

Developing a disciplinary honours programme within an engineering college

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ABSTRACT: To address a low participation rate of engineers in the University Honours Program, a discipline specific programme to recognise some of the College's most outstanding students has been created by the College of Engineering and Engineering Technology at Northern Illinois University. Eligibility and curricular requirements along with research and interdisciplinary experiences necessary to complete a degree with honours designation are specified. The collaborative programme provides simultaneous membership in both the college and university programmes offering a variety of benefits to the students including both technical depth and interdisciplinary breadth. Evaluation and assessment of student performance will be used to continue updating the programme components and benefits, thereby improving the culture of an enriching, research-driven education for engineering honours students.

Keywords: Honours programme, undergraduate engineering research, capstone experience

INTRODUCTION

By their very nature, engineers operate in a manner that attempts to maximise efficiency in most endeavours. This is no different when it comes to course selection and satisfying curriculum requirements for graduation. Engineers often seek the shortest path from arrival on campus to awarding of the degree. Yet, some students do show a propensity to seek out the intrinsic benefits of greater knowledge by making the extra effort to have a more engaged learning environment. Often, the engaged learning extends beyond the passive participation in a large lecture hall by taking the form of a faculty-student relationship. The individual interaction is where students can ask more probing questions indicating their interest in research and deepening their understanding of the major discipline. Many times, these students are not aware of the curricular benefit of their additional inquiry, which is why a new honours programme has been created within the College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU).

Honours programmes have been a growing part of student recruitment to institutions of higher education [1]. Similarly, NIU has a well-established University Honours Program (UHP) that invites high performing students to participate in academic, social and civic activities to further enrich the undergraduate experience [2]. Many benefits are highlighted in the invitation to students, including priority registration for classes, smaller class sizes made up exclusively of honours students, an honours learning-living community within the residence halls and access to grant funding for undergraduate research. One major highlight is the ability to engage with individual faculty, similar to experiences found at smaller, liberal arts colleges. These opportunities seek to satisfy the honours students' intrinsic desire for learning, while taking the first steps toward satisfying careers. However, there is an implicit assumption that more work is required of the higher performing students, which does not yield a financial benefit in the job market [3]. On the contrary, the honours programme seeks to create a qualitatively different learning experience with a more enriching environment.

Despite qualifying for the UHP, a significant number of engineering students do not choose to accept the invitation. Table 1 shows the number of university honours participants from 2008-2011 separated by those in the College of Engineering and Engineering Technology and the other colleges at NIU: Business, Education, Health & Human Sciences (HHS), Liberal Arts & Sciences (LA&S) and Visual & Performing Arts (V&PA). The first observation is CEET's low raw number of participants. Some of that may be explained by the academic rigor of the engineering discipline reducing the overall grade-point-average (GPA), but it contradicts evidence that students' propensity to choose engineering as a major increases directly with higher levels of academic ability [4]. If high performing students are assumed to be uniformly distributed across the university, then the participation of engineers is well below the rate

expected for the College population. Most of the other colleges are represented in the UHP at or above their overall percentage to the University.

One piece of information that is hidden within the data in Table 1 is the increased participation rates of the other colleges at NIU due to department specific honours programmes. The department-level honours programmes are all formally outlined in the University catalogue with GPA and enrolment requirements that match or even exceed the UHP's levels for invitation. The creation of the department honours programme is natural given the wide distribution of disciplines within a large college like Business or Liberal Arts & Sciences. Fortunately, CEET is made up of only four departments in Electrical Engineering, Industrial & Systems Engineering, Mechanical Engineering and Engineering Technology. Rather than have the four separate departments construct and maintain unique honours programme requirements, a proposal was made to initiate a college-based honours programme that is specific to the engineering discipline. Ultimately, it is believed that the new CEET Honours Program will benefit the student educational experience, foster a culture of undergraduate research in collaboration with engineering faculty and build a sense of community and recognition for those students achieving outstanding academic performance [2].

Table 1: Total number of participants in the University Honours Program from 2008 to 2011 separated by different colleges at NIU.

College	Active participants	% of honours population	% of NIU population
CEET	146	3.6 %	6.7 %
Business	702	17.5%	15.8%
Education	238	5.9%	7.8 %
HHS	710	17.7%	14.0 %
LA&S	1,831	45.7%	50.1%
V&PA	234	5.8%	5.7 %

BUILDING THE FRAMEWORK

The first goal in designing programme requirements was to develop uniformity that was applicable to all departments in the College, while maintaining a correlation for simultaneous membership in the UHP. This feature provides a comparable experience and level of expectation for all honours students [5]. To help understand the dual membership, one aspect that must be described is the UHP's separation of Lower Division and Upper Division Honours. Lower Division Honours is for completion of General Education courses and/or core curriculum requirements in compositional writing or oral communication, usually done in the first two years of an undergraduate programme. The requirement achieves the objective for breadth of education outside the major curriculum courses. Upper Division Honours tracks the performance in 300 and 400 level courses, typically those taken in the junior and senior years to satisfy major requirements. Additionally, Upper Division Honours includes a Capstone project, where a student and faculty mentor define the scope of a research experience. The distinction between these two levels is necessary due to the high number of transfer students matriculating to NIU. Between 50%-60% of graduating students have transfer credit from local community colleges or other universities. Hence, Lower Division Honours is populated by students whose first college experience is at NIU, while Upper Division Honours seek to serve upperclassmen that only need to complete major course requirements.

To mimic this form, the CEET Honours Program works only with students qualifying for Upper Division Honours, leaving the administration and advising of Lower Division Honours students to the university-wide programme. The threshold for junior-level status is transcript credit of greater than 60 hours or an associate's degree completed at a community college. By utilising this threshold, the CEET Honours Program works directly with students who have made significant progress toward the degree and are deeply embedded in discipline specific courses. To that end, articulation agreements with community college honours programmes will be formed, so that eligible transfer students can immediately participate in the CEET Honours Program.

Besides the progress through the degree programme, eligibility is also based on academic performance. To match the University Honours Program requirements, the minimum on-campus, cumulative GPA of 3.2 on a 4.0 scale is required. The CEET Honours Program adds the stipulation that a 3.4 GPA must be maintained in courses required in the chosen major. The addition of high performance in discipline specific courses provides some separation of students who may enhance their GPA with lower division general education courses. If a student's GPA drops below these thresholds, they will have a one semester probationary period to improve their status. If the GPA does not increase to the necessary threshold, then the student will not be eligible for the benefits of participating in the programme.

In order to *complete* the degree with honours, three specific curricular requirements must be satisfied: 1) credit hours enrolled; 2) experiential activity outside the discipline; and 3) Capstone project with individual research. First, a student must complete at least 12 hours of honours courses within their major (of which a portion can be the Capstone project course). Unlike most university honours courses, the College utilises mini-sections for enrolment of honours students. These smaller sections (5-7 students), meet for the same lecture as the regular section of the course. The honours students and faculty instructor meet outside class time to define an academically enriching activity suitable for honours

credit. The type of activity is at the discretion of the faculty instructor allowing each mini-section to be flexible in order to satisfy the particular student's interests. Past examples include reading and discussing review papers of research related to the course content, learning a topic in advance of the regular section students and offering the opportunity for students to teach students or a collaborative project to design a physical experiment to display an engineering principle.

To aid students in fulfilling the course requirements, the college-wide list of mini-sections maintained by registration and records was compiled for the first time. All of the courses listed in Table 2 are core curriculum classes required of each of the disciplines. By having honours mini-sections of the core classes, honours students are not compelled to pay tuition and fees for courses beyond their major requirement, satisfying that efficiency trait mentioned at the beginning of the article. If students wish to obtain honours credit for classes besides those listed in Table 2, the UHP has a contract course form to allow more options. Rather than having the instructor seek out students in the honours mini-section, the contract requires initiative from the student to seek out the faculty instructor for an agreement of honours designation. In the contract, the academic enriching activity is proposed and approved by both the CEET Honours Program director, as well as the UHP. The intent of offering many mini-sections and availability of the honours contract is to provide as much flexibility for the honours student to pursue their main academic interests, while still satisfying the tracking of honours credit.

Table 2: Department course numbers and catalogue titles that have indicated honours mini-section according to registration and records.

Electrical Engineering		Industrial and Systems Engineering	
ELE 315H	Signals and Systems	ISYE 334H	Probability for Engineering
ELE 330H	Electronic Circuits	ISYE 335H	Statistics for Engineering
ELE 335H	Theory of Semiconductor Devices I	ISYE 370H	Operations Research: Deterministic
ELE 340H	Electrical Power Systems	ISYE 371H	Operations Research: Probabilistic
ELE 360H	Communication Systems	ISYE 430H	Quality Control
ELE 380H	Control Systems I	ISYE 440H	Production Planning and Control
		ISYE 450H	Lean Manufacturing Systems
Technology		Mechanical Engineering	
TECH 375H	Control Systems	MEE 321H	Mechanical Vibrations I
TECH 391H	Industrial Quality Control	MEE 322H	Dynamics Systems and Control I
TECH 409H	Internship	MEE 340H	Fluid Mechanics
TECH 434H	Human Factors in Industrial Accident Prevention	MEE 390H	Experimental Methods in ME
TECH 443H	Engineering Economy		

The second requirement to graduate with CEET honours is an experience outside the major discipline. This requirement has been the primary hindrance to engineers participating in the UHP. Typically, an honours student is required to take a seminar course with other honours students. The small class setting and dedicated honours instructor is certainly enriching and provides educational breadth to their academic experience. Unfortunately, the curriculum for engineers is quite rigid with little room to manoeuvre and take additional courses. For example, the Industrial and Systems engineering major requires 135 credit hours (including general education courses) for a Bachelor's degree. Assuming regular enrolment of 15 to 17 credit hours per semester, the addition of the honours seminar could unnecessarily extend the graduation date of some students. The concern over value of time spent versus benefit gained has affected participation in other discipline specific honours programmes, where the course load is substantial [6][7].

Therefore, to address the need for experiences outside the discipline, the CEET Honours Program utilises one of two possible mechanisms to satisfy the requirement: either an internship/cooperative education experience or an honours section of the technical elective in systems engineering. It is normal for student interns to find themselves regularly working with other divisions beyond applied engineering disciplines. Some may have multiple meetings with marketing for promoting new products in catalogue images or Web site development. Others may find themselves working closely in procurement making sure the raw materials arrive in a timely manner for manufacturing or assembly. Some may assist the communication division with writing assembly or maintenance manuals. Ultimately, the exposure to the people and concepts beyond the technical components of engineering provides the broader awareness sought by the University honours seminar [8]. Both the student and CEET Honours Program director meet either, before or during the initial stages of the intern/co-op experience to work with the company sponsor confirming that these opportunities will be available. Upon finishing the internship, the student files a brief report indicating how their perceptions changed as a result of the experience. Results may influence how the CEET student thinks about their own discipline or how they can best integrate within the complex framework of a company. The report enables the CEET administration to give *transcript credit* for the experience, thereby, eliminating tuition costs and the need to fit the honours seminar into the tight curriculum.

If a student does not wish to pursue an internship or cooperative education experience during the summer or semesters away from class, then they will enrol in an honours mini-section of the College course sequence in systems engineering (IET 490, 491, 492). By the very nature of systems engineering, the content is interdisciplinary integrating all aspects

of engineering together. Through the small honours section, the content may extend beyond technical computation and consider aspects of global production, impact on the environment or other areas that interest the student and/or instructor [9]. Again, having both options available to students provides the flexibility that students seek in building their own CEET honours experience.

The final requirement for the degree with honours is a Capstone project with individual research [10]. Per ABET's accreditation requirements, all engineering students already complete a capstone senior design project during (or very near) the final semester of coursework. Often, the project is a team effort with three or four students working together. Unfortunately, the collaborative effort inherent in this experience makes it difficult to confirm the individual contribution of the honours student. To enable the design experience to count simultaneously for the department and honours programme requirements, a new procedure is required depending on whether the specific department has a one- or two-semester design sequence. For those departments with two-courses for senior design (Electrical Engineering, Mechanical Engineering and Technology) the honours student is required to meet with the CEET honours director at the end of the first semester. Conversely, for the Industrial & System Engineering majors, where only one design course is required, the meeting will take place at the beginning of the semester. During the meeting, the student and director will discuss the conceptual design that is the project and areas of research that may be pursued. After the meeting, the student will compose a proposal outlining the individual research that will be completed as part of the senior design. This proposal will be reviewed and approved by the course instructor (or project adviser), CEET honours director and the UHP office. When the project is complete at the end of the term, the team project report and individual research report are submitted to both the CEET and University Honours Programs.

The eligibility and transcript requirements described thus far match closely with suggestions and criteria from the National Collegiate Honours Council (NCHC) [11]. Besides the long-term curricular outcome of a diploma with honours designation, the dual participation in the CEET and University Honours Programs offers a wide range of immediate and tangible benefits to students. Some examples of those benefits are described in the subsequent section along with rationale for their inclusion.

BENEFITS OF PARTICIPATION

First and foremost, the University honours student receives priority registration when selecting classes for the upcoming term. The benefit primarily helps offer availability to the most popular general education courses and instructors. This advantage is particularly helpful for engineering courses when sections have different laboratory times. Being the first to select the laboratory sections with limited space enables the student to develop a convenient and efficient schedule each term. Through careful planning, the student is able to participate in activities beyond the classroom, including the extracurricular student societies (ASME, IEEE, IIE, SAE, etc) or independent research with faculty.

The second benefit, for both students and academic staff, is the CEET Honours Program clearly identifying the high performing students who may wish to research science and engineering at the cutting edge. According to the Carnegie Foundation classification, NIU is a Research University with high activity [12]. Naturally, research accomplishments by the faculty are critical in proving capabilities for externally funded proposals and determining promotion and tenure within the College. Due to the relatively young age of CEET - it was officially formed in 1985 - many of the faculty are transitioning from a focus exclusively on undergraduate education to a broader research portfolio. The CEET Honours Program allows faculty to utilise the academic enthusiasm of outstanding students to research new ideas. Students benefit from the additional experiences of conducting experiments in the laboratory, working with software programs to improve analysis methods or developing theories to better explain physical phenomena. If students desire, they can use the individual, independent study activity as the Capstone project to satisfy the research requirement in lieu of the senior design project.

The undergraduate research experience naturally leads to the third benefit of the CEET Honours Program: future placement in industry and graduate programmes. Employers are always seeking hard working, independently motivated students to hire into their company. An honours student's resume and interview can stand out from the rest of the engineering applicants when highlighting and discussing the enriching educational experiences. By showing a willingness to explore new ideas, honours students can encourage industry to continue investing in innovation for the development of future technology. In regard to graduate placement, the student researcher would be working in collaboration with the faculty and, therefore, be listed as a co-author on a submitted manuscript or published journal article. The external validation of the quality of the student's work further enhances the application, which is almost a required component for Carnegie's *very high activity* research universities (RU/VH). The subsequent performance of NIU's students at top-tier research universities will only improve the stature of the College.

In order to support the third benefit, students must have access to multiple opportunities for proposing ideas and sharing results with the research community. Projects can be funded through the UHP's Enhance Your Education (EYE) grant or the multiple options available from the Office of Student Engagement and Experiential Learning (OSEEL). Example programmes include Undergraduate Student Opportunities for Artistry & Research (USOAR), Research Experience for Undergraduates (REU), Research Rookies (first year experience for incoming students), Engineering Undergraduate Research Apprenticeship (EURA), and so forth. The process of composing a proposal offers an enriching experience for students to organise and articulate their ideas for an audience separate from their

faculty research adviser. The more careful writing and using correct terminology without descending into too much jargon is critical for long-term success as a researcher. Regardless of financial funding of a project, students do have an opportunity to display the results at the completion of the work through the Undergraduate Research and Artistry Day (URAD). An abstract of the student's work is published and the poster presentation is open to the entire University. URAD is an excellent opportunity to display and observe the many different disciplines of research conducted by undergraduates at NIU.

Similar to URAD, the connection to students of other disciplines is necessary for a well-rounded education. Through the dual UHP and CEET Honours enrolment, students are eligible to participate in social and service events with the 1000-plus Honours students outside of engineering. The cross-pollination is critical in the development of new areas of collaboration. To dismantle the typical silos of knowledge further, the NIU Honours House is a living-learning community within the residence hall system, where honours students gain from one another's interaction outside the academic realm. Living in community allows a support network to organically develop aiding those first year students making the initial transition to college life, as well as building camaraderie of graduating students managing the final tasks of the Capstone research project. Other benefits from the University Honours Program membership include access to scholarship resources, student staff positions in the Honours office and use of the UHP computer laboratory and quiet study area. The CEET Honours Program partnership with the University Honours Program allows students to receive the full breadth of knowledge and opportunities available to the University's highest performers.

Over time, other discipline-specific benefits will be developed by CEET Honours. Ideas that have worked at other institutions include faculty mentoring [7] and study abroad for globalisation of engineering solutions [9]. The former is very important for long-term planning of a career. Defining interests and confirming vocational plans are sometimes delayed until after the student has completed much of the curricular requirements. As they near the end of the academic career, the student is suddenly thrust into the job search simply because it is the next task. A mentor would be able to provide continual review and advice on long-term objectives and how each academic task is supportive of achieving those objectives. The latter benefit of globalisation requires some investment from the University and/or student. The costs for domestic and international trips to industrial centres may be found through external funding for the programme, support from philanthropic alumni or strategic investment from the university.

Other ideas are being generated from student feedback. When advanced degrees become a major emphasis of future honours students, seminars may be developed on preparing application materials for graduate schools or proposals to the National Science Foundation Graduate Research Fellowship programme. Others are asking for the creation of an alumni network. These could be potential employers looking for the best students or graduate students who have moved to a programme at another university and can offer insight on the atmosphere and expectations of graduate school. As the participating rate of engineers continues to increase, more opportunities will be requested by students seeking the intrinsic components of the academic experience. The enthusiastic commitment from the faculty and administration will help foster the growth.

ASSESSING PERFORMANCE

Rather than simply create a static programme per the descriptions provided above, the administrators will seek to apply engineering control principles to *close-the-loop* when evaluating the CEET Honours Program. Areas of deficiencies, as judged by students or staff, will require improvement, whereas outstanding performance will attempt to be replicated.

To centralise the information, an Honours Program Director will be selected from the College faculty. The director will organise and track the students and faculty contributing to the programme activities. The director will serve as the students' liaison serving multiple purposes: adviser for selection of honours courses; approval of honours contract courses that do not have mini-sections; work with students to find research-active faculty to serve as mentors for the independent capstone projects; or serve in additional capacities requested by the students, college Dean, or Associate Vice Provost of University Honours [7]. By utilising the knowledge of a college faculty member, the discipline-specific details of the CEET Honours will be consistent without creating possible confusion with the UHP requirements.

On the instructional side, the director will collect examples of the academically enriching activities that have been part of the honours programme mini-section courses listed in Table 2. The objective is not to impose a mandate on the faculty instructor as to the type or level of activity that should be part of the honours experience. Rather, the collection of examples would be a centralised resource accessible to all CEET instructors seeking ideas on how to best engage these high performing students, while still matching some criteria suggested by the NCHC [13]. The examples will be extremely useful to new or adjunct faculty who may not have prior experience with honours students. To help foster even more interdisciplinary interaction, the director may call meetings with instructors of honours courses to brainstorm and discuss creative methods to have mini-sections from multiple departments collaborate in a single enriching activity. The possible areas of improvement are boundless.

Of course, full assessment requires some sort of measurable quantity to prove objectives are being achieved. The first goal is simply to increase the number of students registering for honours mini-sections and seeking to complete the CEET Honours requirements. Tracking the numbers over the next three to five years should show an increasing trend as more students become aware of the programme while completing their lower division pre-requisites. Ideally, the

trend will continue as the CEET Honours Program is marketed to future students, making NIU an attractive destination for some of the region's best and brightest students. Beyond simply indicating a desire to access the on-campus benefits, the college administration hopes for an order of magnitude increase in engineering and engineering technology Bachelor of Science diplomas that are awarded with simultaneous designation of Engineering Honours and University Honours.

Lastly, the intrinsic educational benefit of the honours programme experience would need to be assessed. Once the transient growth phase of the programme has levelled, educational research studies will be conducted. Research questions will be asked to determine exactly how the academically enriching activities of the honours programme have improved the students' knowledge and confidence in capabilities [2][3]. In a quantifiable measure, the academic performance of honours eligible students who specifically choose not to participate can be compared to those who are engaged in the programme activities. Areas to consider include GPA success on the Fundamentals of Engineering (FE) examination, quality of senior design project, or other direct measures while the student is on campus. A longitudinal study may also benefit by examining the success of honours versus non-honours students some years after they have completed their bachelor's degree at NIU. Assessment creates the tools to gather large quantities of data that engineers can then use for identifying opportunities for improvement.

SUMMARY

This article provides descriptions as to the need and operational details of a discipline-specific honours programme within engineering. The concise description of the above features that will be added to the 2012-2013 and subsequent undergraduate catalogues appears as follows:

Degree with Honors

The College of Engineering and Engineering Technology (CEET) Honors Program is designed to provide exceptional students an opportunity to conduct in-depth exploration and research of topics in engineering and technology. This program is intended to support the general mission of the University Honors Program with the specific goal of providing students more interaction with faculty, opportunities for undergraduate research, and exposure to research activity expected of graduate programs.

Students who wish to work toward a B.S. degree with honors in engineering or engineering technology should discuss the matter with the departmental undergraduate adviser and a representative from the university honors program. Lower division honors for freshmen and sophomores is managed by the University Honors Program and can be achieved through the registration for honors courses that are part of general education or major requirements. Engineering and engineering technology majors with at least a 3.20 overall GPA and a minimum 3.40 GPA in the courses required in the chosen major are eligible for the CEET Honors Program. Admission to the college's upper division honors program will be considered only for majors in their junior and senior year and requires the approval of the departmental undergraduate adviser, the college honors director, and a representative of the university honors program. Should the student's GPA fall below the minimum requirements for an academic term, the student must achieve these standards no later than the end of the following semester to remain in the program.

Requirements for earning the baccalaureate degree "With Engineering Honors" include a minimum of 12 semester hours of honors courses numbered 300 or above that are within the chosen major program. The senior capstone design course specific to their discipline (i.e. ELE 492H, MEE 482H, etc) must count toward the required hours of honors work and include an individual independent research activity separate from the final design report. The topic and scope of the independent research activity must be approved by the faculty project adviser and the college honors director. A final report of the activity is filed with both the college and the university honors program.

Note: Most engineering honors courses are not separate courses but rather subsections of regular courses with an enriching experience. The honors student may contract an honors designation of those courses without explicit honors mini-sections.

When this language was approved by the College and University curriculum committees in December 2011, invitation letters were sent out to CEET honours-eligible students in January 2012. The response has been remarkable with over 23% of the 144 students expressing some interest in learning more information about how they can participate, far exceeding the prior UHP participation rate of 6%. Unfortunately, some students will be graduating in May 2012 and will not be fully recognised for their active contribution to ideas and fostering a new honours community. However, they will be the first advocates to support a new culture of undergraduate research and collaboration between faculty and the outstanding students at NIU. It is believed that the honours programme can only improve the profile of Northern Illinois University's College of Engineering and Engineering Technology as an excellent environment for outstanding students to receive both the technical depth and interdisciplinary breadth of an honours education.

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BIOGRAPHIES



Dr Nicholas Pohlman is an Assistant Professor of Mechanical Engineering at Northern Illinois University's College of Engineering and Engineering Technology. During his short time at NIU, he has worked with more than a dozen students conducting undergraduate research through USOAR grants, independent study courses and honours mini-section courses. His simultaneous dedication to students' success and advancing research in fluid mechanics and granular flows has been acknowledged by the 2009 CEET Faculty of the Year Award and the Department of Mechanical Engineering awards in Service and Teaching. An undergraduate honours programme helped guide Dr Pohlman to his career in higher education, and he believes that similar opportunities for an enriching learning environment should be afforded to NIU's engineering graduates.



Dr Omar Ghrayeb is the Associate Dean of Outreach and Undergraduate Programmes of Northern Illinois University's College of Engineering and Engineering Technology. He works closely with the industrial sector and spearheads the EIR programme. He is committed to promoting experiential learning as part of engineering education and works with several companies in the area to bring real-life projects into the classroom. His expertise is in process innovation and production planning.



Dr Promod Vohra is the Dean of Northern Illinois University's College of Engineering and Engineering Technology. His commitment to applied research and global engineering education is reflected in his work and philosophy. Dr Vohra has published widely and serves on several national and international committees and boards. He believes the engineering profession must act as an innovation catalyst and create a new economy for the globe.