The impact of alternative rhetoric and AI on inclusivity in STEM education

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Abstract:

We report on the second year of iSTEAM, a program funded by the State University of New York (SUNY), to enhance inclusivity in STEM education by incorporating invitational rhetoric/discourse for fostering diversity, equity, and inclusion in STEM education. Revisions in the program include expanding the offering to faculty from across the SUNY system and integrating inclusive use of AI as well as OER distribution plans into the framework. Workshops were conducted online, with past participants serving as mentors to 38 new participants who completed modules and collaborated across institutions. Feedback from the participants shows the value of the project and the ways in which STEM courses have been made more inclusive. This project will help to grow a community of SUNY STEM instructors who can foster among future STEM professionals diverse perspectives, inclusive approaches, and equitable applications of science in society.

I. Background:

A. Impact of alternative forms of rhetoric on STEM education

Across higher education, and especially in STEM fields, educators are grappling with a systemic lack of diversity, equity, inclusion, and social justice. Universities have not only struggled to diversify their student populations but also to make their educational practices more equitable[1]. Yet we need to be more inclusive of a wider variety of knowledge, cultures, and traditions in our curricular design, instructional and learning practices, and assessment and mentoring. A new dimension to that struggle is the lack of diversity in the scope of scientific knowledge and its traditions, scientific methods and priorities of inquiry, and application and benefits of science to different groups of people in society and the world. Specifically, mainstream teaching/learning practices, as well as communication and collaboration, scientific inquiry and innovation are not only limited to a Greco-Roman-Anglo-American lineage – which determine the scopes of inquiry and methods for advancing/applying scientific knowledge using agonistic framing as the norm – but also based on patriarchal rhetorical norms of competition, conflict, and conversion.[2] Disciplinary knowledge, including in STEM fields, is founded upon provincial and colonial narratives and is yet to expand into the broader world of scientific inquiry and application. Non-western forms of rhetoric, for example forms of argumentation developed from oral tradition in ancient India, sought to establish new knowledge with a focus on

community welfare rather than persuasion[3]. And this certainly is a key focus of engineering design which must take into account the impact on a variety of stakeholders (beyond the end users of the designed technology).

Agonistic rhetoric very often emphasizes a narrow focus on system performance for the key users, and perhaps enhanced profit for the potential manufacturer of the design, with broader community needs (for example) often neglected or deemphasized. For example, many faculty who teach engineering problem-solving and design typically adopt a "survival of the fittest" approach to selecting one design or solution over another. While this may result in viable solutions in industry, framing complex scientific phenomena as debates can be misleading and even harmful. This process also neglects the voices and needs of disadvantaged or socioeconomically challenged populations and leads to adopting technological developments that fail to support a wide range of ecosystems, cultures, and communities. This calls for drawing on knowledge traditions and practices from beyond the mainstream. While exploring the application of non-traditional forms of rhetoric clearly can impact inclusivity, a stumbling block has been the tendency of researchers (and in particular Western researchers) to label many such practices as somehow "mystical" or lacking in rigor needed for success in STEM disciplines, assigning such practices a negative connotation[3]. Clearly there is a need to move beyond these labels if education researchers and teachers are to properly leverage concepts which can enhance classroom inclusivity and hence learning outcomes.

In a 2019 study by Barton and Tan, the integration of "making present" practices (which focused on ensuring that students from diverse backgrounds would fell inclusivity in classroom environments) is a valuable tool in establishing formerly "missing voices" in the development of knowledge in STEM[4]. Modifying the learning environment via inclusion of non-traditional forms of rhetoric can also contribute to creation of a 'safe' learning environment for the expression and testing of new ideas, exposure to genuinely unknown situations via open-ended problem solving, and the use of invitational rhetoric to build inclusive and supportive learning communities for project-based learning. Invitational and other non-confrontational forms of rhetoric have been shown to enhance the learning environment. The invitational approach to classroom instruction is based on foundations of feminist rhetoric and discourse[2] which build upon the principles of self-worth, equality, and agency. This approach helps instructors counter the subtle and normalized traditional discourse that seeks to prove others wrong, silence or suppress marginal voices, and talk over those who lack power and privilege in knowledge or language. Interventions based on introduction of invitational approaches to a group dynamic in problem solving will help faculty use inclusive approaches, including ideas from different knowledge systems as a condition for effectiveness and success. Such interventions may also use inquiry-based teaching that seeks out divergent and creative thinking[5]. Examples of steps within this process may be (a) revision of syllabus to reflect a more inclusive environment, (b) revision of course materials and assignments to reflect a more diverse perspective (for example, choosing readings which reflect a diverse

perspective), and (c) using teaching methods which promote openness and inclusivity (including use of non-agonistic rhetoric). These particular methods have been successfully developed and employed in the authors' iSTEAM workshop program which has been applied to a wide variety of STEM courses. Reported results show an increase in student comfort and motivation, reflected in enhanced learning gains[6]. These rhetoric-based interventions can also help to foster a sense of 'belonging' in STEM, as described by Dunkin[7]. As he states, it is especially important (and even more so for students underrepresented in STEM) to "get to a special place of productive not knowing and learn to be comfortable there" – it is this which allows for the creation of scholarship and new knowledge. Dunkin's description of this space (a place of creation of new knowledge and understanding) as a space which is "often uncomfortable, unstructured, and surprising; and the length of your stay there may be undefined. It is also the place where unique background, experiences, and creative insights of an individual have an opportunity to shine..." leads us to the basis for design of a safe space for learning, one which fosters STEM student identity and self-efficacy.

The i-STEAM project proposes to practically address this challenge by creating and piloting a series of online faculty development learning modules that employ gamification. It will help STEM faculty draw on knowledge-making and communicative practices of diverse cultures to enhance the design and implementation of courses, assignments, and assessments. Employing rhetorical practices of North American feminist invitational rhetoric, justice rhetoric of ancient South Asia, and African discourse traditions of fairness, the modules are designed to expose and address the pitfalls of mainstream persuasive rhetorical practices, which tend to be exclusionary or hierarchical. Participants will make their courses, teaching, and assessments more inclusive by drawing on diverse approaches to learning. Following the pilot, the course will be given a Creative Commons license so that it may be used by any SUNY instructor. Facilitators and participants will also share experience with SUNY faculty to mark the program's second phase.

B. Phase two workshop motivation

The first version of the iSTEAM (faculty training for inclusive STEM education drawing on concepts of arts/humanities) workshop was founded on the concept of introducing methods to build more inclusive classroom environments, syllabi, lectures and assignments based on integration of a more inclusive form of rhetoric[8]. The initial program included (a) four video discussions with outside experts on course design and assessment, focused on enhancing inclusivity in STEM; (b) selected readings; and (c) collaborative faculty development activities, including a game designed and tested to illustrate an inclusive approach to problem-solving. Our initial cohort of 14 faculty/instructors, associated with engineering departments, the medical school, and physical sciences programs) reported a very high level of satisfaction and acquired value from the readings, video discussions, synchronous discussions and activities, with specifically

mentioned in feedback on the program the value of having a group of workshop leaders and participants representing a wide range of STEM disciplines.

The second stage has integrated AI-focused content into the faculty workshop activities. The need for this inclusion is well supported. With dramatic developments in information technologies, the latest being artificial intelligence (AI), the global knowledge economy is increasingly dominated by Western epistemologies; this economy is further curated in the interest of dominant social groups within the West itself. Unsurprisingly, locally and globally, AI tools are aggravating systemic lack of diversity, equity, inclusion, and social justice[9,10], more so than STEM fields did in the past[11]. AI training data excludes vast bodies of knowledge of most cultures around the world, as well as knowledge beyond the Internet; their algorithms similarly exclude non-traditional patterns of thought and discourse. Without highly informed instruction, the use of AI is likely to undermine what achievements universities have made in inclusive STEM education: the appearance of objectivity and universality, now reinforced by powerful black boxes, is making it harder to achieve DEI goals. Similarly, to transcend patriarchal discourse norms of competition, conflict, and conversion, or to break the bounds of provincial and colonial narratives that are based on a construct of a Greco- Roman- Anglo- American lineage[12], science educators must work against the grain of the emerging AI landscape.

A primary motivation behind the development of the current AI-focused activities is a result of the question: what happens if all the human work of pushing the boundaries of scientific knowledge and methods, and of making science more inclusive and just, is displaced by increasingly machine-based science? How could STEM educators instead use AI tools to critically question often-counterproductive framings of scientific method and inquiry? How could we help STEM faculty meet SUNY's DEIJ goals in the face of the new technological advancement/disruption, as our institutions also increasingly depend on contingent faculty and there is a dire need for faculty development support. How could we foster exchange of experience among STEM faculty across SUNY institutions, creating and sharing OER resources?

As a result, our project responds to two urgent calls at the intersection of science education and the influence of AI on higher education at large. First, the faculty training designed will help STEM instructors across SUNY explore ways to teach with AI tools toward greater knowledge about its potential to support STEM education–while also exploring its pitfalls such as inaccuracy, context-blindness, harmful content (generation), and "knowledge drift" due to AI recycling its own content. We call this first dimension "critical AI literacy for effective STEM education." Second, we will support participating faculty to enhance diversity, equity, and inclusion (DEI) by recognizing and mitigating potential harms of AI-integrated science to DEI goals in science education and careers. We call this dimension "AI-assisted inclusive STEM education." Scaling up our 2023-24 project, we developed and shared video discussions, online games, readings, and teaching/learning activities in this project's first iteration: the updated project foregrounds both AI and OER as we scale up the training across SUNY.

Addressing the pitfalls of traditional bivalent/binary nature of dialog, which AI developers admit as the de facto mode of discourse they too want to transcend[13], we built the foundations of this training upon four I's: invitational, inquiry-based, inclusive, and innovative approaches in education. The **invitational** approach to classroom instruction is based on the foundations of feminist rhetoric and discourse**Error! Bookmark not defined.**, which builds upon notions of individual self worth, equality, and self-determination. We also translate powerful ideas from other traditions such as the justice-driven deliberation methods of ancient South Asia and African discourse traditions of fairness. Embracing playful and collaborative learning, it helps faculty use **inclusive** approaches, enabling students to learn from different knowledge systems and apply knowledge in their own diverse lifeworlds. It uses **inquiry-based** teaching that seeks out divergent and creative thinking[14]. Finally, it uses **innovation** as the fourth leg of our methodology, defining it not as simple novelty but creativity with purpose, connecting purpose with diversity and equity, inclusion and justice that help to make the world a better place for all. The use of AI to enhance DEI outcomes requires critical and ethical questioning, even as we seek to harness its vast and emerging potential.

II. Workshop design, objectives and assessment:

Following the general structure of the first generation of the iSTEAM program, each module of the online four-module faculty development training contains a set of read-watch-do tasks, including AI-integrated and gamified activities that participants complete before they come for the weekly collaborative workshop. The primary gamified aspect of the workshop involves inviting participants to learn about and play a student-developed interactive games, "It Takes a Village", a collaborative game designed to underscore the importance of collective effort, resource management, and sustainability within a simulated community context. This game and its reception by participants is discussed in detail in a separate presentation and paper at this conference.

These modules can be summarized as:

- **Module 1 (Orientation – concepts and approach):** Through foundational readings, discussions, and AI-integrated gamified collaborative activities, participants get to know each other while exploring theories and principles behind course and play the "It Takes a Village" game and reflect on its experience. The key readings for this module include "Does STEM stand out? Examining racial/ethnic gaps in persistence across secondary fields" by Riegle-Crumb, et al.[15] as well as several articles from recent periodicals and news sites.
- **Module 2**: **Reviewing and updating a course syllabus**: Exploring AI tools' limitations against and potential for helping expansion of the scope of their discipline's scope, methods, and premises, participants update an existing course by interrogating the sociocultural bases of their discipline,

drawing upon more diverse knowledge and perspectives, and seeking to help students apply science for more diverse communities. Readings include "Promoting equity and inclusion in STEM curriculum design", by Fuji, et al.[16], "Beyond the boundaries: The epistemological significance of differing cultural perspectives" by Balin and Battersby[17], and "The cyclical ethical effects of using artificial intelligence in education" by Dieterle, et al[18].

- **Module 3**: **Updating assignment design and assessment plan**: Participants reflect on and challenge dominant assumptions and norms in learning and assessment. Developing critical-thinking strategies for students' use of AI tools, they revise assignments and assessment plans. Readings include "Is Your Math Course Racist?", an opinion piece by Jose A. Bowen published online at Inside Higher Ed, as well as several websites offering guidelines for creating inclusive assessments for different universities.
- **Module 4: Updating instruction and student engagement strategies**: Contrasting with traditional dialogic/agonistic framing that AI tools use as default, participants apply invitational, inquiry-based, inclusive, and innovative teaching/learning strategies to their teaching practice and for mentoring and engaging students. Readings include Foss and griffin's article mentioned previously, as well as "Invitational Pedagogy" by Teboho Pitso[19].

We focused our efforts on three learning outcomes:

- To support 40-50 STEM faculty members from across SUNY institutions to revise/revamp their course syllabi, assignments, and instructional strategies toward more inclusive approaches and equitable outcomes by interrogating the scope and methods of scientific knowledge represented in their course contents, learning/teaching, and assessment, as well as by leveraging the potentials of AI tools toward those outcomes.
- To help participants explore pedagogical literature on inclusive STEM education and instruction, including scholarship showing how to draw on diverse knowledge traditions and discourse practices for achieving inclusive educational outcomes, as well as literature showing how to critically interrogate AI systems' approach to knowledge, discourse, and application of science in real-world contexts.
- To leverage AI tools and collaborative, gamified learning for fostering inclusive STEM education, helping participating faculty members prepare their students for careers/professions where the students can mobilize emerging AI technologies for inclusive and equitable processes and outcomes while avoiding their potential harms.

We also assign last year's graduates as mentors to small groups for support during the week, as learners are motivated by testing out new ideas as they co-construct knowledge in a community[20]. We will wrap up the program in spring by cascading the impact, having the new cohort share experiences and resources with

a large group of STEM faculty from across SUNY in a workshop in Spring of 2025.

Our assessment process includes:

Program Objectives	**Output Indicators**	**Outcome Indicators**	**Data Sources**	**Evaluation Activities**
1. Co-PIs will: Create and share resources for training STEM faculty, integrating AI-based strategies	Course and materials for Fall 2024 workshops shared in Brightspace	Materials shared on Brightspace, including game, readings, handouts, videos, teaching tips	Self-evaluation of course site by team; testing of gamified activities	Assessment of training materials at end of summer 2024
2. Participants will: Interrogate sociocultural basis of curriculum and pedagogy, including by exploring relevant pedagogical literature and using/interrogating AI	Updated syllabus, assignment, assessment plans from the 50 participants	Materials submitted by 50 participants to facilitators at the end of Fall 2024	Collected syllabi and assessment plans	Identification of key changes in courses; Tabulated Spring 2025
3. Participants will: Revamp a course and teaching approaches by integrating and interrogating AI with a view to effecting greater inclusion in STEM education and in students' STEM careers	Increased engagement of students in the classroom via new discourse approaches (including by using AI tools)	Participants' reflection and notes from class; Numbers and majors of students impacted	Reflections, presentations at Spring symposium, Survey of program impact	Collection of survey data; report summary on impacts (end of Spring 2025)

4. Co-PIs will: Communicate experiences and outcomes with a larger SUNY audience	Presentation materials; Materials posted on Brightspace; Submission of resources to OER repertoire	Number of faculty from other SUNY institutions expressing interest	Feedback forms on project website or via Brightspace course site; Feedback and interest reported from web site	Ongoing collection of feedback from communications in Spring 2025
6. Co-PIs will: Communicate concepts, outcomes, and resources beyond SUNY	Presentation at CIT and American Society for Engineering Education conferences	Online posting of presentations at CIT conference publication in ASEE proceedings	Recorded presentation, posted and available; proceedings availability	Review of presentation availability and publication, including data on access and citations
7. Co-PIs will: use an exit survey and interview a sampling of participants about program effectiveness	Assessment of the response to be included in the program report (and for future iteration of the training)	Participant feedback section in the project report and in resources for future training	Exit survey and interview summaries	Analysis and discussion of results (among PIs and in writing)

III. Results:

In all, 38 new participants completed the expanded workshop. They represented 12 different institutions, including Stony Brook University, Alfred State College, Buffalo State College, SUNY Downstate, Hudson Valley Community College, the University at Buffalo, Binghamton University, Adirondack Community College, Jamestown Community College, SUNY Oswego, SUNY Fredonia, and Farmingdale State College, and many STEM departments (including Mechanical Engineering, Biomedical Engineering, Civil Engineering, Environmental Engineering, Industrial and Systems Engineering, Computer Science, Health Sciences, Biology, Physics, Chemistry, Technology Education, Psychology and Sociology) and all levels of faculty and professional service. The impact of the project will extend to over one thousand undergraduate students enrolled in

courses taught by participants. Four of the faculty participants from the first phase of the project returned as mentors to the group.

The iSTEAM 2.0 project integrated artificial intelligence (AI) to promote inclusive and equitable STEM education across the SUNY system. Understanding AI's transformative potential and challenges, the program emphasized fostering "critical AI literacy" among STEM educators. Participants explored the capabilities and limitations of AI tools in teaching, learning, and assessment while confronting the systemic biases these technologies can perpetuate. The program provides educators with the tools to thoughtfully evaluate AI's influence on STEM education and incorporate DEI perspectives, allowing for meaningful enhancements to their curricula. Throughout the program, participants engaged in dynamic breakout discussions that united perspectives from various SUNY campuses and curricula. These collaborative sessions facilitated a vibrant exchange of ideas, allowing educators to share unique challenges encountered in their courses and offer constructive feedback. A key focus of these discussions was addressing the biases within AI tools and emphasizing the importance of vigilance when using AI-generated content. By exploring real-world examples, participants understood how biases can manifest, potentially undermining efforts toward inclusivity and equity in STEM education. These conversations empowered educators to take a more critical, informed approach to AI integration, ensuring its application supports equitable and inclusive teaching practices.

Overall, survey responses indicated unanimous agreement that the workshop components were valuable, and all participants reported that they are using the lessons learned and workshop activities to redesign syllabi, courses and assessment, and integrate more inclusive learning strategies into their courses. The participants contributed to an online database, summarizing changes made as a result of workshop participation, to enhance inclusivity in their STEM coursework. The pedagogical nature of interventions included:

- **Active learning and engagement** – for example, building on the concept of invitational discussion through collaborative problem solving, “think-pair-share” type discussions, and organizing classroom environments to foster shared concepts and learning.
- **Integrating inclusive and diverse perspectives into course materials** – for example, accomplished through educational content update, student re-interpretation of problems and texts from expanded and diverse perspectives, debate on problems assuming the role of different stakeholder groups, and exploration of the cultural aspects of the science topic under study.
- **Student-centered and personalized learning** – for example, asking students to understand each other’s viewpoints and arguments, using relatable problems in class, use of role playing, and using assignments that build upon students’ own interest.
- **Integrating more collaborative and group work** – for example, exploring mentored collaborative exercises which recognize contributions

form all students, “jigsaw” exercises (in which students work in a group to become “experts” on one particular problem, following which groups are redistributed and a student teaches their problem and solution to other students), weekly online group discussion on real-world problems, and pairing or grouping of students of similar/dissimilar majors and interests.

- **Reflective and critical thinking** -- for example, asking students to consider two or more sides in arguments, fostering invitational discussion, use of cause-driven projects which encourage critical thought, and consideration of a future problem and how course materials might be used to solve that problem in an inclusive fashion.

Based on this feedback, the most common educational interventions used to create a more inclusive learning experience, as reported by participants, include revision of syllabus (to make more invitational), rebranding of “office” hours as “student” hours, increasing diversity of images and names in course lecture materials, increasing diversity (gender, race, origin, nationality) in choices of reading assignments, encouraging participation through soliciting questions and by giving extroverted and introverted students equal opportunities to participate, incorporating diverse and inclusive perspectives via integration of cultural aspects of assignments or questions and exploring different experiences of the same issue, and using technology to foster inclusivity – for example by creating an inclusive introductory video, ensuring accessibility through closed captioning and providing transcripts of lectures, and by using collaborative software such as Google Docs to create dynamic conversations around written responses.

An important lesson learned during the program was the need for structured examples of AI usage tailored to participants' content needs. While early experiments with sample prompts encouraged engagement, they also highlighted the variability of AI-generated outputs compared to expected results. Participants desired more concrete demonstrations of practical AI applications in STEM education.

For future iterations of the program, developing structured examples of AI applications similar to those presented in recent scholarly work[21] would enhance participants' ability to adapt and evaluate AI tools for their teaching. These structured examples help bridge the gap between theoretical discussions and practical applications, providing clearer pathways for incorporating AI in ways that align with educational goals and principles of diversity and inclusion.

IV. Conclusions:

Our first iteration of the iSTEAM project quite effectively informed the design and practice of inclusive STEM teaching by integrating rhetorical/discourse strategies from beyond the dominant agonistic/conflictual framing. In addition to this, the expanded workshop also has successfully explored AI tools for their potential to transcend the dominant framing, which minority scholars have viewed as characterizing dominant Euro-American, colonial, and patriarchal practices. As

a result, 38 STEM faculty from across SUNY have gained valuable insight to fundamentally rethink, redesign, and more effectively teach diverse students. The contributors have shared a wide range of pedagogical methods aimed at enhancing inclusivity and engagement in STEM education. The document, shared via OER resources, emphasizes the importance of creating a welcoming and supportive learning environment that recognizes and values the diverse backgrounds and experiences of all students. Overall, the document provides a comprehensive collection of strategies and interventions that can be utilized to create a more inclusive and effective STEM education experience.

We will share the training model and resources across our campuses and SUNY institutions through the OER portal. With campus support and collaboration with centers for excellence in learning and teaching at partner campuses, we will continue training faculty and sharing module materials. In addition, the upcoming spring 2025 symposium will engage an additional 100-200 SUNY STEM faculty.

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