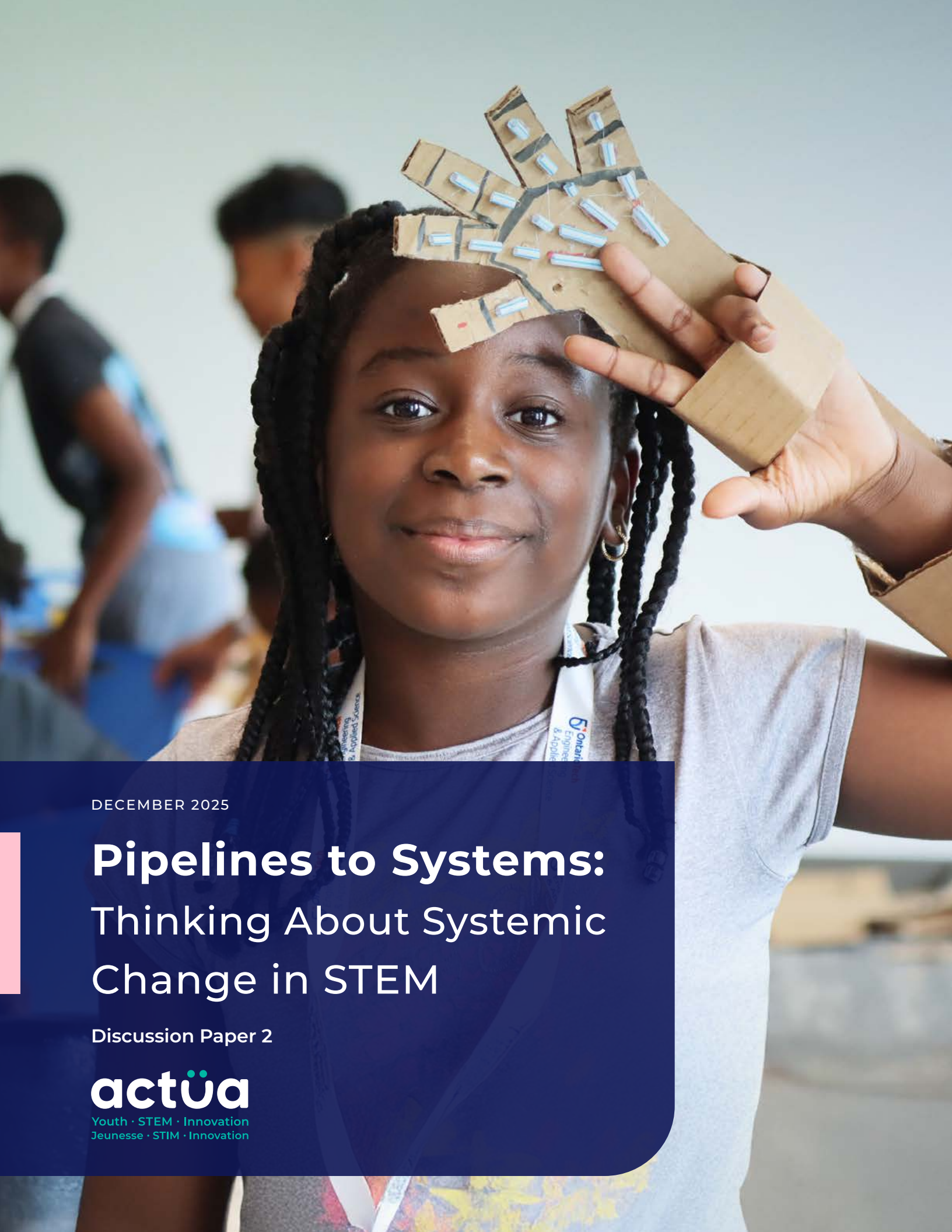

DECEMBER 2025

Pipelines to Systems:
Thinking About Systemic Change in STEM

Discussion Paper 2

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Actua Asks: What is Systemic Change in STEM?

Actua is creating a Canada where every child has the skills and confidence they need to achieve their full potential. As a leading science, technology, engineering and mathematics (STEM) outreach organization, Actua includes over 40 universities and colleges, engaging 500,000 youth in 600 communities each year. For 25 years, Actua has focused on identifying and removing the barriers for entry into STEM and now has national programs dedicated to engaging Indigenous youth, girls and young women, Black youth, those facing economic barriers and youth in Northern and remote communities.

Our mission is to unlock the infinite potential of youth while relentlessly removing barriers to STEM, and we recognize that many of those barriers are systemic. To achieve meaningful systemic change in STEM, we need a clearer understanding of what it is, why it matters and how it can be supported. This paper contributes to that understanding by exploring different definitions of systemic change, examining the role of STEM outreach in advancing it, considering how strategies can be developed and progress measured, and raising key insights to guide future dialogue.

Introduction: From Pipelines to Systems

Decades of efforts to ensure that people who have been excluded from STEM have the skills, knowledge and confidence to succeed have generated some improvements in equity, diversity and inclusion (EDI).[1] Yet, countless skilled, talented and motivated people continue to be left on the sidelines. And many who are engaged in science education and careers often feel disempowered, devalued and marginalized in their roles. What prevents the science ecosystem from making additional progress?

Organizations working to improve EDI are increasingly recognizing that systems are getting in the way. Even when people who work in and manage STEM institutions have good intentions to advance EDI, underlying structures and systems can undermine their efforts and perpetuate injustice.[2] What science and STEM ecosystems need is *systemic change* - that is, efforts that focus as much on reshaping the systems in which people live, learn and work as they do on *equipping individuals* with skills, knowledge and confidence to succeed within those systems. Systemic change aims to bend systems to serve people rather than bending people to fit into outdated, ineffective and unjust systems.

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[1] This discussion paper was prepared by Daniel Munro, Director of Research and Innovation at Actua. For constructive reactions and discussions, we thank Doug Dokis, Jennifer Flanagan, Virginia Hall, Val Iannitti, Tracy Ross and Bissy Waariyo.

[2] The late feminist philosopher, Iris Marion Young, articulated a compelling account of "structural injustice" whereby systems and structures themselves can generate unjust outcomes even if no individual agents working in or interacting with those systems or structures has any intention of behaving unjustly. I.M. Young (2011) *Responsibility for Justice* (Oxford University Press).

But what does that mean in practice? What is a system, exactly? What is systemic change? And how can organizations pursue systemic change to advance equity, diversity, inclusion and empowerment for historically excluded groups in STEM?

> Systemic change aims to ***bend systems to serve people*** rather than bending people to fit into outdated, ineffective and unjust systems.

DISCUSSION PAPER PURPOSE

Canada can do more to achieve systemic change in STEM and our science culture more broadly, but we need a clearer understanding of exactly what systemic change is, why it matters, and what can be done to pursue and support it. This discussion paper contributes to these goals by:

- identifying and synthesizing different understandings of systemic change;
- gathering insights on how STEM outreach can contribute to systemic change;
- examining how strategies can be developed and progress measured; and
- articulating key questions and issues for broader discussion.

REIMAGINING SCIENCE CULTURE IN CANADA

The current paper is the second contribution to our efforts to rethink and reimagine science culture. It complements our first paper that explores and prompts discussion on how to define and think about science culture, and precedes our third paper that examines ways of measuring science culture and systemic change to advance EDI, empowerment and excellence in STEM.

- Paper 1: Reimagining Science Culture in Canada
- Paper 2: From Pipelines to Systems: Thinking About Systemic Change
- Paper 3: Measuring Science Culture in Canada

The first two papers extend how we think about science culture and systemic change, while the third explores practical ways to measure both and offers a rough assessment of how Canada is doing.

Why Science Culture Matters

Why think about systemic change at all? Why not simply continue to address the skills, knowledge, and confidence gaps that individuals face and that shape and constrain their opportunities to pursue STEM education and careers?

Gap filling strategies are essential, but are not enough to improve inclusion and empowerment. Structural barriers exist for many groups that cannot be overcome simply by further upskilling the people facing those barriers. For example:

- Women in Canada hold 34 percent of STEM degrees but represent only 23 percent of the STEM workforce, and earn an average of $20,000 less annually than male counterparts in technology jobs.[3]

- While the proportion of undergraduate Black women enrolled in STEM (20 percent) closely matches that of the undergraduate population of all women (19 percent), undergraduate Black men are less likely than all undergraduate men to be enrolled in STEM (32 versus 37 percent).[4] At the same time, Black Canadians are a little less likely to be enrolled in postsecondary education than the overall population (25 versus 28 percent among those aged 15 to 24) and less likely to be enrolled in a university degree program (14 versus 17 percent).[5]

Gap filling strategies are essential, ***but are not enough to improve inclusion and empowerment.*** Structural barriers exist for many groups that cannot be overcome simply by further upskilling the people facing those barriers.

- Indigenous people in Canada are less likely than the non-Indigenous population to have attained a postsecondary qualification (49 versus 68 percent), although this varies significantly among Indigenous people in or near urban centres (55 percent), remote (43 percent) or very remote locations (27 percent).[6] Among those in technology careers, Indigenous tech workers earn on average $14,000 less annually than non-Indigenous tech workers.[7]

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[3] D. Maclatchey and S. Ghose (2024). *Achieving equity in STEM benefits us all.* https://www.wlu.ca/about/governance/senior-leadership/president/news/2024/winter/international-day-for-women-and-girls-in-science.html; A. Lockhart and V. Vu (2024). *Canada's Got Tech Talent: Diversity of Canada's Tech Workers* (Toronto: DAIS) https://dais.ca/reports/canadas-got-tech-talent-chapter-2/

[4] T. Handler, et al. (2024). *Pathways of Black, Latin American and other population groups in bachelor's degree programs* (Ottawa: Statistics Canada). https://www150.statcan.gc.ca/n1/pub/36-28-0001/2024005/article/00003-eng.htm; Statistics Canada, Table 37-10-0184-01 (author calculations).

[5] Statistics Canada Tables 37-10-0268-01 and 98-10-0351-01 (author calculations).

[6] A. Melvin (2022) *Postsecondary educational attainment and labour market outcomes among Indigenous peoples in Canada, findings from the 2021 Census* (Statistics Canada). https://www150.statcan.gc.ca/n1/pub/75-006-x/2023001/article/00012-eng.htm

[7] A. Usher (2022). *A First Look at 2021 Education Census Data.* https://higheredstrategy.com/a-first-look-at-2021-education-census-data/; Lockhart and Vu (2024).

Gaps in STEM participation and achievement are also experienced by people from rural and remote communities, lower-income families, the LGBTQ2S+ community, people with disabilities, and others – and vary across intersecting identities as well. Preparing individuals for STEM pathways by raising awareness, spurring interest, and developing skills, knowledge and confidence helps close some of the gaps. But more is needed. Too often, talented and motivated individuals from underrepresented groups are blocked from participating in - or actively pushed out of - STEM education and careers.

To achieve real change, we need to focus as much attention on ***reshaping the systems*** in which people live, learn and work as we do on ***equipping individuals*** to succeed. At a minimum, this includes addressing barriers and actively recruiting, welcoming and supporting people from underrepresented groups. Additionally, we need to think about what science is and who science is for. If we want a science ecosystem that empowers all people to participate effectively, to shape scientific priorities and direction, and to benefit equitably, we need to pursue systemic change.

What Is Systemic Change?

What is systemic change, exactly?

Start with systems. *Systems* are arrangements of people, policies, practices, resources and norms that interact internally and with external actors and other systems to achieve outcomes, whether intended or unintended. Taking a closer look, and using healthcare systems to illustrate:

> ***Systems are complex ecosystems*** of actors, institutions, resources, norms and behaviours ***that interact to produce or reproduce patterns***, whether intentionally or unintentionally.

- Systems have many ***parts*** that ***interact*** in complex and often hidden ways to achieve ***outcomes***.
    - A healthcare system, for example, is composed of medical professionals, administrators, policies, schedules, funding, admissions practices, technologies, institutional types, hierarchies, power dynamics and unwritten norms – all of which aim either directly or indirectly to restore, maintain or improve health.
- Systems ***overlap*** and ***interact with other actors and systems***.
    - Healthcare systems interact with governments, the economy, social and cultural norms, unions, neighbourhoods, transportation systems, and other systems and actors.[8] An otherwise well-functioning hospital might have its aims undermined, for example, by taxation systems that underfund it and/or unreliable transportation systems that make it difficult for patients to get to appointments on time.

[8] Women and Gender Equality Canada (2024). *Glossary*. https://www.canada.ca/en/women-gender-equality/funding/funding-programs/continuous-intake/glossary.html#system

- Systems' ***outcomes do not always line up with intended aims***.
    - Healthcare systems generally aim to help maintain the health of all people, but sometimes end up reinforcing existing health inequities by providing differential care that tracks gender, race, class and other demographic identities.[9]
- Some systems have ***questionable aims***.
    - Some private healthcare institutions, for example, while ostensibly focused on patient health also (perhaps even primarily) aim to generate profits. Success in generating profits may conflict with excellence and equity in healthcare and contribute to reproducing health inequalities.

The point is that systems are **complex** ecosystems of actors, institutions, resources, norms and behaviours that **interact** to produce or reproduce **patterns**, whether intentionally or unintentionally. In some cases the patterns or outcomes are positive – such as when they reinforce good citizenship, social and economic well-being, high-quality and equitable healthcare, creativity, food security, and other goods. In other cases – intentionally or unintentionally – the patterns or outcomes reinforce exclusion and inequality that tracks gender, race, sexual orientation, (dis)ability, socio-economic status and other identities and their intersections. In those cases, we need to change the system.

SYSTEMIC CHANGE

What does it mean to change a system? What is systemic change? Organizations working across a variety of fields and sectors have adopted language and practices of systemic change. While they vary, there are some shared features. Systemic change focuses on:

> ***Systemic change takes the burden of achieving social justice off the shoulders of the marginalized*** and places it on those with the resources, power and opportunity to alter unjust systems.

- ***System deficits* over individual deficits.** There is much we can do to equip individuals with the skills, knowledge and behaviours they need to survive and thrive in existing systems. But until we address *structural* injustices, many high potential individuals will continue to be pushed aside. *Systemic* change takes the burden of achieving social justice off the shoulders of the marginalized and places it on those with the resources, power and opportunity to alter unjust systems.

[9] J. Posselt, K. Baxter and W. Tang (2021). *Assessing the Landscape for Diversity, Equity and Inclusions Efforts in U.S. STEM Graduate Education: A Systematic Literature Review* (Sloan Foundation). https://sloan.org/storage/app/media/files/STEM_Higher_Ed/USC-Rossier-DEI-literature-review.pdf

- ***Causes* of exclusion and inequality rather than symptoms.** Many well-intentioned change efforts look at gaps in participation and achievement in STEM and develop initiatives that aim to close those gaps. Systemic change asks *why the gaps exist* in the first place and what is needed to remove or address the causes.

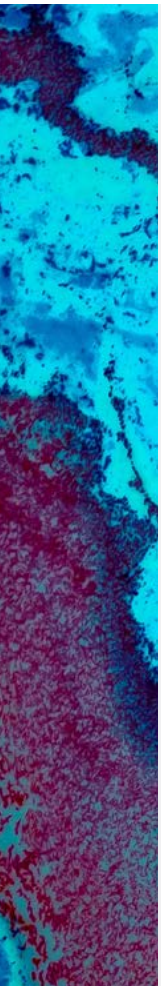
- ***Holistic approaches* to analysis and action.** Systemic change looks at how a system interacts with other factors and systems. The success of an otherwise inclusive and accessible STEM program, for example, might be hindered by non-STEM system factors like poor transportation or food insecurity that disproportionately affect some participants.

- **Ensuring *aims align with justice*.** Systems have aims. They are sometimes explicit, sometimes implicit; sometimes positive, sometimes negative or questionable. Systemic change identifies and critically assesses whether a system's aims are worth pursuing. In some cases, change requires reorienting aims to align with values. In other cases, change requires dismantling a system because it exists only to achieve unjust aims.

PROVISIONAL DEFINITION FOR DISCUSSION

Systemic Change to achieve equity, diversity and inclusion in STEM involves transforming the institutions, policies, practices, resources and norms that exclude and marginalize people who have, or want to develop, the interest, skills and knowledge to participate in STEM.

Systemic change focuses on reshaping systems to serve people rather than reshaping people to fit into unjust systems.



SYSTEMIC CHANGE: SCAN OF DEFINITIONS

- "Systems change captures the idea of addressing the causes, rather than the symptoms, of a societal issue by taking a holistic (or 'systemic') view. Systemic change is generally understood to require adjustments or transformations in the policies, practices, power dynamics, social norms or mindsets that underlie the societal issue at stake. It often involves the collaboration of a diverse set of players…rooted in shared goals to achieve lasting improvement to solve social problems at a local, national or global level."[10] (*Catalyst 2030*)
- "Systemic change refers to changing one or more elements within a system. The objective of the change is to allow women and girls to fully take part in the economic, social, democratic, and political life of Canada."[11] (*Women and Gender Equality Canada*)
- "Systems change is about reshaping the complex web of factors—policies, practices, resources, relationships, and power dynamics—that perpetuate disparities in STEM fields. It's a strategic approach to foster long-lasting equity and ensure that STEM opportunities are accessible, inviting, and supportive for everyone, especially those who have been historically marginalized."[12] (*WestEd*)
- "All systems organize individual pieces into some sort of interrelated whole. Put simply, systemic change occurs when change reaches all or most parts of a system, thus affecting the general behavior of the entire system. However, systemic change is often difficult to envision, let alone encourage, because people generally find it easier to focus on the parts than on the systems that connect those pieces."[13] (*Accelerating Systemic Change Network*)

LEVELS OF SYSTEMIC CHANGE

In Canada's science ecosystem, we might think of four levels of systemic change efforts that aim to achieve equity, diversity and inclusion.[14] These move from more *individual-focused initiatives* to ensure that historically excluded people have the skills and resources they need to participate, to more *transformational initiatives* focused on the structures, practices and norms that perpetuate exclusion and reinforce inequity. While action at all levels is important for achieving equity, diversity and inclusion, the higher levels (i.e., 2-4) are arguably more aligned with the idea of *systemic*, as opposed to *individual* change.

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[10] Catalyst 2030 (2021). *New allies How governments can unlock the potential of social entrepreneurs for the common good* https://catalyst2030.net/resources/new-allies-report/

[11] WAGE (2024). *Systemic Change Tip Sheet.* https://www.canada.ca/en/women-gender-equality/funding/funding-programs/womens-program-general-eligibility-requirements.html#toc2

[12] WestED. *Systems Change and Equity in STEM*. https://www.wested.org/blog/systems-change-and-equity-in-stem/ Note: The URL is no longer active due to ongoing efforts in the U.S. to erase equity, diversity and inclusion from government-funded sites.

[13] Accelerating Systemic Change Network (2020). *Where do I start with change?* https://ascnhighered.org/ASCN/start_change.html

[14] The tiered approach is adapted from Catalyst 2030's framework which envisions three levels of change – *individual* (i.e., individual skills and knowledge to succeed), *structural* (systems that prioritize and organize better arrangements for society), and *transformational* (shifting broader societal norms and values to support better outcomes, whether social or economic). Catalyst 2030 (2021)

LEVEL	ORIENTATION	EXAMPLES
I **Supporting Individual Development & Resilience**	Ensuring individuals - especially from marginalized communities - have opportunities to develop interest, confidence, skills and knowledge for STEM pathways.	• STEM education in schools, with an emphasis on improving STEM awareness, interest, confidence and skills among marginalized youth. • STEM workshops, clubs and camps with an emphasis on improving STEM awareness, interest, confidence and skills among marginalized youth.
II **Addressing Barriers**	Identifying and removing barriers to STEM pathways, including barriers posed by related, but non-STEM, systems.	• Lowering/eliminating program fees for some participants. • Bringing STEM directly to communities rather than expecting participants to find STEM experiences. • Ensuring programs have instructors and curricula that reflect participants' experience. • Providing additional resources where helpful - e.g., mentorship, transportation assistance, food, technology.
III **Institutional & Organizational Change**	Changing institutional policies, practices, and norms that perpetuate exclusion and inequality.	• Reviewing and eliminating exclusionary language and activities from curricula. • Introducing language and activities to curricula that aligns with the experiences of marginalized youth and advances equity, diversity and inclusion. • Ensuring instruction and mentoring are "more sophisticated about the dynamics of culture and identity" and reflect the identities and experiences of excluded youth.[15] • Building distinct, positive spaces and programs for youth from different communities (e.g., girls, Black youth, Indigenous youth programs). • Reviewing and changing hiring, employment and administrative practices that intentionally or unintentionally exclude and disempower.

[15] Posselt et al (2021).

LEVEL	ORIENTATION	EXAMPLES
IV **Transforming Norms & Values**	Reimagining what "science" means and involves Transforming power-holders' understanding of who and what belongs	• Enriching what counts as science and evidence and making space for marginalized knowledge and evidence. • Creating space for excluded and marginalized youth, communities and others to shape science priorities. • Educating instructors, educators, parents and others about the importance and value of EDI and how to practice it in STEM and other spaces. • Educating and empowering instructors, educators, parents and others to critically assess the value and ethics of activities and priorities of science and innovation and the organizations that lead them. • Educating and supporting power-holders and those who benefit from existing systems to develop more inclusive and justice-supporting norms, attitudes and behaviours.

Sources: Catalyst 2030; Actua.

Advancing Systemic Change

In theory, initiatives like those listed in the table above should advance systemic change. But pursuing one or more systemic change initiatives does not necessarily result in systemic change. While we certainly want the latter and should make substantial efforts to achieve it, awareness of how difficult systemic change is should introduce some humility about how we use the term.

That said, if we take a systems change approach to designing and measuring the impact of various initiatives, we can have more confidence that our pursuit is aligned with reasonable chances of achieving systemic change. Women and Gender Equality Canada (WAGE) offers a useful framework of components of a systemic change project.[16]

[16] WAGE (2024).

Issues and Questions

The current paper is intended to spur thinking and discussion, not to offer a fixed guide for pursuing systemic change. Indeed, while we think systemic change is necessary and encourage all organizations to consider ways they can contribute, there are many outstanding questions. The benefits of systemic change are fairly clear, but three features make it challenging for organizations to pursue.

1. There are many possible goals and demographic foci of systemic change. Organizations will want to think about ***who*** their systemic change efforts might serve and ***what goals*** they hope to achieve. Organizations that pick too many goals and constituencies might find themselves stretched in many directions and having little impact. At the same time, goals and demographic foci that are too narrow can obscure the ways that success depends on pursuing a set of related goals and acknowledging that people often have intersecting identities that require attention.

2. Systems are complex and interacting, which means that an individual organization that wants to pursue systemic change might find itself capable of addressing only a very small piece of a larger puzzle and feeling that it is achieving little to nothing. In that case, organizations would be well advised to ***develop relationships with other organizations*** and consider how they might achieve more together. The risk here, of course, is that in trying to work with other organizations and systems, those who want to advance systemic change might run into organizations and systems resistant to change and spend resources and energy trying to convince the unwilling to come along.

3. Finally, organizations will want to be mindful of the fact that systemic change is only one prong of larger strategies to include and empower people in STEM. Equipping individuals with the skills, knowledge and confidence they need to pursue STEM paths still matters. The challenge here is to ***find a balance between continuing efforts to equip individuals with the tools of success while allocating sufficient resources to changing the systems*** that shape their prospects for success.

KEY COMPONENTS OF A SYSTEMIC CHANGE PROJECT

Women and Gender Equality (WAGE) Canada

UNDERSTAND THE ISSUE

- **Gather facts** on the issue you are aiming to address to understand its **root causes**, broader context, **who is affected**, and how experience and outcomes differ among and within groups of people.
- Consider the **elements of a system**: Which elements perpetuate the issue and why? Where are the challenges and opportunities for change?
- Keep in mind that **people with diverse lived experiences and identities might perceive or define the issue differently**.

TAKE STRATEGIC ACTION

- **Identify what you hope to achieve** and **develop an approach to get there**.
- Ensure the proposed action is **workable in scope**, addresses **one or more elements of a system**, and has the **potential for a positive and lasting impact** on those affected by the issue.
- Actions and initiative may be new - based on your diagnosis and design - or adapted from existing approaches that have worked for others.

ENGAGE

- Engage and collaborate with others both on design and implementation, including those:
  - **who are directly affected;**
  - **who can influence change;**
  - **who may be resistant to change; and**
  - **whose perspectives are not frequently heard.**
- One organization alone cannot solve a systemic issue. Diverse partners can bring new knowledge, resources, and networks to advance your initiative and amplify its impact.

LEARN AND ADAPT

- Apply a **continuous learning** approach to your project where possible. Consider **what is and what is not working**, or **how things may be changing**.
- Respond to changes as they occur and build on your learnings by adapting or adjusting your approach if needed.
- **Specific actions may not always lead to the specific impact you intended**. Creating and maintaining a plan to monitor change, and measure project results can help with this component.

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