Proposal for an Undergraduate Certificate in

Global Development Engineering

Department of Civil and Environmental Engineering

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Proposal:
The Department of Civil and Environmental Engineering is proposing a new undergraduate certificate/curricular pathway in "Global Development Engineering." This proposal builds on existing synergies at Pratt and Duke, and attempts to provide more linkages to Centers and Institutes with complementary educational thrusts.

Background and Rationale for the Proposal:
With the increase in awareness and focus on global issues, at Duke and our peer institutions, this proposal seeks to leverage synergistic educational and experiential learning opportunities into a cohesive (and credentialed) curricular pathway. The committee is proposing the formation of a new curricular offering, an interdisciplinary certificate for undergraduates which ties together connected and supporting courses and experiences. By providing more cohesive linkages between existing programs, this proposal seeks to further catapult Duke to the forefront in the area of preparing engineers (and technically oriented non-engineers) for careers in the field of sustainable international development partnering with marginalized or disadvantaged people groups to address both technical and more structural issues related to poverty, wealth inequality, health access, and economic empowerment.

Duke already has centerpiece programs and institutes which are leading in their respective areas. From the Global Health Institute, the Gendell Center for Engineering, Energy and the Environment, the Duke Center for International Development at the Sanford School, and the Center for the Advancement of Social Entrepreneurship (CASE) at the Fuqua Business School, Duke researchers are addressing many of these issues which impact the most vulnerable members of humanity. Additionally, with co-curricular programs like DukeEngage, the Hart Leadership Program and Service Opportunities in Leadership (SOL), Grand Challenge Scholars, and courses linked to the Office of Service Learning and Duke's Center for Civic Engagement, students are empowered to partner with communities to address these issues in meaningful and tangible ways. Finally, with extracurricular, experiential programs like DukeEngage, Engineering World Health and Duke Engineers for International Development, students are expressing their passion in concrete avenues and attempting to use their "knowledge in the service of society." Building on these existing programs, this proposal attempts to provide a unifying web of potential interconnections to "credential" a student as having educational preparation in this important field.

Currently students with an interest in this field likely are majoring in environmental, civil, biomedical engineering (as well as mechanical or electrical engineering) or a related field in Trinity, and then obtaining connected certificates (Global Health/Energy and the Environment) or dual majors (EnvE/BME). This certificate is not meant to replace these programs, but

augment them to specifically focus on how engineering can be brought to bear on the issue of international development, train students with a core set of academic courses, and linked and guided experiential encounters where they can implement their engineering concepts and honestly evaluate the impact of their ideas on an identified issue facing humanity. It is the goal of this proposal to provide a more obvious "engineering" connection to these already existing programs/institutes/etc.

Example Programs at Other (Peer) Institutions

This proposal suggests a program which would further demonstrate Duke's leadership as a premier institution in higher education. Other programs currently exist, but none are as robust, experientially intensive, curricularly connected, and academically rich as the one included as part of this proposal. To better highlight the program being proposed at Duke, the following presents what other (peer) institutions are offering followed by a brief discussion on how the program being proposed is differentiated from these offerings.

Johns Hopkins University – Minor in Engineering for Sustainable Development (http://engineering.jhu.edu/dogee/undergraduate-programs/minor-sustainable-development.html) The minor is seven courses. The core course is "Introduction to Engineering for Sustainable Development" and the final course is "Seminar in Engineering for Sustainable Development" with five courses selected by the student. Of the five additional courses:

- Three must be grouped around a specific theme, region or within a specific discipline. Themes might include, for example, public health, environment, or economic development. Regions include Africa, Latin America or Asia. Disciplinary concentrations might be in Anthropology, Economics, Geography, History, Political Science, Public Health or Sociology.
- Three of the courses must be at the 300-level or above.
- One of the courses must cover methods for gathering and evaluating information in a development context. Examples include: The Logic of Anthropological Inquiry; Anthropology and Public Action; Discourse Analysis: Stories and their Structures; Biostatistics in Public Health; Introduction to Epidemiology; Research Methods for the Social Science

University of Colorado, Boulder - Undergraduate Certificate in Global Engineering (https://mcedc.colorado.edu/education/undergraduate-certificate-global-engineering) The requirements for the certificate are:

- Language: conversation proficiency in a world language (at the third- or fourth-semester college level, minimum, depending on the student's prior language coursework/ability);
- Economics (one course)
- International culture, sociology, or governance: one lower division course and one upper division course
- Technical elective course focused on global engineering (one course)

Colorado School of Mines – Humanitarian Engineering (http://bulletin.mines.edu/undergraduate/interdisciplinaryminors/humanitarianengineering/) This program offers various pathways to:

- Area of Special Interest (ASI) in Humanitarian Studies (12 credit hours)

- Minor is Humanitarian Studies (18 credit hours)
- Area of Special Interest (ASI) in Humanitarian Engineering (12 credit hours)
- Minor in Humanitarian Engineering (18 credit hours)
- Certificate Minor in Humanitarian Engineering (27+ credit hours):

The certificate minor is the most robust and contains the following requirements:

- Nature and Human Values (Gateway Course)
- Ethics
- Two of the following five courses: Engineering Cultures; Writing Proposals for a Better World; Literature and the Environment; Engineering Cultures in the Developing World; or Engineering and Sustainable Community Development
- Two targeted humanities electives in either policy, language, economics, etc.
- Technical Elective
- Senior Design

Michigan Technological University - International Sustainable Development Engineering Certificate (http://www.mtu.edu/d80/programs/isde-certificate/) The certificate is seven courses. An initial core course (Undergraduate Colloquium in Sustainability) and concluding experiential component (International Project Practicum) are positioned around five other courses which are comprised of the following:

- Humanities Elective
- Language or Culture Elective
- Economics Elective
- Environment Elective
- Technology and Society Elective

University of Colorado, Boulder – ***Graduate Program*** in Engineering for Developing Communities (https://mcedc.colorado.edu/education) with different curricular pathways and focus areas. The three different "degree" plans are as follows:

- MS (thesis): 8 required courses including the SCD field practicum (24 credits) plus thesis research and defense (6 credits)
- MS (Project-based): 8 required courses including the SCD field practicum (24 credits), 1 elective course (3 credits), a one-semester project resulting in a Master's Report (3 credits), and a public seminar presentation highlighting field experience.
- MS (Coursework only*): 7 required courses (21 credits), 3 elective courses (9 credits), plus a report or public seminar presentation highlighting prior field experience. Students are exempt from Field Practicum (*only available to those with extensive prior field experience)

Within the degree plans, a core and subsequent specialization must be selected. The following lists the courses which comprise the core, and then the three specialty areas:

Requirements for all EDC Certificate Students (Graduate Program)

- Sustainable Community Development I
- Sustainable Community Development II
- Sustainable Community Development Field Practicum

- Life-Cycle Engineering of Civil Infrastructure Systems

Additional Courses Required in the EDC Track of Environmental Engineering
- Water, Sanitation and Hygiene (WASH)
- Environmental Engineering Processes
- Environmental Engr. Chemistry OR Environmental Engr. Microbiology
- Environmental Engineering Treatment (Water, Wastewater, or Hazardous Waste)

Additional Courses Required in the EDC Track of Construction Engr. & Management
- Engineering Risk and Decision Analysis
- Applied Construction Finance Management
- Safety and Quality
- Managing Project Orgs. or Design Development

Additional Courses Required in the EDC Track of Building Systems
- Energy Analysis
- HVAC Systems
- Illumination
- Renewable and Sustainable Energy

All of these programs provide a framework for the unique program being offered at Duke, but none of them tie together an experiential component leveraged with the unique connections to various entities on campus. In most of these programs, they are unique to one entity or unit, while the program being proposed is interdisciplinary, crosses departments/institutes, and leverages and enhances existing offerings/partnerships/experiential learning opportunities to provide a unique and innovative program that should have a broad appeal to a variety of students.

Proposed Curriculum for the Undergraduate Certificate in Global Development Engineering at Duke University:
The following is a proposed pathway for students in the certificate:

Introductory Course (select one of the following):
- BME 290-02/GLHLTH 390-02: Medical Technologies and Global Women's Health
- CEE 160L. Introduction to Environmental Engineering and Science
- GLHLTH 101 Fundamentals of Global Health
- EOS/ENVIRON 330. Energy and the Environment

Global Competency (select one course from Language and Culture; one from Ethics; and then one from Policy OR Economics - then the student would have competency in three of the four key areas):
- Language and Culture (functional proficiency, e.g., level 203 or higher) OR corresponding curricular competency in another culture, for instance a relevant class (i.e., one with an *explicit focus or major goal* being cultural competency) from one of the following departments:

  - African and African American Studies
  - Asian and Middle Eastern Studies
  - Cultural Anthropology (course specifically related to culture)
  - German Studies
  - Jewish Studies
  - Latin American Studies
  - Latino Studies in the Global South
  - Romance Studies
  - South Asian Studies
  - Slavic and Eurasian Studies
- Ethics (a course related to development ethics, examples would include):
  - PUBPOL 330/GLHLTH 210 Global Health Ethics
  - GLHLTH 373S Global Health Service, Research, Ethics
  - GLHLTH 341 Ethics of Infectious Disease
  - PHIL 281/GLHLTH 241 Global Bioethics
  - PUBPOL 224S Doing Good: Anthropological Perspectives on Development
  - PUBPOL 372 Information, Policy and Ethics
  - PUBPOL 258S Science, Ethics and Society
- Policy (a course related to development policy, examples would include):
  - GLHLTH 303 Global Health Systems & Policy
  - PUBPOL 190FS International Law & Global Health
  - PUBPOL 590 Comparative Health Care Systems
  - PUBPOL 207 Development and Africa
  - PUBPOL 212 Globalization and Public Policy
  - PUBPOL 222 International Political Economy
  - PUBPOL 288 International Trade
  - PUBPOL 289 Public Finance
  - PUBPOL 515S Assisting Development
  - PUBPOL 574 Economic Evaluation of Sustainable Development
  - PUBPOL 579S Collective Action, Environment and Development
  - PUBPOL 582: Global Environmental Health: Economics and Policy
  - PUBPOL 598 Economic Growth and Development Policy
  - ENV 212 US Environmental Policy
  - ENV 265 Environmental Law and Policy
  - ENV 550 Land Use Principles and Policy
  - ENV 577 Environmental Politics
- Economics (a course related to development economics, examples would include):
  - ECON 248 Racial and Ethnic Economic Inequality: A Cross National Perspective
  - ECON 269A Australia and the Asia-Pacific Economies
  - ECON 303A Political Philosophy of Globalization
  - ECON 306 Economic History and Modernization of the Islamic Middle East
  - ECON 324A International Finance
  - ECON 326S Islam and the State: Political Economy of Governance in the Middle East
  - ECON 347 African Economic Development

- ECON 355 International Trade
- ECON 361 Prisoner's Dilemma and Distributive Justice
- ECON 370 Global Capital Markets
- ECON 376A Financial Markets in the Global Economy
- ECON 379 Emerging Markets: Finance, Trade, Institutions and the World Economy
- ECON 442 Development Economics: Theory, Evidence and Policy
- ECON 455 International Finance
- ENV 363/Econ 369 Environmental Economics and Policy
- ENV 520 Resource and Environmental Economics I
- ENV 531 Economic Analysis of Resources and Environmental Policies

Technical Tracks (at least two courses in one of the following study areas)
Water (examples would include):

- CEE 461L. Chemical Principles in Environmental Engineering
- CEE 462L. Biological Principles in Environmental Engineering
- CEE 463L. Water Resources
- EOS 524 Water Quality and Public Health
- EOS 525 Water Pollution
- ENV 501 Environmental Toxicology
- ENV/BIO 564 Biogeochemistry

Energy (examples would include):

- ENRGYEGR 310. Introduction to Energy Generation, Delivery, Conversion, and Efficiency
- ENRGYEGR 490.01. Bioenergy
- ENRGYEGR 490.02 (ME 490.01). Energy for the Built Environment
- ENRGYEGR 490.03. Renewable Energy Technologies
- ENRGYEGR 490.04. Power Electronics
- ENRGYEGR 490.05. Modern Power Systems
  (Note: Since the Energy Engineering Minor/Program is relatively new, these special topics courses [ENRGYEGR 490] are currently undergoing the process of being assigned permanent course numbers and will be updated in this proposal once that process is completed.)
- ENVIRON 631. Energy Technology and the Impact on the Environment
- ME 461. Energy Engineering and the Environment
- ECE 496 Solar Cells
- PHYSICS 137S. Energy in the 21st Century and Beyond

Appropriate Technology (examples would include):

- BME 562 Biology by Design
- BME 563 Transport Process in HIV Transm & Prevention
- BME 567 Biosensors
- BME 570L Introduction to Biomolecular Engineering
- BME 571L Biotechnology and Bioprocess Engineering
- BME 574 Modeling and Engineering Gene Circuits
- BME 577 Drug Transport Analysis

- BME 578 Tissue Engineering
- CEE 422 Reinforced Concrete Design
- CEE 423 Structural Steel Design
- EGR190 Engineering and Human Needs in the Developing World (Ghana)

Design and Implementation Capstone (select one of the following):

- CE315/PPS211/ENV356. Engineering Sustainable Design and the Global Community
- EGR 424L. (or ENV 452) Energy and Environment Design (must have a developing world focus)
- BME 462L Design for the Developing World

Experiential Component

Every student must implement a designed solution to an identified need. This can be accomplished during a DukeEngage experience, or by participating with Duke student organizations like Engineering World Health or Duke Engineers for International Development. The minimum requirements would be a month long experience in an international (or domestic) setting where students can team with a community partner to identify, design and implement an idea to address actual capacity building and be part of the iteration process to develop appropriate, sustainable, local and empowering interventions to identified societal needs. As a quality control step to evaluate if a proposed experience meets this requirement, each student (or group of students) requesting this experience to count must submit an implementation report or sufficient documentation to the oversight committee who will meet to decide if the experience substantially fulfills the objective of the requirement (i.e., every student must implement a designed solution an identified need).

In summary, the requirements will be as follows:

- Introductory Class
- Global Competency (three classes from the following areas):
    - Language and Culture
    - Ethics
    - Economics OR Policy
- Technological Depth (two course from one of the following tracks: Water, Energy, or Appropriate Technology)
- Required Experiential Component
- Design and Implementation Capstone

(The total requirement is seven curricular courses plus one experiential/internship experience.)

Assessment of the Certificate and Achievement of Learning Objectives

The goals of the program are to equip students to both understand the multi-faceted issues related to global development, and equip them with some of the tools necessary to address those goals. This includes both technical understanding as well as cultural sensitivity, and an exposure to some of the other issues related to the topic. Specifically, the goals of the learning objectives of the program are that students will have the ability to:

1. **Apply** mathematical, scientific, and engineering principles to the solution of specific technological problems facing a particular community,

2. **Evaluate** different feasible alternatives for addressing identified community needs, taking into account constraints associated with appropriate technology, educational and training levels, and capital requirements,
3. **Design and construct** interventions based on the **analysis, evaluation and/or interpretation** of data using modern engineering tools and techniques, community input, and engineering judgment,
4. **Design** engineering processes and **fabricate** prototypes to meet a societal need,
5. **Understand** the larger cultural and societal context for applying technological interventions, including issues of marginalization, resource limitations, and privilege,
6. **Function** effectively on multidisciplinary teams, and
7. **Develop** a sustainable approach for ensuring continuity of ownership, empowerment and resiliency.

To assess student's successful accomplishment and attainment of these goals, an oversight committee will meet at least twice a year (once a semester) to review which classes students are using to fulfill the elective requirements and review the syllabi for those classes to make sure the salient material is covered in the course, as well as the student's apparent mastery of the material. The committee will work with instructors in the various courses to incorporate metrics for assessing the above learning objectives for each course, and the committee will evaluate how this assessment is constructed longitudinally across the trajectory of the completion of the certificate. Additionally, the committee will discuss the implementation projects being undertaken by students in the program to ensure that they are "putting into practice" ideas that they have conceptualized, and give advice to students who are proposing projects for future execution. Further, they will discuss the trajectory of the students in the certificate (size of enrollments, patterns in class selection, etc.) that might help in better defining and directing students. These discussions held at these meetings, and any findings/conclusions, will be documented.

Oversight of Certificate

To oversee the implementation and continuing quality of the certificate, a committee of faculty will meet will meet at least twice a year (once a semester) to discuss the program. At this meeting, the oversight committee will review classes being proposed to fulfill certificate requirements (reviewing the syllabi for proposed classes to make sure the course substantially meets the "category" it is proposed to meet). Additionally, in the Fall meeting they will discuss the implementation projects which were completed over the previous summer and ensure that they met the objective of the program. The oversight committee will discuss the quality and direction of the program, and suggest improvements which could benefit the experience and learning environment for the students. There will be at least three members of the oversight committee and they must come from at least two departments, with at least one of those departments in Pratt and one in Trinity. Additionally, At least one of the faculty committee members will be the faculty advisor of Duke Engineers for International Development or the faculty advisor for the Duke Chapter of Engineering World Health. Members of this committee will also be available for formal (and informal) advising of students interested in the certificate. The inaugural committee will be comprised of the following faculty: M. Bergin, F. Boadu, M. Deshusses, M. Jeuland, R. Malkin, J. Nadeau, A. Porporato, N. Ramanujam, and D. Schaad. D. Schaad will serve as the chair of the committee and inaugural "director" of the certificate.

Departmental Resources Required

The certificate in Global Development Engineering will be largely administered through the Department of Civil and Environmental Engineering (CEE) with assistance from the Pratt School. Working in collaboration with all of the contributing departments, the Oversight Committee will:

- be responsible for ensuring that course offerings are up to date, and
- ensure that candidates for certificates/degrees meet requirements,

Since no additional courses are proposed for this major, the effort associated with launching this should be minimal.

Addressing "Problems" and Potential Areas of Concern

During deliberations among the committee and with strategic partners some "problem" areas were identified which warrant special "discussion." These issues are discussed below:

- *Double-Counting Courses*: as with all certificates, this one will allow a maximum of two courses to be "applied" towards **explicit** requirements in the student's major and the certificate program. For instance, a student majoring in Environmental Engineering is required to take the following to fulfill their major requirements:
  - CE160: Introduction to Environmental Engineering and Science, AND
  - CEE 461L. Chemical Principles in Environmental Engineering, AND
  - CEE 462L. Biological Principles in Environmental Engineering, AND
  - CEE 463L. Water Resources

  Based on the requirements stipulated under school policy, they could only "count" two of these toward the certificate and would be required to take additional classes to fulfill the explicit curricular requirements of the certificate. In this example (for instance), they could "count" CE160 (Introductory Class) and CE461 (Technical Depth – 1st Class), but then would be required to take an additional "Technical Depth" Class to fulfill the requirement for two classes in one technical area. However, if a student is required to enroll in an "Upper Level Engineering Elective," a class from the certificate can be used to fulfill this requirement while not being categorized as being "double-counted." This would be true for other classes that are not **explicitly** required (like the 5 SS requirements all Pratt students must complete), students can judiciously select courses to meet those requirements while "fulfilling" both the certificate AND graduation requirements.

- *"Hidden" pre-requisites for Trinity Students:* Many of the technical track courses do have pre-requisites that a student must complete before enrolling in the class. However, it is expected that a student interested in pursuing this certificate will likely already be somewhat technically focused even if they are not an engineer. Therefore, it is likely that they will complete chemistry, physics, and/or biology courses in their course of study. These classes meet most of the technical track pre-requisites (especially in the "water" or "energy" categories), so these important introductory courses should not provide an insurmountable hurdle.

- *Potential "Competition" with the NAE Grand Challenge Scholar Program:* Since the Grand Challenge Scholar Program is already tasking students with tackling some of the

most pressing issues facing humanity, there are definite overlaps in interest (e.g., students interested in clean water for the developing world). However, since one of the major components of the Grand Challenge Scholar program is an intensive examination of one issue – in the form of a three semester research (and/or practicum) experience, it is unlikely that the certificate will "compete" with the program. In fact, since the certificate is "interdisciplinary" and focuses on an experiential "global" component, it is possible that (since these are two of the five requirements for the program) it might entice a few more students each year to consider becoming Grand Challenge Scholars.

- *Potential Bottlenecks or Bandwidth Concerns:* Three potential bottlenecks/bandwidth issues are present regarding course enrollments. The first two are associated with capacity pressures with courses that are "owned" by the Global Health Institute, but also fulfill requirements in this proposed certificate. Specifically, one of the "gateway" courses and one of the ethics courses are also requirements for the Global Health Major/Minor. With the increasing interest in the Global Health Major/Minor, these two courses are near their enrollment capacities, and "additional" students from the certificate may not be able to enroll. Since there are other options for both the gateway course and the ethics course in the certificate, this should not be an issue. In fact, it is expected that students who initially were interested in the Global Health Major/Minor may decide along the way that what they actually want to pursue is the Global Development Engineering Certificate, and this cooperative relationship will allow those students to switch gears without "losing" those credits. This will likely have beneficial results for both the Global Health Major/Minor and this proposed certificate. The other bottleneck is one of the capstone courses (BME462L - Designs for the Developing World). This course is only open to BME majors, and since it is so popular, even they have to join the class using a lottery system. However, since it is not expected that many students will find themselves in this predicament, CE315/PPS211/ENV365 can accommodate both the BME students who cannot take BME462 as well as the other students needing to fulfill their capstone requirements. (Since engineering students can only "double count" two courses anyway, this does not put an undo obstacle to these few students.)

- *Building a "Cohort" in the certificate:* With four options for the gateway course and three selections for the capstone, there is not one course where all of the students of a particular graduating year are together for one curricular experience. To help build a sense of shared vision and direction, as well as a feeling of connectedness, each semester the oversight committee of the Global Development Engineering Certificate (possibly in cooperation with other groups/institutes/programs) will sponsor a speaker/panel/event where issues of interest to the certificate will be discussed/addressed. Prior to (or following) the event, the committee will host a social time (e.g., meal) where students pursuing the certificate can discuss their interests, career goals, etc. with others in the certificate. During the spring meeting, students in the capstone that are pursuing the certificate will be required to present their design (e.g., in a poster session) to provide the opportunity for others to review their work (and be inspired by their projects). Attendance at this event will be required for all students in the gateway and capstone courses and encouraged for all students pursuing the certificate. Another idea that will be piloted/explored will be an off-campus team building activity where students are

challenged with cultural complexities and team building dynamics and given a chance to share, reflect and engage on relevant topics (including why they are interested in the certificate) as well as build a sense of community and a synergistic cohort.

Example "Pathways" for Completing the Certificate

The structure of this certificate has been crafted to make it accessible to both Pratt and Trinity students. Since the Introduction and Global Competency classes are open to any undergraduate and do not have any prerequisites, those four classes are equally attainable (or equally challenging) for all students to complete. Similarly, the applied experiential component also does not have any prerequisites and should be accessible to all students regardless of major affiliation. However, the three technical classes do present somewhat of a hurdle for non-engineers, but it is postulated that more technically focused Trinity majors will have the prerequisites to enroll in the listed classes (i.e., they will have completed Chemistry and/or Biology and can enroll in CE 461 [Chemical Processes in Env Eng] or CE462 [Biological Processes in Env Eng]). The design and implementation capstone is also a division point for the certificate. There are three options offered and it is likely that the following "types" of students will enroll in each of the following capstone options:

- CE315/PPS211/ENV356. Engineering Sustainable Design and the Global Community – has a technical prerequisite (students may select one of a variety of sophomore level engineering classes to fulfill that requirement) – the class is open to all students and will likely have students from both Trinity and Pratt (all four departments)
- EGR 424L. (or ENV 452) Energy and Environment Design – this course is also the culminating experience for the Energy and the Environment Certificate and is open to all students and will likely have student from both Trinity and Pratt (all four departments)
- BME 462L Design for the Developing World – this course is limited to majors in the BME Department.

With these pathways through the certificate, there is enough rigor to ensure that students complete the necessary requirements while having enough options so that bottlenecks in the curricular process can be avoided.

The following table demonstrates an "example" course sequencing to fulfill of the requirements associated with the certificate.

Trinity Students:
Example Course Sequencing for Global Development Engineering Certificate

Freshman Fall	***Freshman Spring***	***Sophomore Fall***	***Sophomore Spring***
First Language Course (required for Trinity students)	Second Language Course Gateway Course	Final Language Course Ethics, Policy, or Econ Course	Pre-requisite class for technical track

Junior Fall	***Junior Spring***	***Summer***	***Senior Fall***	***Senior Spring***
Technical Track – 1st Course	Technical Track – 2nd Course	Experiential Project	Ethics, Policy, or Econ Course	Capstone Course

These can obviously be compressed based on allowable credits (like AP placement) and can be taken in an accelerated sequence if the student so desires. It is entirely possible (and sometimes preferable) for students interested in taking CE315/PPS211/ENV365 to actually take this during their junior spring and design the project they are going to be implementing during the summer prior to their senior year. In this case, the capstone will actually precede the summer experience.

The following table presents similar course sequencing for Pratt students:

Pratt Students:
Example Course Sequencing for Global Development Engineering Certificate

Freshman Fall	***Freshman Spring***	***Sophomore Fall***	***Sophomore Spring***
Pre-requisite class(es) for technical tracks (required for engineers)	Gateway Course	Language/Culture, Ethics, Policy, or Econ Course	Language/Culture, Ethics, Policy, or Econ Course

Junior Fall	***Junior Spring***	***Summer***	***Senior Fall***	***Senior Spring***
Technical Track – 1st Course	Technical Track – 2nd Course	Experiential Project	Language/Culture, Ethics, Policy, or Econ Course	Capstone Course

Availability of Current Course Offerings
The core courses are taught every year. Upper-level courses are typically offered annually as well. It is anticipated that the additional number of students electing to purse the certificate can be accommodated within existing courses that have excess capacity.

New Courses to be Offered
There will be no new courses offered specific to the certificate.

Identification of Teaching Faculty
Students pursuing a certificate will be accommodated within the existing curriculum and teaching schedule. It is not anticipated that faculty teaching responsibilities will be altered significantly, although a modest increase in the size of some courses may occur. There should be no impact, with regards to teaching loads or schedules, on the current CE/EnvE/BME major programs. The faculty in these cooperating departments have reviewed and approved this proposal, indicating their support and willingness to participate.

A list of the teaching faculty contributing to this certificate is included as an attachment to this proposal.

Library Resources Required
No additional library resources are required to support the certificate.

Required Funding
No significant additional resources (space, personnel, or funding) are required. However, depending on the popularity of the certificate, some additional administrative resources may be required to handle the advising load, as well as the oversight role of the committee. It is expected that this can be accommodated within the current workload capacity of the participating member faculty (and supporting departments).

Indication of whether the Proposed Program has a Graduate Component
The certificate in Global Development Engineering does not have a graduate component, although concurrent with the submission of this proposal, another proposal is being considered to offer an M.Eng. in Global Development Engineering (and this proposal is currently being considered for approval by the Engineering Faculty Council).

Proposed Text to Appear in the Undergraduate Bulletin and Online
Global Development Engineering is focused on specific knowledge and skills related to planning, design, construction and operation of engineered systems in under resourced settings using appropriate technology to address issues of social justice and leveraging technological advances to benefit all of humanity, but especially marginalized populations. Duke's Certificate in Global Development Engineering seeks to prepare engineers and other international development professionals for careers in the field of sustainable international development partnering with marginalized or disadvantaged people groups to address both technical and more structural issues related to poverty, wealth inequality, health access, and economic empowerment. The curricular pathway through the certificate includes the following: a) an Introductory/Gateway Class (which must be completed no later than the fall of a student's junior year), b) demonstrated Global Competency (three classes total, with one class from Language and Culture; one from Ethics; and one from Economics OR Policy), c) Technological Depth (two course from one of the following tracks: Water, Energy, or Appropriate Technology), d) Required Experiential Component (putting education into practice), e) Design and Implementation Capstone. The total requirement is seven curricular courses plus one experiential/internship experience.

Conclusion
The proposed curriculum and course of study will equip undergraduate engineers with the foundational and fundamental knowledge and skills of the profession, as well as serve as a spring board for future study and/or practice as an international professional in sustainable development. This program will leverage and enhance existing programs while continuing to provide increasing visibility to Duke's distinctive role in this field.