A great Job, If you can get it

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Concept: What is the future hold for New Engineers in the United States

Definition: Engineer vs. Technician?

- **Are Universities preparing engineering students adequately for transition to entry level engineering positions?**
- **Is there really going to be a shortage of engineers after the wave of Baby-Boomers retire?**
- **What type work will engineers working in the US likely do in the future?**

Overview

- Background
- What's factors are relevant:
  - Faculty
  - Students
  - Industry
  - Socially
- Premise for Sponsored Senior Design
- Behavior
- Student Project examples
- Results
- Concept improvements:
- Conclusions
- Questions

Background (personal and program)

- **1981 AirResearch Avaition - VIP Aircraft Modification, El Segundo, CA**
- **1984 Lockheed Aircraft Service, Ontario, CA (a division of the Skunk Works)**
  - **Associate Designer – Mentored for 2 years with very senior staff**
- **1986 Promotion to Systems Engineer – BIG SAFARI**
- **1996 AIP contract at Unisys/Loral/Paramax/Lockheed Martin**
- **Stop Loss problem:**
  - **Ageing technical staff population – retirement projection > 60% by 2012**
  - **Preparing for the loss of technical expertise?**
    - Findings:
      - 50% of new graduate new hires transferred or terminated in < 2 years
      - Senior engineers don't have time to mentor new hires
      - Fast Track leadership programs create social integration problems
      - < 30% working in discipline that they graduated with a degree in after 3 years
      - < 60 % capable of solving advanced (junior/senior year) equations related to discipline after 3 years
- **Industrial Advisor to 4 universities**

What factors are relevant to industry:

- **Technical skills:**
  - Ability to think critically,
  - Ability to plan in acute detail
  - Advanced ability to reduce problems to formula, model and evaluate solutions costs and risks
- **Technical flexibility:**
  - Solid understanding of: physics, math, engineering theory and application
- **Compensation requirements:** Education costs effect hiring and advancement
- Team orientation & management : ability to integrate into a team and self-manage
- **Communication skills:**
  - Ability to express technical concepts in layman terms for management
- **Business focus:**
  - Understanding the cost benefit of a solution and associated risks
- **Work ethic:**
  - Disciplined, dedicated, honest and forthright, tactful
- **Availability and cost of technical resources:**
  - Home-grown talent takes ~ 2 decades to develop
  - Access to international talent is almost immediate

What factors are relevant or of interest to students?

- Preparation for a technical position (industry vs. research)
- Assistance in finding their personal discriminator (what they are best at, talent)
- What other student teams have accomplished during senior design
- School size: Big=> more opportunities, Small=> one-on-one instruction
- What percentage of Engineers are working in the discipline that they studied in
- What percentage of graduates are still working as engineers 5 years after graduation
- What percentage of new hires have been promoted since hiring
- What percentage of new hires have seen a raise that exceeds the rate of inflation
- What percentage of new hires have continued their education and how has that advanced degree effected their compensation and job assignment
- Availability of Federal funding for R&D work
  - If the Federal Govt. spent as much on all areas of science as Health care the increase would be $11B

What factors are relevant to educational institutions

- **Being able to maintain/expand current physical plant, staff and fund retirement**
  - **Block grant vs. headcount polity**
    - Case Study: U of MN , less class rooms, more faculty, no change in State funding
    - Case Study: UST , $50M grant, new facilities and services, core educational values re-affirmed
- **Drawing the best candidates for students and faculty**
  - Quality of students, not quantity

- **Meeting the demand for product (graduates)**
  - Block grants are counter-productive to graduating student metrics on cost
  - US educational institutions value waning (cost vs. product investment)

- **What are the educational institutions core values?**
  - Discriminators: Public, Private, Research
  - Research schools core focus is producing researchers
  - Research schools = foundry, creating new opportunities (marketing?) Need metrics
  - Public/Private schools prepare students for entry in the community as productive members

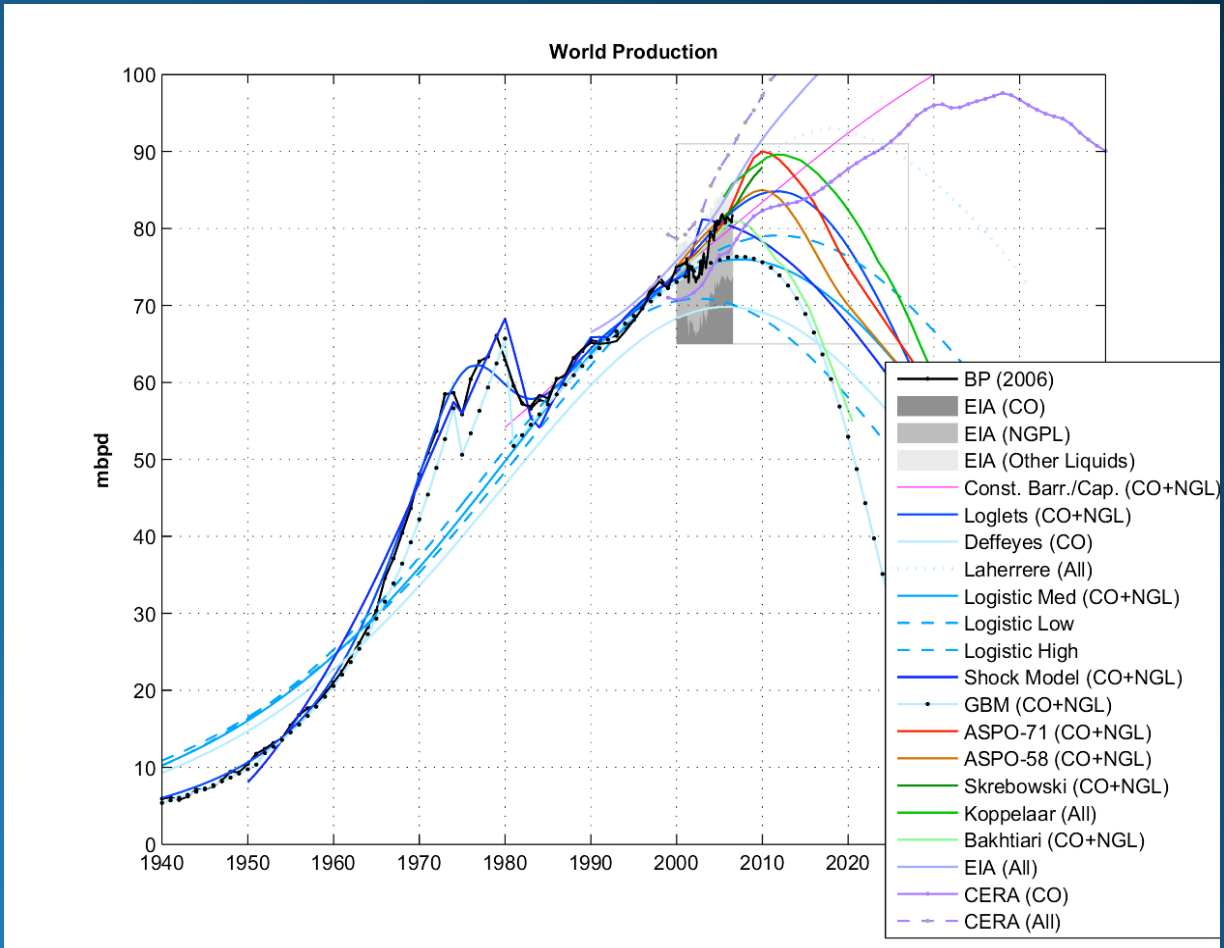
- **Social impact (common goals)**
  - Can do (positive) attitude towards the future
  - Social conscience (do no harm) Global vs. National

What issues, related to higher education, are relevant to society (in the United States)

- **Economic Future of the United States**
  - Previous to 2000 technical expertise and novel design solutions create opportunity for the U.S. to emerge as economic world leader
  - Graduates of Engineering schools peaked in 1965 at 80K/year, output was down 21% and falling in 1999
  - Today, China and India are rapidly taking this role
  - U.S. and EU are on par, with EU gaining slowly
  - U. S. Debt. ,… real debt owed to oil and industrial producing nations
- **Peak oil**
  - **Effects all commodities, everything gets more expensive, will change social fabric of the world**
    - Big Question: What will US Public accept as a solution ?
- **Global Warming**
  - **China and India are not going to agree to neutral carbon discharge**
- **Clean Water & uncontaminated food**
  - **The effects of global warming are already showing**
    - Rapid shift of seasons effecting planting (region and crops) and crop growth
    - Clean water sources are diminishing while populations are growing at exponential rates
- **Affordable Health Care**
  - >90% of lifetime health cost are incurred in the last 3 years of life
  - Doctors are specializing because General Practice doesn't pay the bills
  - Technical Innovation driving cost of health care as well as life expectancy
  - Quality of life issues while in assisted living drives > 80% of families to bankruptcy in < 3 years
- **Federal R&D funds (1963 ~= 2% GDP, 2000 ~= 0.8% GDP**
- **Post Graduate degrees continue to fall in the USA and are exceeded in EU and Asia**

Concept: What is the future for Engineers in the United States likely to hold – Peak Oil, When?

- IN OUR LIFETIME ? -



Effected Systems:

- Transportation
- Agricultural
- Industrial

Premise for Sponsored Senior Design

1. **Develop concept for a challenging system or sub-system**
    - Topic should be in the students discipline
    - Topic should be current and exciting
    - Topic should have the probability that it will yield a novel design
    - Topic should not have been covered by coursework
    - Topic should showcase a capability that senior management will be immediately able to appreciate the value of
    - Topic should be challenging and force the students to look outside of their normal resources for solutions
    - Topic should be achievable given the time and resources available

Premise for Sponsored Senior Design

2. **Develop customer requirements that make sense**
3. **Develop concept of operation consistent with customer requirements**
4. **Provide resources that make sense… not a solution**
   - **appropriate funding**
   - **appropriate tools and materials… if required**
5. **Plan for : Initial review of project with faculty**
   Status reviews (minimum monthly.. As required
   Preliminary Design Review
   Critical Design Review
   Test Readiness Review
   Formal demonstrations and tests .. As required
6. **Formal End of Project presentation onsite at sponsoring facility**

Observed Behavior related to senior design

Related to students today -Two camps:

Non-mentored

- **If team is successful, there is a natural born leader on the team**
- **Problem solving**
  - **Critical thinking skills are largely undeveloped**
    - Current teaching methodology shuns ambiguity over "fairness"
- **Work Ethic**
    - Normal resource time projection at a public/research institution
      - 75 to 130 hrs/student/semester
      - Realized 50 to 85 hrs / student
    - Time management and planning taught as an afterthought or not at all.
    - Students learn to plan for a few days at a time
    - Students learn that they can pass a course by a Herculean effort at the end of a course
  - **<u>Working cooperating/collaborating as a member of a technical team</u>**
    - Team commitments are forced by grades
    - Giving your best effort **<u>widely influenced by other academic and social factors</u>**
- **Create a viable solution and working prototype**
    - Generally are able to create a rudimentary design and partially integrate and test functionality
    - Not much supplementary knowledge learned as a result of integration

- **Biggest mistake: Thinking that the project can be successfully accomplished overnight**

Observed Behavior related to senior design cont.

Related to students today -Two camps:

Mentored

- **Ability to solve complex problems**
  - Able to derive a requirements set from a problem statement
  - Able to form a solution as a team
  - Able to plan and execute a project
  - Able to analyze risk
- **Work Ethic**
  - Normal resource time projection at a private institution
    - 75 to 130 hrs/student/per semester
    - Realized 175 to 250 hrs/ student
  - **<u>Working cooperating/collaborating as a member of a technical team</u>**
    - Able to work in a cohesive, cooperative team, leadership skills
    - Adopt a code of Ethics to meet personal commitments to the team,
    - Plan for loss of team members, sick leave, support of weak member skills
    - Mantra :Give your best effort
      - » Meet objectives set by the project
      - » Finishing on time
      - » Successful demonstration
- **Create a viable solution and working prototype**
  - Able to design and mostly integrate and test/demonstrate system functionality to customer
  - Supplementary knowledge gained as a result of integration exceeds design task
  - Confidence built in ability to perform a task with an ambiguous solution

Observed Behavior related to senior design

Related to Faculty:

- **Teaching the engineering process**
  - Requirements generation and decomposition
  - Arriving at an architectural solution (functional vs. physical)
  - Project Planning (Managing time and resources)
  - Scoping work and work assignments evenly
  - Managing risk
  - Technical assistance with ambiguous problems
- **Establishing grading criteria at the beginning of the semester**
  - Industry uses an “earned value formula” a similar model would alleviate the anxiety experienced by students and facilitate project completion
- **Professional ethics**
  - Mediating when student teams “storm”
  - Honesty and Integrity
  - Balancing workloads between students

- **Biggest mistake: “sink or swim mentality”**

Observed Behavior related to senior design

Related to Industry:

- Under/over estimating the capability of a student design team
- Role played: (Technical vs. Project management)
  - Agreed upon roles with faculty before project starts
  - Consistent contact with student teams
    - Status reports
    - Formal Presentations
    - Formal and informal rewards
  - Consistent support of student teams
  - Meet commitment dates for hardware and financial aid
  - Sponsor Formal Design Reviews with senior management to showcase the student work… students need to know this at the beginning of the term

- Biggest Mistake: Assuming the faculty/school can provide the same or better oversight as an industry advisor (fire and forget mentality)

Student Project examples:

- Optical Landing system
- St Paul Trail Usage System
- Silent Stamina II
- Sky Spirit UAV

Results… so far

Hired personnel:

School	2004	2005	2006	2007
Univ. of MN	2	1	2	2
Univ. of St. Thomas	4	3	1	1

Retention: 100%

Working in discipline: 85%

Transferred to another LM division: 7%

Identified as key personnel: 38%

Working on IR&D/CRAD: 15%

Working on Masters/PhD: 25% (company funded)

Concept improvements:

- **Spiral evolution project - similar to: American Solar Challenge or AUVSI UxV Challenges**
  - Recruit from Freshman Class
  - Identify interns for summer work at all class levels
  - Project has legacy designs where leaving senior members identify target areas for improvement and priority
  - Follow-on project team makes improvements based on skill/knowledge mix
- **Consortium project**
  - A spiral evolution integration project
  - 2 to 4 companies sponsor with equal resources and content
  - Framed around topic such as:
    - DOE Energy Challenge
    - DARPA Robust Portable Power

Conclusions:

- **Polls about job satisfaction in the USA show Engineers at the top of all categories for creativity and recognition**
- **Engineering schools need to address the problem of how to teach students to live with ambiguity in engineering problems.**
- **Engineering schools should start teaching Project Engineering and Integration at the latest by the junior year cycle**
- **Publicly sponsored research universities need to address the core issue of education; ergo, priority of public research contracts and publishing vs. teaching core discipline**
- **Future Engineering jobs in the U.S.A. are likely to be oriented towards System Engineering and Application Engineering. Elemental simulation and design is likely to be outsourced outside the USA.**
- **Industry should sponsor company relevant work and sponsor internships and hiring around the sponsored work**
- **The issue of who owns intellectual property, related to industry sponsored senior projects placed in public universities needs to be vetted and solved uniformly.**
- **Metrics related to engineering student placement, and job tracking throughout their career needs to be started**

There is likely to be a robust need in the future for creative new engineers with an ability to think critically and don't know that (fill in the blank) can't be done. These jobs will hold the promise for great recognition and personal satisfaction,

<u>if you can get one</u>.

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