Bridging Data Science and Ethical Reasoning in Education (Project BRIDGE): Connecting Big Data, Computational Thinking, Coding, and Ethics in Education

Category:
Areas of Future Opportunity and Investment

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Bridging Data Science and Ethical Reasoning in Education (Project BRIDGE): Connecting Data Analytics, Computational Thinking, Coding, and Ethics in Education

SUMMARY. The overarching goal of BRIDGE is to design and research a variety of projects on data analytics [DA], computational thinking [CT], and coding (three components of data science) with an ethics lens, pre-college to university levels. The project engages an interdisciplinary expert team from the Belk College of Business, Cato College of Education, Center for Professional and Applied Ethics, Center for STEM Education, College of Computing and Informatics, College of Liberal Arts and Sciences, and The William States Lee College of Engineering.

This work is imperative due to how the growth of data and computerization affects every aspect of our lives, and the climate advocating increased emphasis in STEM education, particularly involving computing and data. Our project responds to needs to prepare students for future employment in a growing digital world and as citizens in this global data-driven economy. As our world becomes more technology driven, the need for STEM professionals, including computer and data scientists will continue to surge (Huang et al., 2020; Lee et al., 2020). The number of computing technology related jobs in NC is high (NC Dept. of Commerce, 2018) with over 92,000 employed in related sectors, and an anticipated growth of at least 10 percent through 2026. Further, while the United States leads the race in STEM research and development, there are not enough students and teachers entering STEM disciplines (Duschl, Schweingruber & Shouse, 2007; National Science Board, 2014). This project responds to calls for increased emphasis in data sciences and computing, but also the research gap on computational thinking in STEM education in university environments, particularly in teacher education (Farmer & An, 2020; Grover & Pea, 2013; Li & Pustaka, 20202). Technological advances also raise questions in preparing leaders and workers to think more ethically (O'Neill, 2016). Our program will embed ethics so that there is a focus on ways technology affect humanity. There is an urgent need for professionals, teachers and students to have the reasoning skills to understand the relevance of ethics in everyday work.

To address these challenges, Project BRIDGE has developed these priorities for the next 3 years:
1. Submit NSF Noyce proposal - preservice teacher education scholars focused on project elements (data analytics, computational thinking, coding, ethics) (fall 2021);
2. Develop and implement a high school data science project from an ethical perspective (40+ hours, 2022), seek related funding to develop companion teacher professional development– both programs will become regular CSTEM activities (2022-2023);
3. Work with NCI DPI to develop a data science course as a fourth-year mathematics offering
4. Continue to build on international efforts to adjust K-12 STEM content to reflect DA, CT, and technology; co-lead 2nd STEM working group at CERME (European conference);
5. Revisit, if necessary, NSF Proposal on Computational Thinking for preservice teacher education and undergraduate STEM programs (submitted February 2020);
6. Conceptualize and develop a grant proposal around DA, CT, and coding, for university STEM programs with a related ethics component (2021);
7. Implement initiatives to change local/state literacy of DA, CT, and coding, with ethics, such as book studies, lectures, seminars, & engagement with K12 partners (begin 2021);
8. Develop a micro-credential embedding DA, CT, coding and ethics (2021-2022);
9. Establish a STEM Education Ph.D. exploration task force (2021-2023);
10. Conduct quality research on outcomes and impacts of various program activities (2021+).

Evidence of Strength and Excellence:

Our world is changing rapidly under the influence of informatization, automatization, digitalization, and globalization. Project BRIDGE will support educational research and programs with the variety of data in the modern world including collaborative work with programming languages and understanding the way networks work across mobile and computing devices, the development of computational thinking, and the skills to consider the human aspects of data and its uses through ethical reasoning. Our team has the expertise in data analytics, computational thinking, coding, ethical reasoning, and STEM teaching and learning. As such the team will identify problems and propose solutions through an interdisciplinary lens.

This work will build on current collaborations among team members. Drs. Dorodchi, Pugalee, and Rorrer are part of a NSF project, with the Friday Institute at NC State, in a Research to Practice Partnership studying the STEM ecosystem in two diverse middle schools integrating computational thinking. Also, Drs. Pugalee, Dorodchi, Stephan, and Rorrer recently submitted a NSF Improving Undergraduate Education proposal focused on computational thinking for preservice teacher education. The project will develop modules to be implemented into undergraduate STEM content courses in biology, chemistry, physics and mathematics and education courses for 6-12 teacher ed candidates. The computational thinking emphasis will connect data analytics, computational thinking, and coding, with an emphasis on ethical reasoning. Dr. Asala is a chemistry expert on this proposal and is one of our BRIDGE collaborators. If the project isn't funded, the BRIDGE team will review and revisit. This will be in addition to other intended funding opportunities that will be developed by BRIDGE members to support data science in undergraduate STEM education. Dr. Dorodchi has received $2.3M in grant funding and published over 37 papers in the field of computer science education research since 2014. Dr. Rorrer has over $19M in extramural funding support in the last decade and over 30 publications.

Drs. Stephan and Pugalee are working with doctoral student Jordan Register to study data science and ethics in STEM teaching and learning. Stephan, Pugalee, and Jordan have been researching middle and secondary level students' thinking around how mathematics, particularly data applications, can be used to promote bias and injustice. The group will present the paper *Ethical Mathematics Awareness in Students' Big Data Decision Making,* at the international meeting of the Mathematics Education and Society Conference. Register, Stephan and Pugalee have one manuscript under review and are completing a manuscript for a special issue of the international journal *Mathematics*. Both manuscripts present a new avenue for research on the didactics of ethical mathematics. Doctoral student Jordan Register is currently completing the UNCC Graduate Certification on Data Science to develop analytical skills related to this research. Register will design and lead teaching a data science course in summer 2022 for high school students and the BRIDGE team will support development of a framework and curricula for this course. All BRIDGE team members will engage in international efforts related to the project such as developing a presentation on Ethical Data Science for the International Conference on Mathematics for the Future (2022) and a workshop for the International Symposium on Elementary Mathematics Teaching (2023); Dr. Pugalee is on the Board of both conferences. The team plans to become engaged in the Scientia Moralitas Research Institute which was established by the Research Association for Interdisciplinary Studies to promote multidisciplinary research on ethics and stimulate dialogue on ethical issues affecting the real-world. Dr. Pugalee has grant funding

covering approximately 25% or 3 months of his 12 month appointment and has more than 20 publications in the last five year. Dr. Stephan served as co-PI on a NSF Noyce project and is co-PI on a pending proposal. She has over 30 publications and 1000 citations.

The Center for STEM Education is positioned to build on these collaborations which also include prior NSF-funded projects with Dr. Kathy Asala in Chemistry and Dr. Michele Stephan, such as the NSF Noyce 49er Teach which focused on secondary chemistry and physics. Prior collaborations also include initiatives with Dr. Cathy Blat, Assistant Dean for Student Experiences in The William States Lee College of Engineering. The latest effort was a Gates Foundation proposal to address challenges in algebraic foundations in precollege mathematics. The Center is uniquely positioned to support the goals project BRIDGE. Center personnel, also on this project, include Ms. Alisa Wickliff, Associate Director, and Dr. Shagufta Raja, Pre-College STEM Program Director. Ms. Alisa Wickliff has environmental science experience in the private and government sector. She has extensive experience building capacity for teachers and students to engage in STEM student research. Dr. Raja has experience as a high school physics teacher and has expertise in educational technology, which is critical to growing opportunities for digitized programming. Both Ms. Wickliff and Dr. Raja have worked with elementary- through secondary-level students in conducting STEM research. Additionally, Dr. Raja has funding for six Army Educational Outreach Program for students to complete STEM research internships with faculty. Dr. Pugalee, Ms. Wickliff, and doctoral student Jordan Register are co-PIs on a National Security Agency grant to provide cyber security professional development for teachers this summer. Ms. Wickliff and Dr. Raja currently have more than $200,000 in grant funding.

Expertise of team members: Data analytics expertise is provided by Dr. Chandrasekar Subramaniam, Chair of Business Information Systems & Operations Management and Associate Professor of Data Science. He is a co-editor of a special issue on Digital Inclusion for *Information Systems and E-Business Management*. His research interest in the digital divide and digital inclusion complements BRIDGE's focus on data and ethics. His work on patient use of healthcare technologies and impacts has been published in the *Journal of Medical Internet Research*. He developed a new undergraduate programming course focusing on R and Python and redesigned a graduate course to incorporate ethical and social impacts of big data. He worked with graduate students to implement a boot camp "Statistics of Data Science". The work in applications of big data will be fundamental in the developing a data science course to present to the NC Depart of Public Instruction. Leadership in ethical reasoning will be provided by Dr. Gordon Hull, Director of the Center for Professional and Applied Ethics and Professor in Philosophy and Public Policy. Dr. Hull is also Affiliate Faculty in the School of Data Science. Dr. Hull is one of UNCC's leaders on issues of ethical reasoning in data science. He has taught courses on the ethics of data science and procured grants to research bioethics and ethics in medicine and biology. Additional biology and CT expertise will be provided by Dr. Adam Reitzel, Professor and Graduate Program Coordinator in the Department of Biological Sciences. Dr. Reitzel also brings expertise in bioinformatics and health sciences. He recently served on a Design Research Team that explored the role that science plays in provoking high school science teachers to explore their personal biases as well as supporting them to integrate ethics into their HS science teaching. This biology content expertise complements the mathematics, environmental science, physics, chemistry, and engineering content expertise brought to the collaboration from other team members.

Alignment with Regional and National Priorities

Project BRIDGE aligns to several components of the University Vision and Values. The emphasis on teaching and learning computational thinking skills, coding, and big data respond to the "equips students with intellectual and professional skills" and the project's embedding of ethical reasoning aligns to the "ethical principles" of the first bulleted component and "ethically responsible" of the fourth bulleted component. The application nature of this project aligns to the second component "opportunities for experiential education to enhance students' personal and professional growth."

Our work aligns to two of NSF's big ideas. First BRIDGE's emphasis on technology and ethics bridges NSF's emphasis on the human-technology landscape. NSF advocates joining the scientific investigation related to interaction of humans, society, and technology as it shapes the future of work. BRIDGE's emphasis on computational thinking, coding, and big data aligns well with the NSF big idea of "harnessing the data revolution." By playing a role in the interdisciplinary work from "chemistry to biology … to engineered systems .. to education and more" and to "educational pathways – innovations grounded in education-research-based framework".

This project responds to Goal 4 (Enhance Workforce Development for Biological Science) of the NIH Strategic Plan for Data Science. NIH recognizes the multifaceted work of data scientists and is interested in a workforce skilled in this area (Objective 4-1). Objective 4-2 recognizes the increasingly quantitative work of biomedical research and the need for researchers to be equipped with the skills to capitalize on data science applications. Project BRIDGE responds to NIH implementation tactic "enhance quantitative and computational training for undergraduates [and] graduate students," and nurtures important cultural changes which emphasize the role of data science in "discovery and health." Project BRIDGE's connection to K-12 education addresses NIH's goal to "promote biomedical scientific careers among K-12 students." NIH also states that this work requires input from experts in research ethics as well as standards for privacy and use of data (Goal 5: Enact Appropriate Policies to Promote Stewardship and Sustainability).

The Office of Science and Technology Policy has not elaborated on goals under the Biden administration. But brief statements emphasize the importance of 'science-driven' actions to address the nation's priorities. Our work will include a comprehensive equity agenda with approaches to embed racial justice across agencies, policies and programs, and "championing America's values and human rights." These align to the priorities of Project BRIDGE.

BRIDGE's emphasis on research responds to the IES Director's Final Proposed Priorities to "improve education outcomes, and to determine how, why, for whom, and under what conditions they are effective." Further, BRIDGE's commitment to ethics and the emphasis on justice, equity and humanity will govern that we "will promote research to improve education outcomes for all students, and particularly for those students whose prospects have historically been hindered because of their socioeconomic status, race/ethnicity, gender, disability, limited English proficiency, and/or residential or school mobility. Such research will generate knowledge to assist educators and policymakers in assessing and improving the equity of the education system."

To a lesser extent our work also supports the humanities which includes ethics, responding to National Endowment for the Humanities objective 2 to "provide opportunities for teachers to advance their ability to teach the humanities."

Supporting Documents:

Team Members	Titles	Expertise and Contribution
Dr. David Pugalee, Co-Lead	Professor / Director Center for STEM Education, Cato College of Education	STEM teaching and learning, problem-based and project-based learning in STEM; Computational thinking, Co-Lead and management through Center for STEM Education. STEM education research. Teaching experience in K-12 and curriculum development experience (engineering and mathematics). He currently has approximately 25% of salary bought out through grant funding.
Dr. Mohsen Dorodchi, Co-Lead	Teaching Professor, Computer Science, College of Computing and Informatics	Research on data and predictive analytics and visualization, with a focus on applications of analytics in academia and students' learning. In addition, he has been extensively working on evidence-based teaching innovation, computer science education research, educational tool development, and K12 outreach curriculum development and broadening participation in computing. His research has been supported by NSF, State of North Carolina, and industry.
Dr. Michelle Stephen, Co-Lead	Associate Professor, Department of Middle, Secondary & K-12 Education, Cato College of Education & Department of Mathematics, College of Liberal Arts and Sciences	Taught middle school mathematics. Teaches middle and secondary mathematics methods classes. She leads sustained professional development projects for teachers in Cabarrus and Kannapolis County. Expertise in design research methodology, mathematics for the 21st century, lesson imaging for inquiry STEM (lead author on related book with Dr. Pugalee), and advocacy and community engagement.
Dr. Kathy Asala, Collaborator	Teaching Professor / Faculty Fellow – Transforming STEM Teaching and Learning Academy, Department of Chemistry, College of Liberal Arts and Sciences	Faculty Fellow, Transforming STEM Teaching and Learning Academy. Active learning in STEM education research. Mentors undergraduate students in chemistry research and in the Quantitative Analysis Laboratory. Supports Young Scholars, an enrichment course for 4th to 6th grade. Research on STEM Persistence and Retention (NSF funded). Expertise in discipline-based research and chemistry education.
Dr. Cathy Blat, Collaborator	Assistant Dean for Student Experiences and Director of Office of Student Development and Success, The William	Experience as a practicing engineer. Leadership in student success initiatives including prior work as Director of the University Center for Academic Excellence, Engineering Freshman Learning, & WiSE - Women in Science and Engineering. Directed the College of Engineering Mentoring

	States Lee College of Engineering	Program. Experience in software development and database management. Research on mathematics readiness of college students and related learning gaps; Designed the embedded tutoring program including Organic Chemistry I, Chemistry II, Accounting I, and Physics with and without Calculus. Expertise in engineering education research, integrating curriculum, and student support initiatives.
Dr. Gordan Hull, Collaborator	Director, Center for Professional and Applied Ethics; Professor Philosophy and Public Policy; Affiliate Faculty, School of Data Science	Research expertise in moral and political philosophy, particularly problems that emerge at the intersection of philosophy, law, and technology. Recent work examines different ways of understanding power in copyright, trademark and patent policy. Work also spans issues of ethics and privacy, bioethics, power and school issues; ethics in big data and social media, and cultural branding. Expertise in research on ethics and intersection with big data and related applications and issues of power.
Dr. Shagufta Raja	Director UNC Charlotte Pre-College STEM Program, Center for STEM Education, Cato College of Education	Post-doctoral certificates in Advanced College and University Teaching; Essentials of Teaching and Learning, and Instructional System Technology Graduate Certificate; directing STEM student research and developing curriculum for summer enrichment programs for students in grades 5-12; mentoring faculty to work with student researchers; Expertise as physics educator and mentoring students in STEM research. Development of digital learning environments for STEM student research and STEM topic explorations.
Dr. Adam Reitzel, Collaborator	Professor, Graduate Program Coordinator, Department of Biological Sciences	Operates laboratory is interested in answering integrative questions concerning the evolution and ecology of coastal invertebrates by using an interdisciplinary approach that combines comparative genomics, molecular biology, population genetics, evolutionary ecology, and field studies. Research combines bioinformatics, leading edge sequencing technologies, and explicit experimental or geographical sampling. To facilitate this training, Dr. Reitzel is PI on a pending T32 training grant proposal with Dr. Cynthia Gibas (BINF) to provide a unique graduate training opportunity that combines biology and computational approaches to prepare

		underrepresented minority students for future careers in the biomedical sciences. Expertise in interdisciplinary STEM research, computational methods, and working with underrepresented students.
Dr. Audrey Rorrer, Collaborator	Research Associate Professor, Department of Computer Science, College of Computing and Informatics: Center for Education Innovation	Research and Evaluation for The Science and Art of Broadening Participation in Computing, recognized domain of critical importance in STEM workforce development and educational programming. Extensive work focused on educational programs, outreach and collective impact activities that expand the national pipeline into computing careers, college student development and faculty career development are central themes across her body of work. She approaches endeavors from a servant leadership philosophy, which prioritizes growth and service, and shared power. Expertise in computing, philosophy, and research evaluation.
Dr. Chandrasekar Subramaniam, Collaborator	Chair of Business Information Systems & Operations Management (BISOM) Associate Professor of Information Systems Associate Professor of Data Science & Business Analytics; Belk College of Business	Research includes electronic commerce/e-business, IT and enterprise business processes, and inter-organizational information systems. Funded projects through Caterpillar, Motorola, and State Farm Insurance and the Center for e-Business and IT Management. Research used big data and data analytics techniques including the use of twitter data and natural language processing tools, data from CMS, HIMSS Analytics, FEMA and other public sources and a combination of text processing and analytics tools. Expertise in data science, programming and business; research in applications of data across multiple fields.
Alisa Wickliff	Associate Director, Center for STEM Education, Cato College of Education	Working on doctoral degree in Curriculum & Instruction with an emphasis on project-based teaching and learning in STEM. Work experience in environmental science. Extensive work in teacher development around mentoring student STEM research; leadership development of STEM teacher educators; and expertise in supporting K-12 student STEM research. Expertise in K-12 teaching and learning, mentoring STEM student research, and directing student STEM research competitions.