Do Independent Studies Help Students Learn Better? A Case Study on Student Perception and Attitude

Dr. M A Karim, Kennesaw State University

Kennesaw State University, Marietta Campus, 655 Arntson Drive, Marietta, L-114, Georgia 30060, USA. Phone: (470) 578-5078 (W) / (804) 986-3120 (Cell); Emails: mkarim4@kennesaw.edu / makarim@juno.com

Dr. Karim spent about six years as a full-time faculty at the Bangladesh University of Engineering and Technology (BUET) after he graduated from the same university in 1989. He came to the USA in 1995 and finished his PhD in Civil/Environmental Engineering from Cleveland State University in 2000. He worked for about three years for ALLTEL Information Services in Twinsburg, Ohio, as an Applications Programmer. Then he worked for about eight years (in two separate times) for the Virginia Department of Environmental Quality (VDEQ) as a Senior Environmental Engineer and taught at Virginia Commonwealth University (VCU) as an Affiliate Professor before he went to Trine University in January 2008, as a full-time faculty of Civil & Environmental Engineering. He taught part-time at Purdue University Fort Wayne (PFW) while employed at Trine University. During his time at Trine University, he taught an online course for VCU. He also taught at Stratford University, Richmond, Virginia campus as an adjunct faculty while working for VDEQ. Since the fall of 2011, Dr. Karim has been working for Kennesaw State University (KSU), Marietta Campus, Georgia, as a full-time faculty in Civil and Environmental Engineering. He served as an Assistant Department Chair and an Interim Department Chair of Civil and Environmental Engineering Department at KSU. He is a registered professional engineer for the State of the Commonwealth of Virginia and the state of Georgia. He has more than forty journal and proceeding publications and three professional reports in soil and sediment remediation, environmental management, waste treatment and management, wastewater treatment, statistical hydrology, engineering education including project- and problem-based learning (PBL). He is a fellow of the American Society of Civil Engineers (F.ASCE), a member of the American Society for Engineering Education (M.ASEE), and a Board-Certified Environmental Engineer (BCEE) from the American Academy of Environmental Engineers and Scientists (AAEES). He is also an ABET EAC and ETAC Program Evaluation Volunteer (ABET EAC PEV) for civil engineering, environmental engineering, and environmental engineering technology programs.

Dr. Youngguk Seo, Kennesaw State University

Youngguk Seo is interested in the characterization of multi-phased transportation materials such as asphalt concrete, Portland cement concrete, and foundation soils. Research tools include Accelerated Loading Facilities (ALF) at TFHRC in Virginia and a full-scale test road at ETRI of Korea Expressway Corporation. His research topics also cover the design and build of sustainable infrastructure, greenhouse gas emission quantification during construction and operation of highways, and snow melting using new and renewable energy sources.

Parth Bhavsar, Kennesaw State University

Do Independent Studies Help Students Learn Better? A Case Study on Student Perception and Attitude

Abstract

Independent study called "Undergraduate Research" at our university is a highly effective method to inspire students in scholarly work through research. A literature review underscores the manifold benefits of independent study/undergraduate research, including enhanced academic performance, increased motivation and confidence, heightened awareness of students' limitations, and improved self-management skills. Notably, this approach allows teachers to tailor tasks to individual students, fostering social inclusion and mitigating feelings of alienation. Another inspiring factor for students is the flexibility afforded by not having to attend traditional for 3 hours per week in-class lecture to earn course credit. Over the years, the authors have implemented this course within the engineering disciplines of the authors, diligently collecting data on the student perceptions and attitudes towards independent study through a questionnaire survey via Qualtrics. The survey questions were strategically designed to explore the benefits of learning, the long-term retention of acquired knowledge, and the overall learning processes. Analysis of the data demonstrated a positive student perception and attitude towards a few crucial skills, such as teamwork and time management, technical writing and subject matter proficiency, Excel uses, data analytics, communications, and organizational timeline skills. Students expressed a preference for the hands-on aspect and freedom associated with the undergraduate research. Furthermore, students acknowledged the significant influence of undergraduate research on their academic careers, citing improved understanding of their chosen fields, and a heightened interest in pursuing graduate school.

Keywords: independent study, undergraduate research, motivation, students' attitude and perception

Introduction

Independent study as it can be achieved either by doing research or design work as project that can be part of project-based or problem-based learning (PBL). In both cases the idea is to provide the students with flexibility to choose topics and types of work they want to do independently at their own pace and learn independently either by a single student or students in a group [1]. It allows students to learn about a subject that is unavailable in traditional curricula or about a topic students would like to explore in greater depth. Faculty and students create the course, determine what to study, and then work one-on-one or group of students to earn academic credit. A study conducted by Zaka et al.[2] in flipped class room teaching found that students universally enjoyed learning independently and appreciated the increased collaboration induced by the flipped approach. The flexibility of the approach enabled a range of independent learning and collaboration, and students were able to find learning styles that suited them.

Several studies [3] [4] [5] indicated that more benefits include the opportunity to cover more material over a short period of time and freeing up more time for active learning, collaboration, critical thinking, problem solving, and deeper understanding of the content. An independent learning as class preparation for first year engineering students [6] found favorable perception are similar to those reported by most authors for comparable 'flipped' approaches. A study by Kaul et al.[7] indicated that although both students and faculty mentors acknowledge the impact of undergraduate research experiences, some students are ambivalent about the relevance of research to academic performance and excessive project complexity may result in reducing student motivation unless students receive adequate support in the form of strong mentorship and appropriate guidance. Multiple studies indicated that structured undergraduate research was perceived by participants as a positive influence in their academic career, which taught them to focus on their goals and made them more marketable for employment after graduation [8], the participation in research is associated with increased student success, as measured by GPA [9], students with below-average GPAs and students with average or below-average participation in research showed a decline in research benefits as they moved through their college years, gains from research varied by major discipline [10]. Based on the final year research projects, undergraduate research provides a measurable benefit to all students, but this impact is larger for some, though not all, historically underrepresented or underachieving groups of students [11]. Undergraduate researchers from underrepresented groups reported higher learning gains than comparison students. The results replicated previously reported data from this survey and the follow-up survey indicated that students reported gains in independence, intrinsic motivation to learn, and active participation in courses taken after the summer undergraduate research experience [12]. Results of an intensive summer research program at the University of California, San Francisco [13] demonstrated significant gains in critical thinking skills, research abilities, science identity, applied science skills, and readiness for a research career. In that study the participants exhibited improvements in understanding the research process, scientific thinking, science writing, and problem-solving. Most of the studies are subjective in nature through surveys and interviews of the participants, therefore; to create research experiences that meet the needs of interested students and make effective use of resources, a study [14] encouraged systematic and iterative studies with multiple indicators of success.

This study was mainly for undergraduate research under a course number CE 4400 and the study was designed to answer a question: *What are the students' perceptions and attitudes about the undergraduate research specially doing research work for course credits*? The authors offered the undergraduate research for several semesters for number of students for last few years. An objective was formulated to understand the students' perceptions and attitudes about the undergraduate research. The objective was accomplished via an online anonymous survey through Qualtrics. The primary goal of this study was to understand the overall effect of undergraduate research on students' perceptions and attitudes.

Study Methodology

The instructors circulated the topics around and solicited students interests or students approached the authors and authors created the course for the students. The assessment instruments used to conduct this study were online surveys via Qualtrics. To understand the effect of independent study on the perceptions and attitudes of students, surveys were conducted at the end of the semester with 11 questions to gather students' experiences. The survey questions are presented in Figure 1. The first three questions were asked to understand the students' class and course taking status. The next six questions were asked to understand the students' perceptions and attitudes about the independent study/undergraduate research they undertook during their undergraduate years. The last two questions were open-ended and asked to see what kind of transferable skills they gained, how the study will help them in their career plans, and finally any comments/suggestions they might have. The independent study here really means undergraduate research study as the participants involved in the survey were undergraduate research students.

Q.1. What was your student status (Junor or Senior) when you first took the independent study as undergraduate research (CE 4400)?

a. Junior
b. Senior

Q.2. How many times have you taken CE 4400 so far?

a. 1
b. 2
c. 3
d. 4

Q.3. What were total credit hours of CE 4400 you earned towards your degree?

a. 2
b. 3
c. 4
d. 5
e. 6

Q.4. Do you think that your independent study/undergraduate research experience benefited you in classroom learning?

a. Yes
b. No
c. I do not know

Q.5. Do you think that your independent study/undergraduate research experience benefited you in personal growth?

a. Yes
b. No
c. I do not know

Q.6. Do you think that your independent study/undergraduate research helped you graduate on time?

a. Yes
b. No
c. I do not know

Q.7. Would you like to recommend your peers to consider taking CE 4400?

a. Yes
b. No
c. I do not know

Q.8. Overall, did the independent study/undergraduate research meet your expectations?

a. Excellent (5)
b. Above Average (4)
c. Average (3)
d. Below Average (2)
e. Very Poor (1)

Q.9. Do you think that independent study/undergraduate research experience helped you learn the subject matter better?

a. Excellent (5)
b. Above Average (4)
c. Average (3)
d. Below Average (2)
e. Very Poor (1)

Q.10. What kind of major-related transferable skills did you learn during the independent study/undergraduate research? Please list them below:

Q.11. Please explain how independent study/undergraduate research experience influences your academic and career plans. Also, you can make suggestions that could improve participant experience in the future course offerings.

Figure 1: Survey questionnaire for the study

The data collected through the surveys were analyzed to understand the students' perceptions and attitudes about the independent study. The Qualtrics survey was sent to about 22 students who took the independent study with the authors in the last few years, only 12 that is 55% responded. The analysis of data was performed with simple statistics using Excel. The results of the data analysis are illustrated in the following section. Please note that some of the responses to questions/options/choices, as seen in the Tables and Figures, might not sum up to 100% as few students did not respond to all the questions or selected all options or preferences.

Results and Discussions

Based on the responses to Q.1, the majority of participants (92%) were seniors and only 8% participant were juniors. It appears that undergraduate research is more attractive to senior level students than junior level students.

Based on the response to Q.2 (Figure 2), 9 participants (75%) took the research course once, while the rest 3 (25%) took it twice.

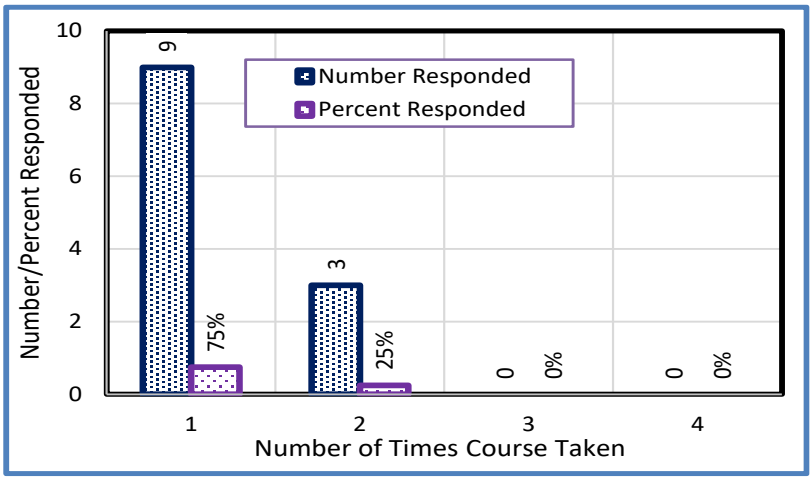

Figure 2: Participant responses for Q.2

As shown in Figure 3 (Q.3), only 1 participant (8%) took the course for 1 credit hours, no one took it for 2 credit hours, 7 (58%) took it for 3 credit hours which seems to be a normal scenario, and 3 (25%) took it for 6 credit hours. No one took it for 4 or 5 credit hours.

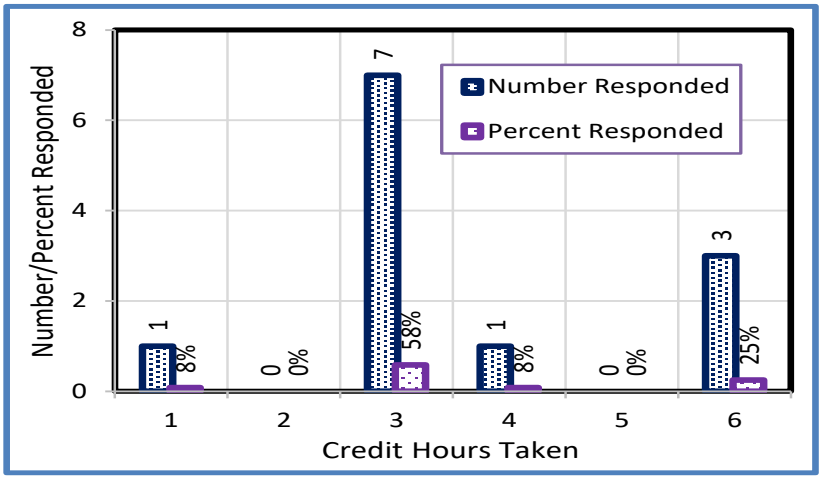

Figure 3: Participant responses for Q.3

Since the responses for Q.4 (experience benefited in classroom learning), Q.5 (experience benefited in personal growth), Q.6 (the research study/course helped them graduate on time), and Q.7 (whether they would recommend this kind of course to peers) were similar (like "Yes", "No", and "I don't know"), the responses for these questions are presented in one graph (Figure

4). Twelve participants (100%) responded “Yes” to Q.4-they benefited from the course in their classroom learning, Q.5-they were benefited by the course in their personal growth, and Q.7-they would recommend the course to their peers. Ten participants (83%) responded “Yes” to Q.6-the course helped them graduate on time that is within four years of enrollment and 2 (17%) responded “No”, that means the course did not help them graduate on time. It appears that almost 100% students viewed that the independent study benefited them in classroom learning and personal growth as well as helped them graduate on time.

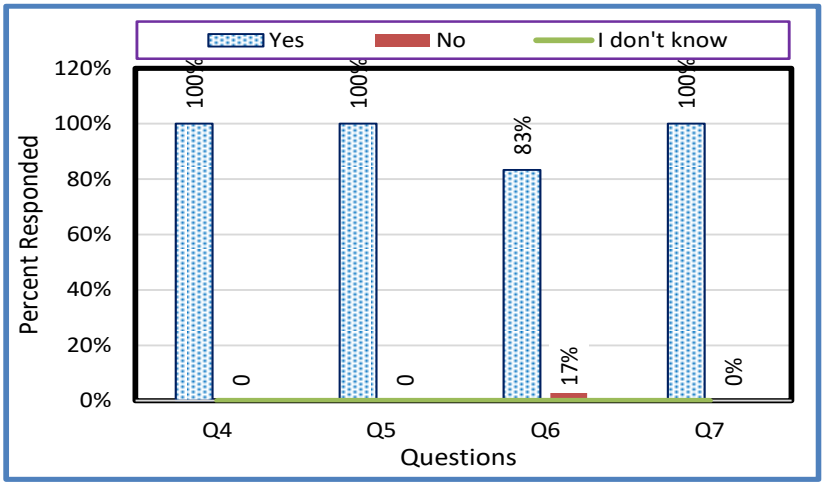

Figure 4: Distribution of responses to Q.4, Q.5, Q.6, and Q.7

Based on the responses to Q.8 (Figure 5), the participants felt that the independent study met their expectations the way the study was designed and offered. Overall, about 75% of the participants chose a Likert scale of “5-excellent”, 8% chose “4-above average” scale, 17% chose “3-average” scale, and 0% chose “2-below average” and “1-very poor” scales with a weighted average score of 4.58. Similarly in response to Q.9 (Figure 5), the participants viewed that the independent study helped them learn the subject matter better. Overall, about 67% of the participants chose a Likert scale of “5”, 33% chose “4” and 0% chose “3”, “2” and “1” scales with a weighted average score of 4.67. The weighted average score was estimated using the percent of student responses as weight. For example, the weighted average score for Q.8 = (1x0%+2x0%+3x17%+4x8%+5x75%)/(0%+0%+17%+8%+75%) = 4.58.

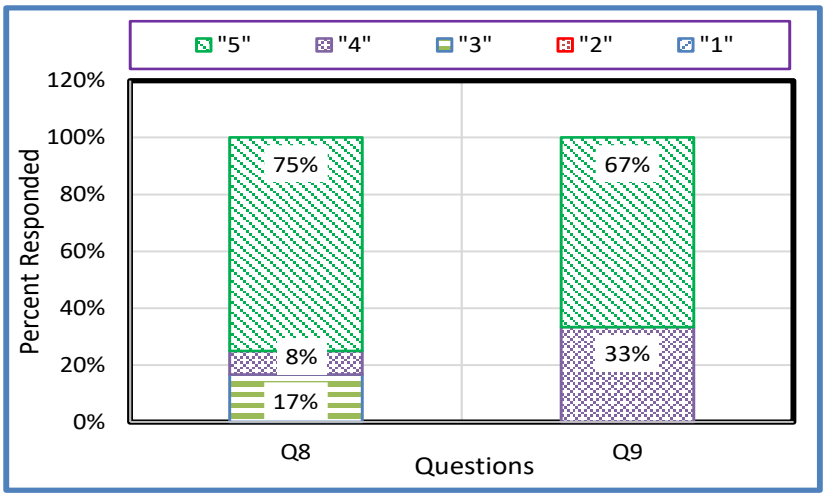

Figure 5: Distribution of responses to Q.8 and Q.9

When the question asked (Q.10) as to what kind of major-related transferable skills did you learn during the independent study/undergraduate research, the participants responded several times that it helped them understand the teamwork, improve technical writing and subject matter skills, use MS-Excel, analyze data, learn communications and organizational timelines, etc. A few statements from the survey are directly quoted in Figure 6.

"Working on adjusting procedures in the lab to improve testing methods and being confident in decisions. Working with multiple teammates to help and improve each other's research."
"Learning to communicate and organize timelines to be able to complete tasks efficiently. Willingness to ask questions or for help when I did not understand something."
"In this direct study, I gained many skills that can be transferred to my major and future career. I think that working and researching independently has been the primary/significant skill I gained in CE 4400. This direct study is different from the other courses that I have taken toward achieving my academic degree because working and researching independently is the main objective of this course (CE 4400)."
"During my independent study, I was able to learn about the scientific research process and apply this knowledge and skills learned to complete this independent study. Furthermore, after evaluating some of the issues that arose at the beginning of this independent research, I have been able to plan, conduct, and analyze data effectively."
"During materials of civil engineering, you learn about concrete, aggregates, and asphalt. We learned about it in the classroom and in the lab, but the independent study allowed me to take a deeper dive into concrete design, application, and alternative methods in a time span of 12 weeks instead of 2 weeks."

Figure 6: Student direct statements in response to Q.10 for the study

When the participants were asked (Q.11), “Please explain how independent study experience influences your academic and career plans. Also, you can make suggestions that could improve the participants’ experience in the future course offerings.” The participants responded several times that it helped them enjoy the aspects hands-on and freedom as opposed to a normal classroom setting, influence academic career, understand the contractors, manage teamwork and times, generate interest in going to graduate school, etc. partially supported by a study conducted at The university of California, San Francisco [13]. A few statements from the survey are directly quoted in Figure 7.

“I really enjoyed the hands-on aspect, and the amount of “freedom” as opposed to a normal classroom setting.”
“It influences my academic plans by helping me taking decisions on where probably I want to land next in my Civil and Environmental Engineering journey, also it opens the door of encouragement to dive into new learning and hands-on experiences within the field of Civil Engineering. It could be improved by broadening the type of hands-on experiences throughout adding more options that will probably cover all the different fields within Civil Engineering.”
“Since I did not have the opportunity to have an internship, this helped me gain experience and knowledge on how to work with others and on my own time not in a lecture setting like it would be in my professional career. I knew that I wanted to go into job that would allow me to have field work because this taught me that I enjoyed being hands-on and I learned better that way. I wanted to start with a job that would be similar to this experience so I could learn as much as I can for when I progress in my career. One suggestion I would make is for the students and professors to meet in the very beginning to set clear goals and timelines and to constantly give each other updates since sometimes there were issues that would come about and would change the timeline completely.”
“I think working on a project in the field of study I thought I wanted to pursue was invaluable. It taught me how to manage my time more effectively as well, since my progress on the project wasn’t monitored closely by my professors.”
“My independent study experience influences my academic career by making me inquire about all aspects of the research process and understand why processes are being done.”
“Post graduation, my primary responsibility is the procurement of concrete, contract management of concrete, quality control, and quantification of concrete. So, the undergraduate course helped me take a deeper understanding of concrete.”
“I can understand contractors to a higher degree coming out of my degree.”
“Going to graduate school.”

Figure 7: Student statements based on Q.11 for the study

Study Limitations

The main source of bias for this study could be that the authors were the only persons who designed this study, conducted the survey, collected and analyzed the data. The evident conflict of interests and potential unconscious bias could genuinely affect the validity of this study. The other limitation could be the size and type of the data, as it is only for topics in engineering discipline. Research in non-engineering fields, more faculty collaboration, and more semesters of study can generate reasonable size data and could make the study dependable and further conclusive. Another important limitation could be the students' negative responses to independent study strategies. Student resistance to independent study, including reasons for this opposition and strategies to prevent or respond to it was not considered. Recognizing factors - that lead to students' resistance to independent study- is important to mitigating these barriers to acceptance and learning. The study is in progress and the authors are planning to broaden the study to include multiple disciplines (engineering and non-engineering) through a university wide survey in the future.

Summary and Conclusions

In this paper, an effort was made to assess the perceptions and attitudes of students about the independent study which is designated as undergraduate research through course credits. Literature review indicates that independent learning/study benefit students to improve academic performance, increase motivation and confidence, provide awareness of students' limitations, and improve their ability to manage themselves. It also enables teachers to provide personalized tasks for students and foster social inclusion by countering alienation. Another obvious motivation for students is that they don't need to sit in a class for 3 hours per week to get credit. Our university has a filler course number CE 4400 that is used to offer independent study with a variable credit of 1 to 6 hours for junior or senior level students with a cumulative GPA of 3.0 or better. The authors have been offering this course in different areas of engineering for number of years and collecting data on the student perceptions and attitude towards the independent study/learning through a questionnaire survey via Qualtrics. The collected data revealed the positive students' perception and attitude towards understanding the teamwork and time management, improving technical writing and specific subject matter skills, excel uses, data analytics, communications and organizational timelines skills. Students enjoyed and liked hands-on aspect and the freedom as opposed to a normal classroom setting. Students also felt that the independent study influenced their academic careers, helped understand the contractors, and generated interest in pursuing graduate studies.

References

[1] M. A. Karim, "Project Based Learning of Environmental Engineering: A Case Study," in *Proceedings of ASEE's 122nd Annual Conference & Exposition, Seattle, Washington, June 14-17, 2015 (Paper ID # 11366).*, Seattle, Washington: ASEE, 2015.

[2] W. H. Fox and P. D. Docherty, “Student perspectives of independent and collaborative learning in a flipped foundational engineering course,” *Australas. J. Educ. Technol.*, vol. 35, no. 5, pp. 79–94, 2019.
[3] U. Cunningham, “Language pedagogy and non-transience in the flipped classroom,” *J. Open Flex. Distance Learn.*, vol. 20, no. 1, pp. 44–58, 2016.
[4] G. S. Mason, T. R. Shuman, and K. E. Cook, “Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course,” *IEEE Trans. Educ.*, vol. 56, no. 4, pp. 430–435, 2013.
[5] K. Yelamarthi and E. Drake, “A flipped first-year digital circuits course for engineering and technology students,” *IEEE Trans. Educ.*, vol. 58, no. 3, pp. 179–186, 2014.
[6] A. Pejuan and J. Antonijuan, “Independent learning as class preparation to foster student-centred learning in first-year engineering students,” *Res. Post-Compuls. Educ.*, vol. 24, no. 4, pp. 375–400, Oct. 2019, doi: 10.1080/13596748.2019.1584447.
[7] L. Gow and D. Kember, “Does higher education promote independent learning?,” *High. Educ.*, vol. 19, no. 3, pp. 307–322, 1990, doi: 10.1007/BF00133895.
[8] D. H. Kinkel and S. E. Henke, “Impact of Undergraduate Research on Academic Performance, Educational Planning, and Career Development,” *J. Nat. Resour. Life Sci. Educ.*, vol. 35, no. 1, pp. 194–201, 2006, doi: 10.2134/jnrlse2006.0194.
[9] A. J. Sell, Naginey, Angela, and Standon,Cathy A., “The Impact of Undergraduate Research on Academic Success,” *Counc. Undergrad. Res. Q.*, vol. 1, no. 3, pp. 19–29, Mar. 2018, doi: 10.18833/spur/1/3/8.
[10] R. Taraban and E. Logue, “Academic Factors That Affect Undergraduate Research Experiences,” *J. Educ. Psychol.*, vol. 104, pp. 499–514, Jan. 2012, doi: 10.1037/a0026851.
[11] J. Parker, “Undergraduate research, learning gain and equity: the impact of final year research projects,” *High. Educ. Pedagog.*, vol. 3, no. 1, pp. 145–157, Jan. 2018, doi: 10.1080/23752696.2018.1425097.
[12] D. Lopatto, “Undergraduate Research Experiences Support Science Career Decisions and Active Learning,” *CBE—Life Sci. Educ.*, vol. 6, no. 4, pp. 297–306, Dec. 2007, doi: 10.1187/cbe.07-06-0039.
[13] G. Galvez, D. W. Killilea, S. Berry, V. Narayanaswami, and E. B. Fung, “Increasing STEM Skills, Knowledge and Interest Among Diverse Students: Results from an Intensive Summer Research Program at the University of California, San Francisco,” *Innov. High. Educ.*, Feb. 2024, doi: 10.1007/s10755-024-09701-z.
[14] M. Linn, E. Palmer, A. Baranger, E. Gerard, and E. Stone, “Undergraduate research experiences: Impacts and opportunities,” *Science*, vol. 347, p. 1261757, Feb. 2015, doi: 10.1126/science.1261757.

M. A. Karim

Dr. Karim spent about six years as a full-time faculty at the Bangladesh University of Engineering and Technology (BUET) after he graduated from the same university in 1989. He came to the USA in 1995 and finished his PhD in Civil/Environmental Engineering from Cleveland State University in 2000. He worked for about three years for ALLTEL Information Services in Twinsburg, Ohio, as an Applications Programmer. Then he worked for about eight years (in two separate times) for the Virginia Department of Environmental Quality (VDEQ) as a Senior Environmental Engineer and taught at Virginia Commonwealth University (VCU) as an Affiliate Professor before he went to Trine University in January 2008, as a full-time faculty of Civil & Environmental Engineering. He taught part-time at Purdue University Fort Wayne (PFW) while employed at Trine University. During his time at Trine University, he taught an online course for VCU. He also taught at Stratford University, Richmond, Virginia campus as an adjunct faculty while working for VDEQ. Since the fall of 2011, Dr. Karim has been working for Kennesaw State University (KSU), Marietta Campus, Georgia, as a full-time faculty in Civil and Environmental Engineering. He served as an Assistant Department Chair and an Interim Department Chair of Civil and Environmental Engineering Department at KSU. He is a registered professional engineer for the State of the Commonwealth of Virginia and the state of Georgia. He has more than forty journal and proceeding publications and three professional reports in soil and sediment remediation,

environmental management, waste treatment and management, wastewater treatment, statistical hydrology, engineering education including project- and problem-based learning (PBL). He is a fellow of the American Society of Civil Engineers (**F.ASCE**), a member of the American Society for Engineering Education (**M.ASEE**), and a Board-Certified Environmental Engineer (**BCEE**) from the American Academy of Environmental Engineers and Scientists (**AAEES**). He is also an ABET EAC and ETAC Program Evaluation Volunteer (ABET EAC PEV) for civil engineering, environmental engineering, and environmental engineering technology programs.

Youngguk Seo

Degrees and Appointments: B.S. (Civil Engineering), University of Seoul, 1993; M.S.(Civil Engineering - Structural), Seoul National University, 1996; Ph.D (Civil Engineering - Transportation Materials), North Carolina State University, 2003. Researcher (1996 - 2006) and Deputy Research Director (2006 - 2013) at Expressway and Transportation Research Institute (ETRI), Korea; Pavement Engineer at Turner Fairbank Highway Research Center (TFHRC) of Federal Highway Administration (FHWA), 2013 - 2014; Assistant Professor of Civil Engineering, 2014 - 2020; Director of Georgia Pavement and Transportation Research Center (GPTRC website), 2019 - present; Associate Professor of Civil Engineering, 2020 – present. Research Overview: Dr. Seo is interested in the characterization of multi-phased transportation materials such as asphalt concrete, Portland cement concrete, and foundation soils. Research tools include Accelerated Loading Facilities (ALF) at TFHRC and a full-scale test road at ETRI of Korea Expressway Corporation. His research topics also cover the design and building of sustainable infrastructure, greenhouse gas emission quantification during construction and operation of highways, and snow melting using new and renewable energy sources. Find out more from his personal (https://yseo22.wixsite.com/research-site).

Parth Bhavsar

Dr. Parth Bhavsar is an assistant professor in the Department of Civil and Environmental Engineering at Kennesaw State University. His research interests include intelligent transportation systems (ITS), transportation data analytics, connected & automated vehicle technology (CVT), and alternative fuel vehicles (AFVs). Dr. Bhavsar received his Ph.D. in 2013 and his M.S. in 2006 from Clemson University, South Carolina. He also has experience in the private sector in developing transportation engineering and planning solutions, specifically traffic micro-simulation projects. He has published in peer-reviewed journals such as Transportation Research Part C: Emerging Technology, Transportation Research Part D: Transport and the Environment, and Transportation Research Record Journal of the Transportation Research Board. Dr. Bhavsar has received funding of 5.46 million since 2014. Specifically, he has received over $1.9 million as a principal investigator (PI). He has worked with various agencies such as National Science Foundation, New Jersey Department of Transportation (NJDOT), New Jersey Department of Community Affairs and U.S. Department of Transportation. Dr. Bhavsar will serve as a PI for the proposed USDOT Attain grant and manage all research, development, pilot-testing, and deployment activities.