how Mechanical Engineering and Aerospace Engineering are placed among other engineering disciplines with regard to the number of annual job openings.

In conclusion; Connecticut will remain competitive in the future knowledge economy if the State is able to prepare and recruit enough qualified engineers, to be successful in the future, Connecticut needs at least twice as many engineers as all CT universities graduate every year, providing that all graduates stay in CT upon graduation. Our new engineering program is a positive response to these two challenges.

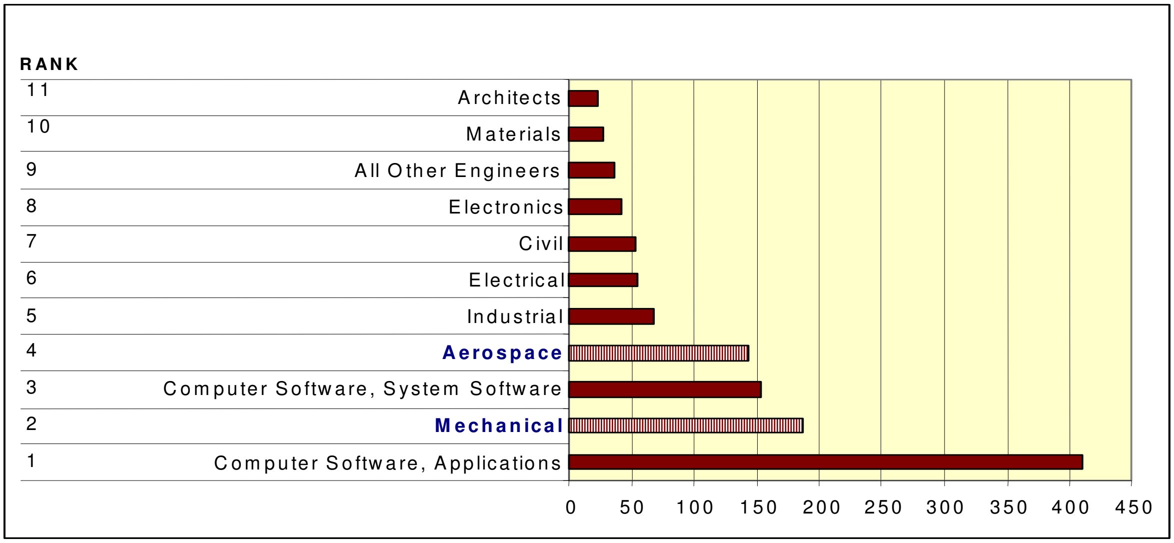


Fig. 4. Annual openings in engineering positions in CT.

Following the NAE recommendation (aspirations) on unconventional recruitment of diverse population (see Table 1), we have developed a project to reach out to underrepresented and underprivileged groups of talented students.

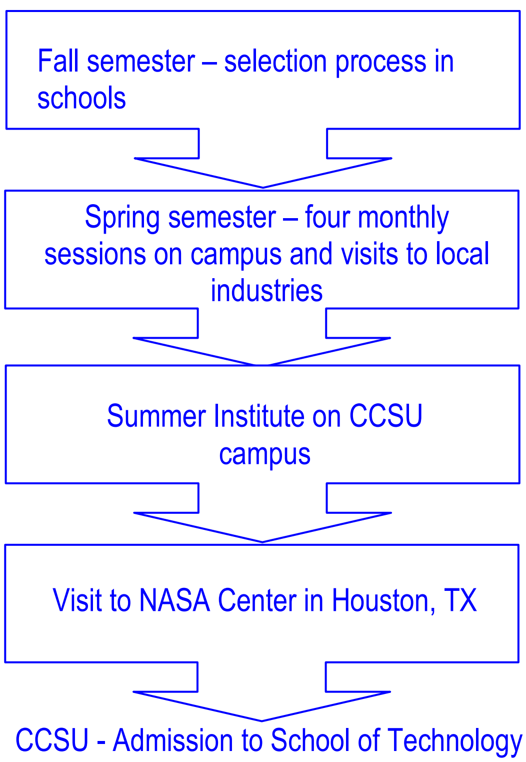
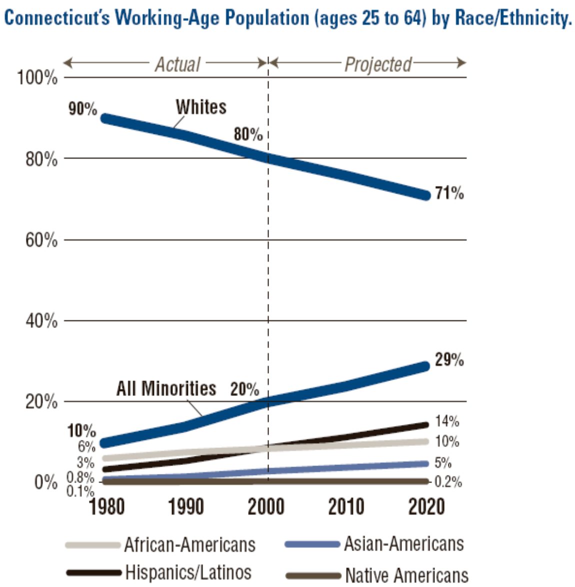


Fig. 5. The four-step recruitment plan.

To accomplish the goal of pro-active recruitment of underprivileged groups, CCSU proposed a four step, comprehensive program that would enroll high school students during their junior year (Fig. 5). The four steps will address all critical aspects related to successful recruitment of engineering students, in order to assure future high retention and graduation rates.

Recruitment for engineering programs is a real challenge for most universities, nationwide. Unfortunately, math and science are not the subjects of first choice for the majority of American high-school students. Comparably, in China some 60% of all college graduates emerge from the Sciences, Math, Engineering, and Technology (STEM), while in the US, barely 5% of degrees are earned each year in those disciplines. In fact, STEM enrollment has dropped 12% in the past five (5) years [8]. At the same time, some 10% of high school high achievers never go to college (this 10% is comprised largely of underprivileged / underrepresented groups). What is more disturbing; the retention rate for engineering students is one of the lowest [1] (some 60%) among all college majors. In part this is due to very demanding and rigorous curriculum, but the fact that some engineering students realize quite late that the program is not the best fit for them also has a negative impact.

"Having programs available won't do much to address shortages unless those programs attract students. Marketing of these programs needs to be an integral part of the process. This marketing can be done in partnership with businesses and community-based organizations as well as high schools. New strategies will have to be developed to target groups that have not traditionally sought out higher education opportunities. Given the population and demographic trends in Connecticut, that may be where the next available pool of workers will come from." [7]



Source: POLICY ALERT SUPPLEMENT
Fig. 6. CT demographic trends.

The share of Connecticut's workforce consisting of whites (particularly those under age 45) is declining rapidly, while the share made up of other racial/ethnic groups is projected to reach 29% by 2020 (see figure). The growth is almost completely within the Hispanic/Latino population, whose share of the workforce is expected to jump from 3% in 1980 to 14% in 2020. Thus, a recruitment plan focused on attracting minorities becomes sheer necessity when comparing current minority representation among college and university students with their societal representation. The severity of this problem is high-lighted in the illustrated trend in demographics (Fig. 6). Future recruitment efforts need to reach out to a diverse population of talented high-school students.

5. Conclusions

The two reports; *"The Engineer 2020; Visions of Engineering in the New Century"*[1] and "*Educating the Engineer of 2020; Adapting Engineering Education to the New Century*"[2] developed and published by the National Academy of Engineering are probably the first documents of such scope and impact on the future of engineering education in the first quarter of the 21st Century in the United States.

Because of the visionary nature of the reports, their findings represent potential rather than definitive outcomes and their recommendations are more general than specific and detailed. Particularly, the recommendations published in the second report [2], presented in Table 3, are quite heterogeneous. They are very different in terms of their importance, implementation feasibility, magnitude of potential impact on future engineering education, etc. However, at least seven recommendations (# 4, 5, 6, 8, 9, 10, and 12) can be implemented directly at a university/school level, as we aspired to do, when planning and shaping our new mechanical engineering program.

We found especially inspiring the "key attributes" of "*The Engineer 2020"* presented in Table 2. In developing program curriculum, the attributes seem to be directly related to program and even course objectives. Therefore, we have developed a chart illustrated in Fig. 4, which was very helpful not only at the stage of program objectives development but constitutes a sort of "road map" when drafting course syllabi and relevant learning objectives.

Based on the NAE key attributes and subsequent educational recommendations, "practical ingenuity" is as important as analytical skills. Therefore at the early stage of our project we have adopted a very important goal regarding practical aspects of the engineering curriculum.

There were also some statewide studies [6], which also recommended that "Connecticut needs to ensure a balance of more applied and user-inspired basic research with more traditional academic research……" In this context our undergraduate program is a perfect example of this type of approach to "problem based engineering education". A strong laboratory component, two semester research projects and the industrial / professional requirement are intended to equip our graduates with an excellent understanding of the practical aspects of the engineering profession.

6. Bibliography

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Appendix – BS in Mechanical Engineering - program sheet.

General Education	Crs
STUDY AREAS:	
I. Arts & Humanities (9 credits)	
English Literature	3
PHIL or Fine Arts	3
English Literature or PHIL or Fine Arts	3
II. Social Sciences (6 credits)	
History	3
ECON or GEOG or HIST or POL. SCI. or ET 399	3
III. Behavioral Sciences (3 credits)	
Anthropology or Psychology or Sociology	3
IV. Natural Sciences (8 credits)	
PHYS 125-Univ Physics I	4
PHYS 126-Univ Physics II	4
SKILL AREAS:	
I. Communication Skills (6 credits)	
ENG 110-Freshman Composition*	3
COMM 140-Public Speaking	3
II. Mathematics *	
MATH 152-Calculus I	4
MATH 221- Calculus II	4
III.a Foreign Language (0-6 credits)**	
III.b International (6 credits)***	
IV. University Requirements (2-3 credits)****	
PE 144-Fitness/Wellness	2 or 3

* Placement examination may be required before enrolling in English and Mathematics.

**Refer to University Catalog, Academic Programs for Foreign Language proficiency requirements.

***Courses with designator [I] in course description fulfill not only the General Ed. requirement, but also fulfill the international component.

****Refer to University Catalog.

Major Requirements		Crs	Sem. F	Sem. S
ENGR 150	Introduction to Engineering	3	X	X
ENGR 251	Engineering Mechanics I- Statics	3	X	
ENGR 252	Engineering Mechanics II - Dynamics	3		X
ENGR 257	Mechanics of Materials	3		X
ME 216	Manufacturing Engineering Processes	3		X
ME 258	Engineering Thermodynamics	3		X
ME 345	Engineering Statistical Analysis of Operations	3	X	
ME 354	Fluid Mechanics	3	X	
ME 367	Machine Design	3		X
ME 370	Instrumentation	3		X
ME 454	Heat Transfer	3	X	
ME 497	Senior Project I: Project Research	2	X	
ME 498	Senior Project II: Project Design	2		X
Electives or Specialization Requirements				
General Engineering Electives				
	Technical Elective	3		X
	ME Elective	3	X	
	ME Elective	3		X
	ME Elective	3		X
Aerospace Specialization				
ME 403	Mechanical Systems and Control	3		X
ME 480	Propulsion Systems	3	X	
ME 483	Aerodynamics	3		X
ME 486	Aerospace Structures and Materials	3		X
Manufacturing Specialization				
MFG 226	Principles of Numerical Control	3		X
ME 360	Manufacturing Operations Analysis and Simulation	3	X	
ME 460	Manufacturing System Design	3		X
ME 466	Inventive Engineering Design	3		X
Additional Requirements				
CET 236	Circuit Analysis	3	X	X
CHEM 161/62	General Chemistry I	4	X	X
CHEM 163/64	General Chemistry II	4	X	X
CS 151	Computer Science I	3	X	X
ENG 403	Technical Writing	3	X	X
ETM 260	Computer Aided Design & Intergrated Manufacturing	3	X	X
ETM 356	Materials Analysis	3	X	X
ETM 467	CAE Applied Finite Element Analysis	3	X	
MATH 222	Calculus III	4	X	
MATH 226	Linear Algebra and Probability for Engineers	4	X	
MATH 355	Introduction to Differential Equations	4		X
	TOTAL CREDITS **minimum**	127		
	maximum	135		