Practicing mindful inclusion in STEM innovation

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Introduction

Innovation means the introduction of something new. Over the course of this century, globalization and digitization have made it possible to expand the definition to mean introduction of something new *for everyone*. Research has shed light on some pressing challenges that can turn into threats if left unaddressed – shallow understanding of complex problems, lack of diversity among innovators and embedded bias in emergent technologies. This guide on practicing mindful inclusion in STEM innovation discusses four concepts and their actionable best practices to ensure our innovations meet at the intersection of problems and social discourse.

1. Broadening the scope of STEM innovation

Definition

The disciplines encompassing Science, Technology, Engineering and Mathematics (STEM) are traditionally recognized as the biggest contributors of innovation. Some of the best and most unique innovations have solved problems in a multidisciplinary manner. Think of the first iPod launch by Steve Jobs, where he listed the criteria for how the revolutionary device should be designed (dimensions of a card deck that is designed to fit in our hands, battery life that can last a flight from the west coast to the east coast, etc.). These criteria could not have been learned in an engineering course in 2001.

Innovations such as the iPod are prime examples of how broadening focus within STEM fields can also broaden the range of problems that may be addressed and the creativity of solutions. Broadening the scope of STEM innovation means inclusivity, drawing on diverse perspectives and disciplines to tackle complex problems. Computational biology, actuarial science and user experience are relatively new fields that leverage thinking from multiple lenses to solve problems.

Research

Books, articles and scholarly research have long focused on the need to broaden the scope of STEM innovation. Some highlights include:

    a. **Limited diversity:** In a 2014 analysis, USA Today concluded that "top universities turn out Black and Hispanic computer science and computer engineering graduates at twice the rate that leading technology companies hire them."[1] A lack of representation in STEM fields hinders innovation by excluding valuable perspectives.

b. **Bias in hiring:** In January 2017, Bloomberg reported that although Facebook had started giving recruiters an incentive to bring in more women, Black and Latino engineering candidates back in 2015, the program was netting few new hires. According to former Facebook recruiters, this was because the people responsible for final hiring approvals — twenty to thirty senior leaders who were almost entirely white and Asian men — still assessed candidates by using the same metrics as always: whether they had gone to the right school, already worked at a top tech company, or had friends at Facebook who gave them a positive referral.[2]

Discussion

Benefits of broadening the scope of STEM innovation:

a. **Wider range of problems:** By incorporating diverse viewpoints, we can tackle a broader range of societal issues in unique ways, from climate change as a communication problem to social justice as an engineering problem. Such interdisciplinary collaborations foster innovation by combining knowledge and methodologies.

b. **Increased innovation:** Engaging a wider talent pool means unlocking the full potential of creativity. The user experience can be looked at from various viewpoints.

Undoubtedly, challenges in broadening the scope exist:

a. **Shifting mindsets:** Overcoming established norms within STEM institutions and funding structures can be a hurdle. It is crucial to consider the impacts of a multidisciplinary approach.

b. **Evaluation criteria:** Rethinking how we evaluate research and innovation projects to account for broader impacts beyond purely technical metrics is necessary.

Best practices

As an educational institute, we have the responsibility of disseminating mindful considerations of the value of broadening the scope of STEM innovation.

a. **Inclusive problem definition:** Beth Simone Noveck, professor at Northeastern University and director of the Governance Lab, in her book 'Solving Public Problems' explains that even more important than shared agency and teamwork is problem solving by beginning with problem definition, instead of handing students problems. Too often, such as in capstone projects, students are taught to solve well-structured problems

working from preexisting cases. By contrast, the Reach Alliance at the University of Toronto is an honors capstone, where students from medical engineering, public policy, management and biology form teams to address complex development challenges.[3] Let's strive to integrate social justice and its value into our education. Let's encourage our students to consider the societal impact of their work to ensure an inclusive world.

b. **Embracing the complexity:** As described in Noveck's book, problems of the kind tackled in Toronto's Reach program, such as eliminating malaria in Sri Lanka or addressing food insecurity in Ethiopia, are rarely well structured. As they do in Reach or in Fukuyama and Weinstein's Policy Engineering at Stanford, real innovators must discover the problem, not work on one already presented.[4]

2. Challenging stereotypes and reframing narratives

Definition

Lone genius scientist and tech-bro entrepreneur are stereotypes that continue to limit incoming innovators in STEM. Silicon Valley has long profited for a mysterious identity through titles such as "user experience unicorns," "rock star designers" or "ninja JavaScript developers."[5] By challenging these stereotypes and reframing narratives, we can promote representation and in turn, a more inclusive vision of who can excel in STEM. We have the power to dismantle limiting beliefs and broaden our innovation potential.

A culture where our current stereotypes and narratives thrive discourages students from underrepresented groups from pursuing STEM careers. We also thus stay away from a diverse workforce full of thoughts and experiences necessary for truly groundbreaking innovation. Interdisciplinary collaboration, open communication and inclusive practices can become the pillars of a holistic STEM education.

Research

Research showcases the threats of continued stereotypes and narratives in fostering an inclusive environment for budding STEM innovators:

a. **Imposter syndrome and stereotype threat:** Belonging is an essential concept to encourage participation in STEM. People belong when they experience psychological safety, an enhanced sense of trust and respect. Stereotypes about who can excel in STEM (lone genius scientist or tech-bro entrepreneur) can contribute to imposter syndrome as people don't feel the sense of belonging. This particularly trends in underrepresented groups.

b. **Expanding the innovation pipeline:** A wider range of voices in problem solving and innovative thinking leads to a richer pool of ideas and a more comprehensive understanding of complex problems. Steve Jobs was one of

three in Pixar's braintrust, where thought collaboration is common practice. The successful animation company has had 14 box office hits in a row and it is all because of their capacity of think together.[6]

Discussion

Challenging stereotypes and reframing narratives are advantageous for the following reasons:

a. **Increased diversity:** When we highlight diverse role models and showcase the contributions of underrepresented groups, we inspire participation in STEM. We have the medium to push deserving people from all occupations and it is more important than ever to leverage that.

b. **Socially relevant innovation:** By reframing narratives to emphasize the potential of STEM to address real-world problems, we can motivate individuals to pursue careers that have a positive societal impact. Thorough research on the problem definition can shed light on the relevance of solving it.

c. **Broadened problem-solving:** We must shift our focus to think beyond purely technical solutions. In doing so, we can encourage a more comprehensive approach to innovation, considering both the functionality and social implications of new technologies.

Challenges inevitably exist:

a. **Institutional bias:** Entrenched biases within academia, funding agencies and the tech industry are perpetuating stereotypical narratives.

b. **Shifting the Focus:** Moving away from narratives such as the "lone genius scientist" means acknowledging the collaborative nature of STEM innovation, which can be difficult in the multigenerational STEM workforce.

Best practices

We are in the forefront of reshaping narratives as we continue to challenge stereotypes through the promotion of inclusive excellence. On an individual level, we can do more:

a. **Highlight diverse role models:** It is nothing new – representation is one of the fundamentals of diversity, equity and inclusion. We can highlight the achievements of scientists, engineers and innovators through required readings by authors of multidisciplinary fields and diverse guest speakers. It is a small gesture to encourage belonging in classrooms.

b. **Support storytelling initiatives:** In a 2020 study, 47% of NYU faculty responded that op-ed writing is socially impactful.[7] Encouraging scientists, engineers and innovators to share their stories in classrooms, media

platforms and through public outreach can invite thoughtful conversations about crucial topics.

    c. **Rethink STEM education:** It is time we incorporate social justice and ethics into STEM education. Sheryl Sorby, the former head of the American Society for Engineering Education (ASEE), writes, "Personally, I think it is time that we take a long, critical look at our curricula to ensure that we are preparing our students for their unknown and perhaps unseeable future careers in the current century. To ensure that we are attracting and retaining a diverse pool of learners to our programs, we need to examine what we are teaching and how we are teaching it."[8]

    d. **Deconstruct gendered language:** Avoiding the use of gendered language such as "you guys," "mankind," "he/she," is one of the easiest steps to ensure everyone in our classrooms feels welcome and included.

3. Designing equitable technology solutions

Definition

Former Associate Dean of Diversity, Equity & Inclusion, Dr. Karen Thomas-Brown is not alone in experiencing the bias of automatic faucets in not detecting her skin tone. Laser hair removal technology has been designed for only some hair types for the longest time. And Alexa and Siri not being able to understand my Indian accent continues to be a setback.

Designing equitable technology solutions is more than a mere functionality improvement. We are talking about a paradigm shift, moving from a one-size-fits-all approach to creating solutions that are universally usable, inclusive and creating advantages for all communities. A user-centric approach means considering the diverse needs, experiences and contexts of people, ensuring technology empowers everyone to participate meaningfully in our constantly digital world.

Research

The importance and challenges of designing equitable technology solutions are in front of us:

    a. **The digital divide:** Studies show that a lack of access to technology and skills limits opportunities for certain groups of the population, adding to the existing social and economic inequalities. A 2020 study by the Center for Urban Innovation found that a lack of access to technology and digital skills is a major barrier to employment, particularly for low-income workers and workers of color.[9]

    b. **Benefits of equitable design:** Equitable design practices can help to identify and address gaps, inspire STEM innovators to lead the development of

solutions that benefit a broader range of users. When people feel that technology is designed for them and takes their needs into account, they are more likely to trust and use it. For example, technology designed to be accessible to people with disabilities can create new opportunities for participation in education and employment.

Discussion

Designing equitable technology solutions benefits us all:

a. **Increased accessibility:** Technology becomes usable for a wider range of people, regardless of ability, income level or location when it is designed to be usable for everyone.
b. **Reduced bias and discrimination:** Proactively well-researched design solutions minimize biased outcomes and promote happier user experiences with technology.
c. **Empowerment and inclusion:** Equitable technology empowers individuals and communities because it ensures that everyone has the opportunity to participate in the digital world.

Some challenges continue to threaten the change in status quo of technology:

a. **Identifying diverse needs:** Understanding the varied needs and contexts of different user groups is complex.
b. **Balancing functionality and inclusivity:** Designing for a broad range of users sometimes requires functionality trade-offs. In such cases, it is imperative to be values-driven to make equitable decisions.

Best practices

a. **User-centered design:** Involve diverse user groups throughout the design process, from idea to implementation. In doing so, we ensure user needs inform every stage of the solution development.
b. **Accessibility considerations:** Integrate accessibility features from the beginning, adhering to established guidelines like WCAG (Web Content Accessibility Guidelines).[10] Screen reader compatibility, closed captioning for videos and alternative text descriptions for images are good starting points.
c. **Inclusive design principles**: Employ inclusive design principles that consider factors such as age, ability, language and cultural background.
d. **Testing with diverse users:** User testing needs to be conducted with a representative sample of the target audience. In the process, usability issues and potential biases can be detected early in the development process.

e. **Iterative design:** Embrace an iterative design process by incorporating user feedback throughout problem solving to refine and improve the solution equitably and inclusively.

4. Promoting responsible AI development

Definition

With the increased use of Google AI overview, ChatGPT, Copilot, DALL-E and so many other AI-powered technologies, it is imperative to have built-in opportunities to flag. At the end of the day, they are *artificial* and bound to stir *real* consequences if not developed with societal and cultural contexts in mind.

Artificial Intelligence (AI) systems must be ethical, transparent, accountable and beneficial to society. Some important concepts include:

a. **Fairness:** Minimizing bias in AI algorithms and datasets to prevent discriminatory outcomes.
b. **Transparency and explainability:** Making the decision-making processes of AI systems clear and understandable.
c. **Privacy and security:** Protecting user data and ensuring the security of AI systems.
d. **Human control and oversight:** Humans maintaining ultimate control over AI systems and their deployment.
e. **Societal impact assessment:** Considering the potential social and ethical implications of AI technologies.

Research

Some highlights of the importance and challenges of responsible AI development are:

a. **Algorithmic bias:** Studies reveal that AI systems can perpetuate societal biases present in their training data, leading to discriminatory outcomes in areas like loan approvals or facial recognition. Dr. Joy Buolamwini introduced us to the term "coded gaze," which is the evidence that discrimination and exclusion have unfortunately been encoded in our tech products.[12]
b. **Explainability challenges:** Understanding how complex AI models arrive at their decisions remains a challenge, hindering accountability.
c. **Benefits of responsible AI:** Research suggests that responsible AI development fosters trust and public acceptance of AI technologies, leading to wider adoption and positive societal impact. According to Dr. Buolamwini, "the first step to addressing a problem is acknowledging it exists." Thus, hopes such as the AI Bill of Rights and the EU AI Act remind us that a good community collaboration means we can all benefit.[13]

Discussion

Promoting responsible AI development offers significant advantages:

a. **Reduced bias and discrimination:** Mitigating bias in AI can ensure fairer and more equitable outcomes for all.
b. **Increased trust and transparency:** Understanding how AI systems work fosters public trust and acceptance.
c. **Mitigated risks:** Addressing ethical concerns surrounding AI minimizes potential negative societal impacts.

However, challenges persist:

a. **Balancing efficiency and explainability:** Designing highly explainable AI can sometimes affect efficiency.
b. **Global collaboration:** Ensuring responsible AI development requires international cooperation and coordinated efforts.

Best practices

a. **Data collection and curation:** Proactively address bias throughout the AI lifecycle. This begins with collecting diverse datasets that represent the intended population for the AI system.
b. **Algorithmic transparency and explainability:** Develop AI models with built-in mechanisms that explain their decision-making processes. Additionally, investing in research on Explainable AI (XAI) can help to develop more transparent and trustworthy AI systems.
c. **Human oversight and control:** Maintain human oversight throughout the AI development process, from design and training to deployment and monitoring. Humans should be responsible for making final decisions and ensuring that AI systems are used appropriately.
d. **Impact assessments:** Conduct thorough societal impact assessments before deploying AI systems. These assessments should consider the potential social, economic and environmental impacts of AI systems both positive and negative. By anticipating potential risks, developers and policymakers can take steps to mitigate them.
e. **Public education and awareness:** Educate the public about AI and the importance of responsible development. This can help to raise awareness of the potential benefits and risks of AI and foster public trust in AI technologies. Educational initiatives can target both the public and policymakers.
f. **Collaboration:** Foster collaboration between researchers, developers, policymakers and the public on responsible AI development standards and best practices. By working together, these stakeholders can develop a

comprehensive framework for responsible AI development that considers the ethical, legal and social implications of AI technologies.

Conclusion

Imagine a world where innovations are celebrated because of their far-reaching impact, unbiased approaches and novel narrative-shaping. We have the power to make this vision into a reality. We have the power to ensure our groundbreaking solutions reflect the richness of our creativity. We have the power to unlock the full potential of innovation. All it takes is an active commitment to diversity, equity & inclusion.

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