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Contribution to 9 UN Sustainable Development Goals through Service, Applied Research, and Education

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ABSTRACT
The purpose of this paper is to show the author's contribution to UN Sustainable Development Goals (SDGs) through service, applied research, and education. This paper is organized into four sections: (1) Service, (2) Applied Research, (3) Education, and (4) Combination of Service, Applied Research, and Education. Using these four components, the paper shows the author has made a significant contribution to 9 of the 17 UN SDGs. (i.e., ,1, 4, 5, 7, 8, 9, 11, 12, 17) through his outstanding service, cutting edge applied research, and excellent teaching. The following is the ranking of his contribution: 17, 4, 5, 9, 11, 1, 8, 7, 12. These contributions reflect the author's National Outstanding Teaching quality, value of his service and applied research and his emphasis on gender and geographicdiversity.
KEY WORDS: *Sustainable Development, UN SDGs, Service, Applied Research, Education*

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I. INTRODUCTION

The purpose of this paper is to demonstrate the author's contribution to 9 UN Sustainable Development Goals (SDGs) through his work in the areas of Service, Applied Research, and Education. The paper is organized into four sections: (1) Service, (2) Applied Research, (3) Education, and (4) Combination of Service, Applied Research, and Education. The author has contributed to the following 9 SDGs.These goals constitute a majority of the 17 UN SDGs. The order is according to the ranking of author's contribution. The ranking is based on author's quality and magnitude of his contributions.

1. SDG 17-Partnership to Achieve the Goal
2. SDG 4-Quality Educators
3. SDG 5- Gender Equality
4. SDG 9-Industry, Innovation, and Infrastructure
5. SDG 11-Sustainable Cities and Communities
6. SDG 1-No Poverty
7. SDG 8- Decent Work and Economic Growth
8. SDG 7-Affordable and Clean Energy
9. SDG12- Responsible Consumption and Production

II. SERVICE

SDG 17-Partnership to Achieve the Goal

Partnerships in engineering and outside engineering organizations, are essential to advancing the goals of sustainable development. These global organizations seekto develop international standards for engineering education and professional competencies, and to support capacity development in engineering around the world. These organizations work on equipping engineers to achieve the 17 SDGs 1.

The authorpartneredwith the Accreditation Board for Engineering and Technology (ABET) and Temple University, and six international and national organizations: American Society for Engineering Education (ASEE), American Society of Mechanical Engineering (ASME), American Institute for Chemical Engineers (AIChE), International Association for Bridge and Structural Engineers (IABSE), International Arts Association (IAA), American Red Cross (ARC).

ABET: In 2008 the author served as Chair of the Temple University College of Engineering Committee for undergraduate education and oversaw ABET documentation for nine programs in the college. From 2016

through 2020 he served as the ABET coordinator for the Civil Engineering Program and oversaw the process of ABET documentation preparation for the Department of Civil and Environmental Engineering which consists of approximately 150 students and over 50 courses. Under his leadership in 2017, the department won 6 years ABET approval without a single deficiency.

ASEE: During the 2008-09 academic year,the author won three society level awards: (1) Best Campus Representative, (2) membership recruitment award for recruiting the highest number, 23, of new professional members and (3) membership recruitment award for recruiting the highest number of new faculty memberships, 19. In 2016 he won the award for recruiting the highest number, 18, of new professional members. In 2021 he recruited 25 new professional members.

ASME: In 2019 he won a society level award for recruiting the highest number of professional members, 103 from 6 continents. To date the author has recruited 430 professional members from 6 continents.

AIChE: In 2016 the author received the Most Valuable Player certificate from the AIChE President for recruiting 10 professional members, the highest number by an individual. He met that record again in 2017. In 2018 he recruited 11 professional members, 31 in 2019 , 36 in 2020 ,and in 2021 he made a new record by recruiting 41 professional members. He created a total of6 institute level records, each one not only the year's highest performance but also the highest in the organization's history.

IABSE: The author received three certificates from the IABSE President for recruiting 12, 13, 42Professional members in the years 2017, 2018 and 2019 respectively. These records were not only the year's highest performance but also the highest in the history of the organization.

IAA: The author recruited 10, 29, 31, and 34 professional members in the years 2018, 2019, 2020, and 2021 respectively. He created four association level records for the year's highest performance and for the highest in the history of the organization.

He created 19 international association level records (for all the organizations mentioned in this section), each one not only the year's highest performance but also the highest in the history of the respective organization.

American Red Cross: He has volunteered over 10,000 hours on various disasters including home fires, floods, building collapses, sewer pipe breakages, and home fire preparedness.

Applied research

SDG 7-Affordable and Clean Energy

Clean energy helps reduce or eliminate greenhouse gas emissions. New types of energy storage contribute to accessible and affordable sources of reliable energy. Low-cost, accessible technology has a significant impact on the social fabric and economies of developing countries, especially in remote rural areas.1

The authorcontributed to these efforts by co-authoring applied research papers published in peer reviewed international journals on efficient methods of producing and storing clean energy through hydrogen.

Applied Pedagogical research

The author has published 26 peer reviewed, applied pedagogical research papers in international journals and conference proceedings. He has published the most papers on engineering education and applied research in engineering education.

Education

SDG 4-Quality Educators

Education at every level, including college, is important for development. [2] Following are the author's contributions in engineering and engineering technology education.

The author has taught over 5,000 students, of these 3,000 were in engineering and technology and 2,000 in 40 non science majors. He helped the non-science majors develop an appreciation for engineering and science through the course "Intro to Environment". During Covid-19 the author used E-learning in 9 courses. Students in Philadelphia and across the world have benefitted from these courses. The author consistently provided the highest standard of teaching for his students as evidenced by his National Outstanding Teaching award from the ASEE.

SDG 1- No Poverty

Engineering directly contributes to economic growth thereby helping alleviate poverty. The development of basic infrastructure underpins modern economies.[1]The authorhastaughtmore than 3,000 engineering and engineering technology students overthe past 30 years. Civil engineering and construction management technology students were taught and trained in transportation, intelligent transportation, and air transportation. Civil engineering and mechanical engineering students were taught preparatory courses such as statics, dynamics, and strength of materials. The author trained civil, mechanical, and electrical students in six

multidisciplinary senior design projects on transportation infrastructure and the analysis and optimization of the most troubled, signalized intersections in the nation. In 2001 he served as the Senior Design Co-Ordinator for the College of Engineering. He trained 180 Civil, Mechanical, and Electrical Engineering students using 51 senior design projects directly or indirectly related to infrastructure. The training focused on developing both written and oralcommunication skills.

Combination of Service, Education, and Applied research

SDG 8- Decent Work and Economic Growth

Current reports indicate half the world's population exists on less than US$2 per day and has uncertain access to stable employment (SDG Tracker for Economic Growth at https://sdg-tracker.org/economic-growth). Engineering has long been considered essential to a nation's economic growth. The Center for Economic and Business Research for the Royal Academy of Engineering showed a positive relationship between a country's economic growth and the number of engineers in that country 3 (CEBR, 2016). For example, roads and airports, essential infrastructure for all countries, are designed, developed, and maintained by civil engineers. Energy and housing, basic servicesfor healthy, productive lives, can also be attributed to engineering.

Engineers help diversify national economies and create new jobs (SDG 8.2). They create new industrial jobs and manage resource consumption, a key goal for sustainable development (SDG 8.4), by developing new technologies and innovations. These projects, building and maintaining the infrastructure create jobs for many people in developed and developing countries.1

Many of the author's graduates currently work as engineers and leaders in different fields in USA. Several of his graduates work in areas (e.g., infrastructure)which have asignificant and immediate impact on the GNP of USA. These graduates produce a high-velocity, ripple effect on the GNP by creating more services and goods in other areas. While credit goes solely to these graduates and their hard work,the author educated and trained them. More than 5000 graduates that work in USA were given the foundational tools they needed for their professional accomplishments.The authorenabled the powerful leverage factor of 3000 which, in turn, caused a high-speed ripple effect producing amazing results.

The following is the effect of Dr. Brooks' graduates on the US GNP.

US GNP = $20 trillion /year

The GNP of these 3000 engineers in 153 million workforce of USA=

(3000/153,000,000) x$20 trillion = $0.39billion per year. This translates to$11.7billion in their work span of 30 years.

SDG 9-Industry, Innovation, and Infrastructure

Engineering is essential to sustain modern economies. The UN noted that productivity and income growth, and increased positive health and educational outcomes require investment in infrastructure. 4 Engineers must strive to design, construct, and maintain sustainable, resilient and inclusive the infrastructure (e.g., roads, transport, buildings).

Infrastructure is responsible for industrial development and profit. Industries employ people, thereby increasing income, and produce goods for domestic and export markets. Infrastructure enablestrade by developing local, national and international transportation systems (i.e., roads, ports, railways, airports).

Studies show the number of engineers in a nation has a positive correlation with the nation's innovative and productive capacity. [5] The development of new industries and investments in research and development are important goals (see SADG 9.5). Rapidly emerging innovations in AI, robotics, cloud computing and big data drive economic growth and employment in many areas (e.g., transport to drive logistics and autonomous vehicles). New technologies create new industries and new jobs, and enable more people to become entrepreneurs or become more creative at their present jobs. 1

The author has published over 50cutting edge research papers on innovation and infrastructure in civil engineering and transportation engineering in international, peer reviewed journals such as National Academy of Sciences' Transportation Research Record, American Society of Civil Engineers Journal of Materials, American Society of Civil Engineers Journal of Transportation Engineering.

Dr. Brooks' course, Intelligent Transportation Systems, emphasized the application of big data and artificial intelligence (AI) in solving the unpredictable problems of traffic control (e.g., traffic volume, human error, accidents). This unpredictability makes traffic system behavior modeling difficult, leading to problems in the transportation industry. Students in this course made presentations of AI applications using observed data and reducing unpredictability. They learned the ways big data is used in the transportation industry to prevent errors in delivery and pickup, real-time route optimization, strategic network planning, operational capacity planning, risk evaluation and resilience planning. He taught students about the design and management of sustainable airports in the course Airport Engineering.

SDG 11-Sustainable Cities and Communities

By 2050, studies predict more than two-thirds of the global population will live in cities. Given this prediction, SDG 11 addresses the development of safe, inclusive and resilient cities (SDG Tracker for cities at https://sdg-tracker.org/cities). This goal includes affordable housing, accessible public transportation, clean air, potable water, efficient and environmentally friendly energy sources, protecting natural and cultural heritage assets, and resilience against natural disasters 6 in both developed and developing nations.

Civil and structural engineers play a vital role as they work with policy-makers and planners to design and develop cities that are habitable,resilient and sustainable. Engineers and engineering use advanced technologies to help plan and develop energy efficient smart cities including: energy efficient buildings, smart lighting, efficient transportation systems (ITS course), renewable sources of energy, and effective water resource management. 1

Red cross work

According to the American Red Cross,the vast majority of disasters they respond to are home fires, making home fires the number one urban disaster. [7]For the past 30 years, students in Civil Engineering Materials and Transportation Engineering courses, core courses in Temple's BS-Civil Engineering degree program, have been taught the importance of community service. "The Environment" class, a required sophomore and junior science course for approximately 40 majors, was taught 23 times from Fall 1991 through SP 2013. Over the life of the course, 161 students took time during their semester breaks to install 10-year LED smoke alarms in homes and educate residents on fire prevention and escape preparedness in some of the worst fire-prone areas in their home cities. The cities and the number of students who participated in the program in each city are: Philadelphia (107), Trenton, NJ (12), New York (8), Washington, D.C. (8), Los Angeles (7), Chicago (6), Huston (6), Dallas (4), and Boston (3). The students wrote reports on alternative materials that could mitigate fire loss and enhance safety.Through this program, Dr. Brooks created a paradigm shift in student humanitarian service as well as contributing to mitigation of the devastating effects of home fires.Details of this project are published in a peer reviewed international conference paper. [8]

SDG 5- Gender Equality

Ensuring women's access to technology and engineering will close the gender gap and ensure women can benefit from and participate in the technology revolution, as well as take up leadership positions (SDG Tracker27). The participation of women in the development of advanced technologies, especially engineering, is critical to achieving not only this SDG, but the others as well. Diversity of thought is vital for innovation and the development of solutions that reflect community standards, values, and aspirations. 1

The author has taught over 1500 female students, 1100 in 40 non-science majors and 400 engineering majors. The non-science majors gained an appreciation for engineering and science through his course "Intro to Environment. " He treated his female students with respect, creatinga collegial atmosphere where they felt free to ask questions and actively participate in their learning. This isevidenced by his receiving the National Outstanding Teaching standard of the American Society for Engineering Education.

The author has recruited over 200 women professional membersfor various international engineering organizations from all the six continents.

What Distinguishes Dr. Brooks' long-term performance from that of his peers?

The following points distinguish Dr. Brooks' 30-year performance from that of his peers.

(1) The range, number and quality ofhis service efforts focusing on stakeholders' partnership is unprecedented.

Range: From AMSE through ABET, IAA, and American Red Cross.

Number: 8stake holders.

Depth of stake holders: 19 times broke and built the all-time recruitment records in two professional organizations.

(2) 4 US Presidents including 2 Nobel Laurates (President Carter and President Obama) have congratulated him on his work with over 50 superlatives and adjectivesdescribing the quality of his work in a wide variety of areas (Appendix 1).

(3) His service efforts focusing on diversity of gender and geography are exemplary. He has taught a total of 5000 students,over 1500were women. The students come from all 50 states of the United States as well asfrom other countries. He recruitedover 430 professional members including over 200 women members,from six continents tovarious professional organizations.

(4) The authorreceived the National Outstanding Teacher (the society's highest award) of the ASEE, one of the two greatest engineering education societies.

(5) He has published the most articles in the combined fields of applied research and engineering education.

(6) He created a paradigm shift in student humanitarian service by encouraging his students to volunteer with the American Red Cross to work on mitigating the effects of home fires, the number one urban disaster. The details are published in a peer reviewed international conference paper. [8]

III. CONCLUSION

This paper outlines the author's contributions to nine of the 17 UN SDGs(i.e.,1, 4, 5, 7, 8, 9, 11, 12, 17) through outstanding service, cutting edge applied research, and excellent teaching. The following is the ranking of his contribution: 17, 4, 5, 9, 11, 1, 8, 7, 12.

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Appendix 1

Superlatives (Content Quality Descriptors) from President Clinton

I am delighted to congratulate (1) you on being named Young Engineer of the Year by the Engineers' Club of Philadelphia.

This award is a fitting (2) testament (3) to your visionary work (4) in transportation engineering. The future success of commerce in our nation requires us to remain at the forefront of innovation in highway and runway technology, and you can take great (5) pride (6) in your contributions to this important endeavor (7). More than this, your devoted (8) humanitarian (9) work, particularly during last summer's floods, brought hope (10) and comfort (11) to many Americans (12) whose lives had been devastated by this disaster. Your knowledge (13) and compassion (14) in all of your efforts set a standard (15) of personal excellence (16) to which we can all aspire (17).

I commend (18) you for your commitment to progress (19) and extend best wishes for every future success.

Superlatives (Content Quality Descriptors) from President Obama

I recently learned of your being honored for your teaching, and I wanted to take a moment to extend my warm regards.

It is clear you are driven (1) by a powerful (2) dedication (3) to expanding (4) and enriching (5) the understanding of students and peers alike (6). Through that commitment (7)—at the core of your body of work—you are helping inspire (8) new generations (9) of scientists (10) and innovators (11), and our country (12) will be strong (13) for it. Congratulations on all you've achieved. You have my very best.

Superlatives (Content Quality Descriptors) from President Trump

I recently learned of your work as an American Red Cross volunteer. On behalf of our Nation (1), I offer my sincere (2) gratitude (3) for your excellent (4) service (5).

Your charitable (6) efforts (7) have brought relief (8) and hope (9) to so many (10). I am heartened (11) by your willingness to help (12) those you had never met (13) and may never see again (14). The countless hours (15) you have spent assisting those in need (16) represents the valued (17) American virtue (18) of selfless service (19).

Thank you for the example you set for all Americans (20). May God bless you.

Superlatives (Content Quality Descriptors) from President Carter

Rosalynn joins me in sending you our commendation (1) on a remarkable career (2). The thousands (3) of outstanding student evaluations (4) you have received, and your National Outstanding Teacher Award (5) from the American Society for Engineering Education would be enough cause for celebration (6), but you have gone above (7) and beyond (8) your professional obligations (9). Your status as an American red cross captain (10) is

testament (11) to your dedication (12) to ensuring the safety (13) of your fellow citizens and has inspired (14) your students to do the same. We join your colleagues, peers, and students in congratulating (15) you on your many achievements (16), and we send our best wishes for continued success.
Total number of superlatives = 68 (19+ 13+ 20+ 16)
These 68 superlatives describe the quality of the works done by Dr. Brooks

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