

3. The need to make communications an everyday part of the learning experience. It is necessary to use various techniques in both the universities and the work place in developing improved communication skills for primarily the foreign born engineers.
4. The need for state professional engineering boards to require English proficiency as part of the evaluation process.
5. The need to emphasize the role of communications in averting engineering and scientific disasters.

Summary of the Report:
Foreign and Foreign-born Engineers in the United States
by
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I am delighted to be here at the Annual Meeting of the Transportation Research Board with this distinguished group of transportation experts to talk about foreign and foreign-born engineers, a subject that involves engineering personnel who work in transportation areas, but which goes much beyond these personnel in terms of its implications. I will try to summarize this report, but there may be points at which my views will creep in. When that happens, I will certainly try to tell you. Of course, my views do not necessarily represent the views of the Committee or the National Academy of Engineering or the National Research Council of which the Office of Scientific and Engineering Personnel is a part.

The study was commissioned because of the rising concern about the growing prominence of foreign personnel both in our engineering work force and in our engineering educational system, particularly in the graduate schools. What the Academy of Engineering asked the Committee to do was (1) to develop all of the relevant issues that might be appropriate to that growing prominence, (2) to assess those issues as best it could, and (3) where possible, to arrive at conclusions about whether this is good or bad for engineering and for the country. The Committee commissioned seven papers, which were presented at a workshop. It gathered every statistic it could find that related to the subject. Finally, it met several times to review the evidence, to review the papers, to review the discussion that took place at the workshop, and to try to develop a report through which its findings could be disseminated.

I am going to talk about the findings briefly, move from the findings to the issues these findings raised, and then turn to the conclusions the Committee reached based on these findings and their deliberation on these issues and to some of the conclusions they didn't reach because they couldn't. And again, I'm highlighting the report. The report contains lots of information so what I present is clearly my perception of what I think are the important findings and recommendations.

There are three major findings. The first was that the proportion of foreign-born engineers (not necessarily foreign citizens, but foreign-born engineers, including both foreign citizens and naturalized American citizens) in the United States work force has been increasing. We were able to find data for the period 1972 and 1982 which described comprehensively the engineering work force in the United States. Thus, over that period, we were able to track the growth. The prevalence of these foreign-born engineers went from roughly 8% to roughly 18% over that period. The largest increase that took place among the foreign born was the increase in the naturalized citizens. So what we are experiencing is no different from what we have experienced in the past; immigration of foreigners to this country in areas of employment opportunity.

The second finding, and perhaps even more dramatic, is that the increase has occurred disproportionately in the academic sector. This finding shows that, if you look at all engineering faculty, the proportion who were foreign or foreign born, rose between 1975 and 1985 from 10% to almost 50%.

If you focus on those at the assistant professor rank, who are 35 or younger, the proportion went from about 10% to over 50%. In one year, the proportion went as high as 55%. So there has been a very marked and dramatic increase in foreign presence among our engineering faculty.

Finally and also importantly as we'll see later on, the largest numbers come from areas of the world that include the Far and Middle East and India. This is a contrast to earlier immigrations which came from Western Europe and Eastern Europe for political reasons. We don't know whether this recent migration is politically motivated or is motivated simply by differential opportunities; that's still an open question.

Those were the findings. What are the issues that are raised by these findings? I presume those of you who are here are interested in what civil engineering looks like in all of this. If you look at foreigners as a proportion of all undergraduate engineering students in the United States in 1985, the number is 13%. And that is the largest proportion at the undergraduate level in the disciplines of engineering that are being reported. Industrial, electrical, materials, mechanical, chemical, aerospace, nuclear and others are all much below that. The next largest fraction is in industrial engineering where it is 10%.

The other finding that I think is of interest is at the post-doctorate level. Two-thirds of the postdocs in engineering today are foreign born. And among those who are civil, about 60% are foreign born and that's lower than the average. So there's a sense of the civil being strongly concentrated at the undergraduate level as opposed to the graduate level.

Let me talk about the issues. Starting with the question of, "What does this mean for our economy?" The first question the Committee addressed was, "Do we need these foreign-born engineers?" The answer was an unambiguous yes. Without these foreign-born engineers, both in our work force and in our graduate schools, we would have a very difficult time meeting national goals in both the academic and the industrial work force. One of the papers commissioned for the study, written by Peter Canon, surveyed about 20 directors of major R&D labs in this country, who reported that without these foreign-born engineers, important work would not get done, and they are growing in relative importance. By implication, of course, these findings suggest that they are not replacing American engineers in these functions.

A corollary to the presence of foreign-born engineers in this country is the issue of the absence of American students. The Committee very clearly takes the position that the foreign born presence in this country is not the problem. The problem is the absence of American students interested in taking particularly engineering work at the graduate level. This is what needs to be focused on.

The quality of those foreign-born engineers, both in the work force and in our graduate schools, is very high. Thus, the quality of our work force is not being undermined as a result of their being present. So, they are needed and they fill an important role, and given their quality, they fill it very well.

However, like any new group of immigrants coming to this country, problems do arise as they attempt to integrate into our society. The Committee was very concerned about those problems and tried to address them in a very direct, straightforward way. It was difficult and there was a lot of deliberation in committee meetings to try to arrive at the cultural implications of their arrival in this country.

The question that was of concern was, "What is their effect, particularly on engineering education, since their prominence in academia is so pronounced?" Three levels of concern were raised and addressed by the Committee. The first,

of course, is possible language barriers. There may be a qualitative problem in the sense that foreign teaching assistants or faculty may not be able to communicate well with student bodies because of the fact that English is a foreign language to them. With respect to the language barrier, the Committee said that it could be a problem.

The second issue of concern was more cultural and had two components to it. One component was, "How do they affect under-represented groups in engineering, i.e., women and members of minority groups?" An allegation is frequently made that some foreign-born and foreign engineers come from cultures where women are second-class citizens and that cultural attribute comes through in the way they deal with women in this country. What happens is that women become unenthusiastic about considering careers in engineering as a result of their contact with such faculty members or teaching assistants. The allegation is also made with respect to members of the minority groups, particularly blacks.

With respect to the cultural attitude towards women and minorities, there was much debate within the Committee about this issue and its relevance. There are no hard data to document, that either refute or confirm this allegation. As a result, it was very difficult for the Committee to evaluate the implications of this allegation. Thus, it concluded, "We don't know, but there is enough concern about it, that it must be further evaluated as an issue."

The third area was the effect of foreign engineers in the academic work force. Their effect on engineering education was much more subtle and, I think, much more relevant to your concerns. That was the issue - how these foreign faculty affect the character of engineering education. My simple way of trying to break this issue out is to think about two types of engineering education. One which is frequently called engineering science, where the emphasis is on the analytic, modeling and theoretical aspects of engineering. The other dimension of engineering education is called "hands-on" engineering--the design, the practical end of what engineers do. The concern that the Committee addressed was that foreign engineers from some cultures come with an orientation towards engineering science; towards the theory, towards the analytic, and look down upon the practical, the "hands-on". If that attitude is conveyed, particularly to undergraduate students, this may have very serious implications, given the kind of engineering that we need today to maintain our competitive edge and to stay even with the rest of the world.

The Committee deliberated at great length. Examples were drawn of people who had that attitude and counter examples were drawn of people who didn't. Some members of the Committee noted the fact that these foreign engineering faculties with this analytic bent are being hired by faculty which is predominantly non-foreign and that may say something about the philosophy and direction of engineering education in this country. That may be a more fundamental question that needs to be raised.

Again very little hard, systematic evidence was available that could support or refute that allegation. But the allegation is being felt strongly by many in the engineering community. Therefore, it was felt that it couldn't be ignored. So the Committee put it on the table as an unresolved issue.

The final issue can be paraphrased as, "Is it wise policy to subsidize the training of foreign students?" This issue comes up again and again in state legislatures and the Halls of Congress. It is a very important issue in terms of education policy and how it interacts with the question of foreign engineering in our country. On this issue the Committee was much clearer about how it felt. They concluded that it is a wise policy. The reason it's wise policy is a very large fraction, about 60% of those who are here on temporary visas and 90% who are here on permanent visas, stay in this country. It varies by field and, if I recall correctly, civil engineering is one of the fields in which a relatively large fraction go back compared with other fields. Nevertheless, a large fraction do stay here and contribute to our society. Moreover, their quality is high. Finally, many of them come as students and

eventually parlay their student status into naturalized citizenship status. They come with education up through the undergraduate level already in hand. So you could argue that we are being subsidized by the home country of these students for their pre-graduate school educations. So for all those reasons, the Committee thought that allowing the foreign students to study in our graduate schools was wise policy.

Several ancillary issues were also raised by the Committee. One of the questions was, "Do these foreign engineers displace Americans either in the work force or in the graduate schools?" The answer was no. If these engineers were not here, certain jobs would not get done and some engineering departments would have difficulties in terms of filling their available slots.

Another ancillary issue was, "Do these foreign engineers lower the wage rates of American engineers?" The answer to this question was also no. If you look at data, and we did have some analysis that we could draw on here, that compared salaries of American and foreign-born engineers, controlling for a wide variety of characteristics (i.e., their age, their field, whether they're in the academic sector or the industrial sector, education levels, etc.), there was no difference in the earning rates of foreign engineers and American engineers. On the other hand, the fact that these engineers add to the supply of engineering talent available to our work force, tends to lower the average wage of all engineers. Just simple economics of supply and demand analysis tells you that a larger supply means less upward change in wage rates.

Those were the major issues. Now let me talk to the recommendations that came out of the report.

I think the most important recommendation was not explicitly emphasized in the report: "Don't do anything to make it more difficult for these foreign engineers to come into this country." I personally believe there is a lot of xenophobia in this country about the presence of foreigners in our work force and in our society. The Committee report clearly shows that, in engineering, these workers are important and essential. Thus, any measures that restrict that flow and make that flow more difficult, making it more difficult for firms to recruit and hire these foreign-born engineers, are not wise policy.

The second recommendation addresses the lack of American students. That recommendation is to make it more attractive for American students to pursue a graduate education in engineering. That means increasing the number of fellowships that are available for this kind of education and increasing the stipend levels as well.

We all know that the average beginning engineer coming out of the undergraduate programs in this country can now earn about \$30,000 a year. Moreover it takes six years to get an engineering Ph.d. Multiplying six years times \$30,000 (if you don't get any stipend) the prospective students gives up roughly \$180,000 for a graduate engineering education. Financially speaking, a substantial cost must be overcome to make graduate education in engineering attractive as a package. Thus financial support clearly has to be considered, and it has to be more than the average amount of financial support provided to other disciplines.

In fields such as chemistry, physics, mathematics, for example, the starting salaries for B.A.s is no where near the \$30,000 figure I just cited. This may be the reason why engineering has such a large fraction of foreign students and such a small fraction of American students. The returns to an undergraduate education are so high that it doesn't pay to go on.

A third recommendation was that language proficiency should be monitored. That responsibility lies in the hands of the university administrators on the campuses. Before a foreign-born teaching assistant or an assistant professor should be allowed in the classroom, it should be very clear that he or she is able to communicate proficiently. If not, the institutions have the responsibility and obligation to take remedial measures to either give them the language skills or keep them out of the classrooms.

The fourth recommendation is that argument: pre-college math and science education has to be dramatically improved in this country. That, I think, is a commonly accepted conclusion. It's particularly important to say that in engineering, however, because without the requisite math and science competence coming into the colleges, the student considering an engineering career is at a very extreme disadvantage and may not succeed. In effect the pool of possible engineering talent is constricted if you don't allow students the right kind of education in science and math before they enter college.

Another recommendation was made to develop a firmer factual base on which the issue of the quality of engineering education, and what might happen to it as a result of foreign presence, could be judged. We need more hard data. We also need more hard data on whether or not there is a difference between foreign engineering faculty and teaching assistants and native born faculty with respect to their performance in the classroom, their ability to communicate with students, their attitudes, and whether the foreigners are more likely to turn off women and minorities.

Finally, there is a need to examine more extensively the characteristics of engineering education and how it might be influenced by the increasingly important role that's played by foreign faculty. As I mentioned earlier, the issue of the character of that education raises fundamental questions and goes beyond just the foreign born questions.

Foreign Engineers--Implications for Transportation Engineering:
An Academic Perspective

by
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Judging from the composition of the panel, each of us is to respond to this issue from his own perspective: that of the university, the consultant and the state DOT. In preparing my comments for this session, I identified a few questions and then tried to answer them.

My first question as an educator is, "Why are we seeing so many foreign-born students in our engineering programs?" Note, this phenomena does not exist to the same extent in other professional fields.

Part of the answer is in the nature of engineering as a profession. In the United States this field has historically attracted the sons and daughters of blue collar workers, because it was perceived as an entry into the world of leadership and decision making, where scientific and mathematical skills coupled with understanding of technology, are the prime requisites for respect, financial reward and advancement. Engineering has traditionally been a "boot strap" route from the factory to the board room. It provided a route for an individual with little in the way of cultural and social advantages to practice professionally as an individual, or head a government bureau or a division in a private corporation. Other professions like law, medicine and business typically require more financial support and a greater number of years of education to be qualified, and often required a network of connections for admittance to the better schools and development of a successful practice. The culturally or economically disadvantaged had a much greater probability of success in engineering than in these other professional fields.

Today the disadvantaged blue collar worker's son or daughter (many from emigrant backgrounds) no longer exists in large numbers. This group is being replaced by bright foreign students who see the opportunity for "making it" in this country by pursuing an engineering career. The opportunity is further enhanced because most U.S. born undergraduates are electing to join the work force upon graduation rather than pursuing advanced degrees. Thus, places in