

AC 2007-378: THE DOCTORAL PATHWAY, AN INSTITUTIONAL JOURNEY OF DEVELOPMENT

Ronald Kane, New Jersey Institute of Technology

Ronald S. Kane is Dean of Graduate Studies and Assistant Vice President for Academic Affairs at New Jersey Institute of Technology. Before that he had been Dean of Graduate Studies, Research, and Continuing Professional Education and Professor of Mechanical Engineering at Stevens Institute of Technology and before that served as Mechanical Engineering Department Chair at Manhattan College. He has industrial experience in the energy and aerospace industries and worked for a number of years on nuclear safety and alternative energy systems, with focus on modeling and evaluation of thermal/fluid system problems. He is a Fellow of the American Society of Mechanical Engineers.

Dr. Kane has been an ABET visitor and has been active in ASEE since 1984, presenting numerous papers and moderating sessions on graduate education, international students, and minority issues. He has served on the ASEE Board of Directors and held every major position in the Graduate Studies Division and is a Fellow of ASEE. He has also been active as a member and officer of the Council of Graduate Schools and the Northeastern Association of Graduate Schools, and still continues as President of the Association of New Jersey Graduate Schools. He recently completed a four year term as a CGS representative to the Boards of the Graduate Record Examination (GRE) and the Test of English as a Foreign Language (TOEFL).

Clarisa Gonzalez-Lenahan, New Jersey Institute of Technology

Clarisa Gonzalez-Lenahan has been the Associate Director of the Office of Graduate Studies at New Jersey Institute of Technology since 2000. Before that she held a number of other positions at NJIT as Acting Director of the Ronald McNair Achievement Program including coordination of the undergraduate research experience component, Acting Director of the University Learning Center, Assistant Director of the Education Opportunity Program, and Coordinator of the NSF Educational Learning Assistance Program at NJIT. She is active, and a former Board Member, in the Hispanic Association for Higher Education (HAHE) and has presented at previous ASEE meetings.

AC 2007-378: The Doctoral Pathway, an Institutional Journey of Development

GSD, MIND, WIE, INTD

Ronald Kane and Clarisa Gonzalez-Lenahan

The history of one institution's transformation from a regional specialized institution to a leading research university can be a model for others in times of limited state resources to support graduate education. Through the 1980's, New Jersey Institute of Technology, known earlier as Newark College of Engineering, was best known as a primary source of practicing professional engineers. Through visionary leadership, reasoned planning and goals setting, an engineering approach to tactics, quality measures, and strategic resource allocation, NJIT became a major producer of graduate degrees, with increasing emphasis on research and the doctorate. Among its priorities were an increase in graduate program participation in both master's and doctoral programs by those traditionally underrepresented in engineering by both ethnicity and gender. A step-by-step approach is described: data gathering and analysis of student achievement, setting of admission and retention criteria, new program connections for a diverse undergraduate population, policy setting for academic quality, financial support standards and control, retention standards and intervention, faculty and campus community empowerment, and connections with other universities and support groups. A measure of achievement is the growth in doctoral graduates from 14 in 1991 to 75 in 2006, at a public university with a total enrollment of fewer than 8500 students.

Introduction

During 2005-2006, New Jersey Institute of Technology had 75 doctoral students complete their degrees in 18 disciplines. This continues the trend of successive record numbers of PhDs over the past 4 years. NJIT's total enrolment in Fall 2006 was 8, 209 including 2, 396 master's and 433 doctoral students. The 2006-2007 Almanac issue of the Chronicle of Higher Education dated August 25, 2006 shows a table "Number of Colleges by Enrollment, Fall 2003". For NJIT's enrollment (5,000-9,999) and status (public), 377 institutions are indicated with not one being in the Doctoral Extensive Carnegie Classification. (Ref. 1)

The Doctoral Extensive category requires an institution to award 50 or more PhDs per year over 15 or more disciplines. The next category, Doctoral Intensive, requires the award of 20 or more PhDs overall. While, the Carnegie Classification System has been recently revamped, the table suggests that NJIT has achieved the status of being the top producer of PhDs for its enrollment size and type among the 377 institutions. Among all 4,140 institutions in the United States regardless of enrollment size, and type, the table reports that only 151 institutions were in the Doctoral Extensive category and 107 in Doctoral Intensive category. NJIT's inclusion in either category represents unique growth in doctoral degrees awarded and a major shift in the focus of the institution over the last 10 years.

History

The table below shows the number of doctoral degrees awarded since 1990 compared to the total and doctoral enrollment of the university:

Year	PhDs awarded	Disciplines	Total Enrollment	Doctoral Enrollment
1990-1991	14	5	7670	164 (F90)
1991-1992	17	2	7417	189 (F91)
1992-1993	29	6	7682	223 (F92)
1993-1994	30	6	7533	280 (F93)
1994-1995	33	9	7489	291 (F94)
1995-1996	43	8	7885	351 (F95)
1996-1997	46	8	7837	303 (F96)
1997-1998	39	11	8133	327 (F97)
1998-1999	39	9	8191	320 (F98)
1999-2000	54	13	8257	349 (F99)
2000-2001	56	14	8822	378 (F00)
2001-2002	41	12	8862	410 (F01)
2002-2003	58	15	8828	433 (F02)
2003-2004	70	15	8770	480 (F03)
2004-2005	74	18	8249	457 (F04)
2005-2006	75	18	8058	433 (F05)

The degree data includes a few PhDs (usually 3 or less, in only 1 or 2 disciplines) in some years where some degrees were awarded by a joint or collaborative program agreement between NJIT and the Newark campus of Rutgers University (Ru-N). By agreement among the two institutions, faculty from one institution who may supervise doctoral students from the other institution can have completed degrees included in the count of PhDs awarded by the home institution of the faculty member. A similar arrangement will come into effect soon for students in joint doctoral programs with another nearby university in Newark, the University of Medicine and Dentistry of New Jersey (UMDNJ). The joint programs and collaborations that have already led to completed doctoral degrees are in Management, Biology, Mathematical Sciences, and Applied Physics.

The full list of doctoral programs having completed students includes:

PhD degree	First Year Degree Awarded
Applied Physics	1998-1999
Biology	2002-2003
Biomedical Engineering	2004-2005
Civil Engineering	1972-1973
Chemical Engineering	1963-1964
Chemistry	1994-1995
Computer Engineering	2002-2003
Computer Science	1992-1993

Electrical Engineering	1964-1965
Environmental Engineering	2000-2001
Environmental Science	1994-1995
Industrial Engineering	1996-1997
Information Systems	1997-1998
Management (Rutgers)	1985-1986
Materials Science and Engineering	1999-2000
Mathematical Sciences	1997-1998
Mechanical Engineering	1959-1960
Transportation	1994-1995

The list of degrees awarded, particularly the dates of the first degree, show the growth of NJIT from its roots, primarily as an engineering school. NJIT was originally founded as Newark Technical School in 1884 and grew into a Bachelor's degree granting institution in the 20th century as Newark College of Engineering. The first graduate degrees were awarded after World War II to help meet the needs of returning servicemen. The PhD degree table shows that the first doctoral degrees were awarded in the 1960's. With the addition of the School of Architecture in 1975, the name of the university was changed to New Jersey Institute of Technology. In 1994, the New Jersey Institute of Technology Act was approved by the legislature and signed into law by the governor. This legislation changed NJIT from an annual by-contract institution providing services to the state into one of the three recognized state research universities, designated as New Jersey's public technological research university.

Other colleges and schools were formed between 1975 and 2001. Currently NJIT has six colleges and schools including: Newark College of Engineering (NCE), New Jersey School of Architecture (NJSOA), College of Science and Liberal Arts (CSLA), School of Management (SOM), College of Computing Sciences (CCS), and the Albert Dorman Honors College (undergraduate only). A relatively new PhD program, Urban Systems, centered at NJSOA, is soon to have its first PhD graduate. This program is joint among the three partner institutions in Newark: Rutgers, UMDNJ, and NJIT.

The majority of the current doctoral degrees awarded at NJIT are still in the four traditional engineering disciplines of Chemical, Civil, Mechanical and Electrical Engineering, but the growth into Interdisciplinary, Applied Science, Biological Science, and Computational and Informational Technology areas is apparent. This growth is consistent with NJIT's focus on applications and service to the state and regional industry. A growing number of doctoral students are part-time and still employed in industry. NJIT has taken advantage of the large number of technologically advanced industries located in the state and the region, by student choice of dissertation topics and by inclusion of industrial leaders on a number of dissertation committees.

Funding Shifts

The type of growth seen in the doctoral completion tables could not have occurred without major growth in both external research funding and some changes in priorities within the institution. The expectation at NJIT is that full-time doctoral students should be supported and be provided

competitive support packages. The university model is that PhD students will have multiple sources of support that reflect their progress through the program. Engineering programs and science programs tend to have slightly different approaches to the timing of such support but the overall intent is the same. This also reflects the difference between traditional start-points for engineering PhDs compared to science and non-science PhDs. In engineering, the start-point tends to be at the conclusion of an appropriate prior Master's degree. In the sciences, this tends to be at the conclusion of an appropriate prior Bachelor's degree with a Master's degree having a different status in some of these fields than it does in engineering.

In 1990, there was a major change in the structure of graduate education administration at NJIT with changes in personnel, oversight, quality control, and priorities. The internal funding available to support graduate students, a significant instrument to assist changing priorities, was carefully evaluated. It was concluded that redirection of these resources from their former use was essential to the growth of NJIT into a major research university. In 1990, a large percentage (more than 40%) of the funding available to support graduate students was directed to support of graduate students in non-academic offices with the laudable intent to use these monies to encourage the enrollment of Master's students and to provide service to a university that was not heavily staffed.

The monies that were allocated directly to the academic departments had not been regularly evaluated against departmental and program needs and was based on continuing practices rather than priorities. The re-evaluation looked at the following factors by college, by department, and by program: overall graduate enrollment (master's and doctoral), doctoral enrollment alone, completion record for doctoral students, external funding by faculty, undergraduate enrollment and calculated need for Teaching Assistants (TA), and seed money required for new or developing programs. Recommendations for re-allocation were then made, and continue to be made annually, by the graduate dean to the university provost, with consultation and input from the college and school deans and from members of the faculty.

While all factors were important and impacted reallocation of graduate students support monies, the most influential factors were doctoral enrollment and need for Teaching Assistants. Some programs with better records of external funding and doctoral completion received increased allocations over the nominal compared to others with weak records of external funding or weak records in doctoral student completion. Some changes in allocation were difficult but the approach was to make gradual changes from year to year rather than immediate changes each year to reach "equity." For example, if a program had experienced declining doctoral enrollment and warranted a reduction of two full doctoral Teaching Assistant positions, perhaps only a one TA reduction might occur for the first year. The determination of changes proceeded, whenever possible, early in the academic year for application to the following academic year to allow some planning of recruitment and support arrangements as far in advance as possible.

The evaluation of "equity" looked at the relative funding of the colleges and schools and then within the colleges and schools, at the relative funding of various departments and programs. Strict formulae do not always work and the primary factors sometimes do not agree. Departments with heavy service commitments for undergraduate courses require large numbers of Teaching Assistants. These are not always the same as the departments and programs with

large doctoral enrollments or strong records of external funding or doctoral completion. In general, a rational allocation system having limited funds will result in no programs being "over-funded" and some understanding by the departments about why the allocation was as it was. Because no system can simultaneously meet all these conflicting needs, a small portion of the available funds should be held in reserve (if possible) by the graduate dean, provost, or other allocation source, to handle last-minute emergencies and unforeseen needs.

At NJIT, limited internal funding caused the number of available support slots (stipend, tuition and fee support for each student) to remain relatively constant over the years. The dollar amount corresponding to each support slot or student support package increased annually with increases in tuition and fee rates and regular stipend increases. However, the amount of funding, because of some budget cuts during lean years in the state, has not changed significantly for many years and is remarkably similar to the amounts seen in the 1990's. Nevertheless, the individual academic departments have been hardly impacted by flat or reduced overall (internal) budgets for support of graduate students. In fact, many programs, particularly the newer ones have seen increases in support that reflect their development and expected growth in their doctoral enrollment.

The apparently conflicting result of reduced overall budgets and increased individual academic department budgets for graduate students support was achieved through careful attention to the former non-academic department uses of the overall support budget. As note before, this "non-academic" portion of the budget was a significant proportion of the total (over 40%) in 1990. Over the years, each non-academic use was evaluated and gradually eliminated with the monies then shifted to the academic departments. This portion of the budget was essentially driven down to zero within ten years; effectively increasing the original academic portion of the budget by almost 70%. These changes were difficult for the non-academic departments who had, in some cases, become dependent on graduate student workers. It was shown that hiring of graduate students for the maximum of 20 hours per week with stipend, tuition and fees included was, in fact, far more expensive than hiring full-time staff people, particularly in clerical positions.

Support Policy

Additional efficiencies in use of support monies were achieved through a combination of carefully considered academic support policies and careful monitoring of the nominations made by faculty and programs for students to be supported. With the shift of NJIT priorities toward research and doctoral study, the allocations of internal monies were, in general, directed to those programs offering doctoral degrees and specifically only for students in doctoral programs. Other mechanisms were needed and created to attract and support Master's degree students but the funding allocated by the university was now all exclusively intended for doctoral students. The exceptions were for a few major programs with terminal Master's degrees. Careful controls were placed on the approval of continuing internal support for individual students based on their academic record and progress toward the degree. Academic records are reviewed each semester and PhD degree progress reviewed annually.

Policies on use of external student support funding from external research grants were purposely made much more flexible in terms of choice of Master's or PhD students for support in recognition of faculty needs, contract deliverables, and to encourage continued grantsmanship. Base level policies on academic progress for students on external funds do still apply but have not proven to be an impediment for faculty or students working on grant-funded research. There are policy connections between internal support for individual PhD students and external support for the same student.

The most typical situation for an individual student is to have internal support as a Teaching Assistant for the first year or two and then to be shifted to an externally funded research grant for support and service as a Research Assistant over the remaining years of doctoral study. It is now a university policy to avoid having a student supported for the entirety of their doctoral career as a Teaching Assistant or for faculty, without external funding, to assume that an assigned Teaching Assistant is in reality an assigned Research Assistant. Before a two-year TA support limit became policy, a complete study of the funding history of successful doctoral students was done to determine if this policy was feasible and realistic. In the course of the study, it was found that students who are not shifted to research grants tend to have slower completion rates. As seen in reports by "The Center" of the University of Florida, the total research expenditures at NJIT have allowed these shifts more easily over the past 10 years by significantly increased external funding (Ref. 3).

Academic Quality Controls for the PhD

In addition to the major changes made in support use policies over the years, the graduate dean worked closely with the graduate admission office and the major faculty committee for graduate education at NJIT, the Graduate Council, to establish quality controls on admission and retention of doctoral students. Studies of prior academic records of successful and unsuccessful doctoral students at NJIT were done; and environmental scans of practices at other universities were considered to establish minimum levels of achievement for admission and retention. Actual PhD completion was the most important concern with time to degree also an important consideration. The following factors were also considered in order to establish current university base-level requirements for doctoral admission:

- Undergraduate or Master's grade-point average.
- Level or quality of prior academic study.
- Graduate Record Examination (GRE) scores.
- Test of English as a Foreign Language (TOEFL) scores for international students.
- Class of prior degree for international student applicants.
- Letters of Recommendation.
- Prior research activity if any.

While the graduate dean did much of the background work and made the proposals to the Graduate Council, it was the Graduate Council, representing all graduate programs at NJIT that made the final decisions on what the minimum university quality levels would be for admission and retention. Programs are permitted, within reason, to set higher standards for admission and

retention than university minima, but cannot relax these standards below the university minima. Exceptions are rare and require review by the graduate dean.

Particularly for the most highly correlated factor for doctoral degree completion and success, prior grade point average in undergraduate and/or master's study, the minimum levels were set to avoid bringing in and supporting students with very little likelihood of doctoral completion. The studies showed that while students having high grade point averages were not guaranteed to be successful, students having grade point averages below the minimum were almost certainly guaranteed to be unsuccessful. The exceptions are very rare. It is noted that the grade point averages, undergraduate and Master's, do not both need to exceed the minimum for doctoral admission and likely success. The Master's record is allowed to over-ride if it is strong. A weak master's record, even after a reasonably successful undergraduate record, has almost always foretold failure in the doctoral program.

Addressing Diversity

Simultaneously with the review of funding processes and allocation and the development of quality control standards for admissions, retention, and program operation (including dissertation committee and dissertation document issues), the diversity of the doctoral and graduate student populations at NJIT was considered in terms of the priorities of the university, its service to the state, and the diversity of its undergraduate population. (Another paper (Ref. 2) discusses the BS/MS and BS/PhD programs that were developed and enhanced at NJIT in order to attract the university's own highly diverse population to part-time and full-time graduate study.) The graduate office and the university therefore made a concerted effort to have NJIT involved and active in a number of regional and national programs to address diversity in its doctoral programs. Since 1990 therefore, NJIT has become a member of or more active in the following programs:

The Ronald E. McNair Post-baccalaureate Achievement program.

The National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM).

The Minority Academic Career Program of New Jersey.

Project 1000 consortium centered at Arizona State University.

Alliances for Graduate Education for the Professoriate (MAGNET consortium centered at the City University of New York).

Bridges to the Doctorate (program component centered at Drexel University).

The graduate dean's office has also established a support reserve for exceptional students to enhance diversity, both by ethnicity and gender, including a highly competitive package of Fellowships, called Presidential Fellowships, at NJIT. Many other endowed graduate level fellowships are also aimed at increasing diversity in the NJIT doctoral and full-time graduate population. All of these initiatives have worked toward creating a critical mass of scholars from diverse communities and to markedly increase the number of NJIT's own students who have gone on to full-time graduate study, both at the master's and doctoral level.

Conclusion and Perspective

Despite an overall enrollment that has not greatly changed in over 15 years, NJIT has used existing internal resources and increased external funding to markedly change the character and quality of the university from a primarily undergraduate institution concentrated in the basic engineering fields to become a major research university. Careful attention to cost efficiencies and academic quality have helped to move the university to its current status and can serve as a model for other smaller universities seeking similar growth.

References:

- (1) Anon. "The Chronicle of Higher Education, Almanac Issue 2006-7, Volume LIII, Number 1, P. 36; August 25, 2006.
- (2) Kane, R., Gonzalez-Lenahan, C., and Eck, S., "Accelerated Dual Degree Programs," 2007 ASEE Annual Conference paper, AC 2007-63.
- (3) Anon. "The Top American Research Universities," The Center, University of Florida, 2005.