An Alternative Reading for STEM (h-STEM): From Market-Driven Education to Human-Centered Education

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ABSTRACT

This paper proposes a critical re-examination of the traditional STEM (*Science, Technology, Engineering, Mathematics*) educational framework and presents an alternative interpretation that prioritizes human values over market demands. While traditional STEM education has inclined to produce technical professionals since its formal conceptualization done by the National Science Foundation of the United States in 2001, this approach has inadvertently created an educational paradigm that serves capital market economies rather than holistic human development. This paper argues for a re-conceptualization of STEM as Solidarity, Tolerance, Empathy, and Mindfulness, a framework designed to foster sustainable, inclusive, and humanistic education for the 21st century and beyond.

Keywords: STEM education, Humanistic Education, Solidarity, Tolerance, Empathy, Mindfulness

THE CONVENTIONAL APPROACH OF STEM EDUCATION

The Science, Technology, Engineering, and Mathematics (STEM) initiative, formally established by the United States National Science Foundation in 2001,[1] emerged as a response to perceived deficiencies in technical education and workforce preparation.[2] While STEM concepts had been applied in industrial contexts since the Industrial Revolution, their systematic integration into educational curricula represents a relatively recent phenomenon that has fundamentally reshaped educational priorities worldwide.

Professor David W. White of Florida Agricultural and Mechanical University in his research titled, 'what is STEM education and why is it important?' provides comprehensive definitions of the traditional STEM disciplines, each rooted in empirical observation, technical application, and quantitative analysis.[3] Accordingly, **Science** stands for the systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms. **Technology** can be defined as the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science. **Engineering** means the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants. **Mathematics** is a group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation.[4]

[1] Daniel N. Donahoe, *The Definition of STEM?* (IEEE, 2013)
[2] David W. White, *What Is STEM Education and Why Is It Important*? (Florida Association of Teacher Educators Journal Volume 1 Number 14, 2014), 1-9.
[3] *ibid*.
[4] *ibid.*

The Evolution of STEM Education

The formal codification of STEM education represents a culmination of concerns about national competitiveness and technological advancement. Historical precedents for integrated technical education can be traced through various industrial and post-industrial developments, yet the 21st-century implementation of STEM reflects specific economic and political priorities rather than scholarly innovation alone.

Contemporary STEM education operates under several implicit assumptions such as; (i) technical proficiency drives economic growth,[5] (ii) specialized knowledge creates competitive advantage,[6] and (iii) educational systems should align with labor market demands.[7] These assumptions create what we can call "instrumentalist education" learning designed primarily as a means to economic ends rather than as intrinsic human development.[8]

The Market-Education Nexus

The alignment between STEM education and capital market demands has created unprecedented focus on producing 'scientists, technicians, engineers, mathematicians and other related professionals for the labour market.' This utilitarian approach to education reflects broader neoliberal influences on educational policy, where institutions increasingly function as workforce development agencies rather than centers of comprehensive human learning.[9]

Market-driven education fundamentally prioritizes capital gain over human development, creating a paradigmatic shift from humanitarian to economic approaches to learning. When education systems are designed primarily to serve market needs, they inevitably transform from institutions dedicated to human flourishing into mechanisms for economic production. This transformation represents a fundamental philosophical departure from education's traditional role as a means of cultivating wisdom, character, and social responsibility.[10]

This market-centric approach generates several concerning outcomes. First, it creates educational hierarchies that privilege technical disciplines over arts, humanities, and social sciences, devaluing forms of knowledge that contribute to human understanding but may not immediately translate to economic productivity. Second, it reduces students to potential workers in the labour market rather than developing human beings with intrinsic worth and diverse potentials. Third, it fails to address complex global challenges that require interdisciplinary thinking, ethical reasoning, and cultural understanding, as these capabilities often cannot be easily quantified or directly monetized. Most critically, this approach subordinates educational purpose to market logic, fundamentally altering the relationship between learning and human development.

The Sustainability Crisis

The current global trajectory characterized by environmental degradation, social and economic inequality, and technological disruption suggests fundamental limitations in purely technical approaches to human challenges. Climate change, biodiversity loss, social fragmentation, and democratic erosion require solutions that integrate technical knowledge with ethical reasoning, cultural sensitivity, and collaborative problem-solving.

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[5] Rodney Ramcharan, *Higher or Basic Education? The Composition of Human Capital and Economic Development,* (IMF Stoff Papers Vol 51 No 2, 2004), 309-326.

[6] Slykhuis, D. A., Martin-Hansen, L., Thomas, C. D., & Barbatom S., *Teaching STEM through historical reconstructions: The future lies in the past*, (Contemporary Issues in Technology and Teacher Education, 15(3) (2015). https://citejournal.org/volume-15/issue-3-15/editorial/teaching-stem-through-historical-reconstructions-the-future-lies-in-the-past.

[7] Giotis, Georgios, Themistoklis Gogas, and Konstantina Gouda, *Education and Employment* (Encyclopedia 5, no. 2: 2025) https://doi.org/10.3390/encyclopedia5020085.

[8] Soudeh Oladi, *The Instrumentalization of Education* (The Atlantic Journal of Graduate Studies in Education: Special Edition, 2013). Retrieved from: http://ejournal.educ.unb.ca.

[9] *ibid.*

[10] Gordon Ade-ojo & Vicky Duckworth, *Exploring the Concepts: Instrumentalism, Philosophy of Education, Ideology and Value Positions*, (Adult Literacy Policy and Practice: From intrinsic values to instrumentalism Ed.1st Chapter:1, Palgrave Macmillan, 2015)

The assertion that "science without humanity will lead the world to extinction" reflects growing recognition that technical capability divorced from moral reasoning and social consciousness creates dangerous possibilities. Historical examples from industrial pollution to social media manipulation to artificial intelligence risks demonstrate the need for educational frameworks that cultivate both technical competence and ethical wisdom.

An Alternative Framework: STEM as Human-Centered Education

A humane-oriented education should prioritize human development over mere economic growth. This calls for an alternative approach to STEM that represents a true paradigm shift in education. The humane-oriented STEM (h-STEM) model should therefore be understood as a transformative framework one that reinterprets traditional education and reorients it toward cultivating human values, social responsibility, and sustainable well-being.

Accordingly, the new h-STEM model can be described as follows:

S - Solidarity: Building Collective Responsibility

Solidarity represents the foundational principle of shared human experience and mutual support. In educational contexts, solidarity manifests as recognition of interconnectedness, commitment to collective well-being, and active engagement with social challenges. Unlike individualistic competition that characterizes contemporary education, solidarity-based learning emphasizes collaboration, shared responsibility, and communal problem-solving.

Solidarity-centered education produces scholars who understand their role within broader social systems and feel responsible for collective outcomes rather than merely individual advancement.

T - Tolerance: Cultivating Respectful Practice

Tolerance could be defined as the willingness to accept, respect, and coexist with differences in beliefs, practices, cultures, and perspectives, while maintaining one's own values and promoting peaceful dialogue across diversity.

Scholars developing tolerance learn to consider multiple perspectives, anticipate consequences, and make decisions based on careful analysis rather than immediate impulses or external pressures.

E - Empathy: Fostering Human Connection

Empathy, the capacity to understand and share others' experiences represents perhaps the most crucial capability for addressing contemporary global challenges. Empathetic education moves beyond abstract knowledge to emotional and social intelligence, creating learners capable of genuine human connection and compassionate action.

Empathetic scholars possess the emotional intelligence necessary for effective leadership, collaborative problem-solving, and creating inclusive societies.

M - Mindfulness: Developing Present-Moment Awareness

Mindfulness, maintaining present-moment awareness with openness and non-judgment provides the foundation for all other aspects of human-centered education. Mindful learners develop the capacity for sustained attention, emotional regulation, and clear perception necessary for both personal well-being and effective engagement with complex challenges.

Mindful education produces scholars capable of sustained focus, emotional resilience, and clear decision-making under pressure.

Implementation and Implications

To effectively implement the new human-oriented suggestion to STEM education, attention must be paid to updating and upgrading the teaching, learning, and assessment methods. Accordingly, curriculum revisions, updated assessment methods, training programs for trainers, and institutional reviews are essential in this matter.

Curricular Integration

Implementing human-centered STEM requires fundamental restructuring of educational priorities and practices. Rather than replacing technical education, this approach integrates human development with disciplinary learning through the cultivation of solidarity, tolerance, empathy, and mindfulness within every aspect of the curriculum. The goal shifts from creating skilled professionals to nurturing holistic human beings who happen to possess technical competencies.

Integrating human values into the curriculum has the potential to fundamentally transform the educational experience. For instance, blending the traditional STEM disciplines with the principles of humane-oriented STEM (h-STEM) offers a profound reorientation of conventional education. In this model, science courses would not only advance knowledge but also explore the ethical implications of research, fostering solidarity through collaborative inquiry and cultivating empathy for research subjects and affected communities. Technology education would emphasize social impact assessment, nurturing mindfulness about consequences and tolerance for diverse perspectives on technological change. Engineering would embed principles of sustainable design, strengthening solidarity with future generations and empathy toward environmental impacts. Finally, mathematics would connect abstract concepts with human-centered applications, encouraging thoughtfulness in problem-solving approaches and cultivating mindfulness in logical reasoning.

This integration ensures that students develop as complete human beings emotionally intelligent, socially conscious, ethically grounded, and spiritually aware rather than merely as technical specialists equipped for market demands. The outcome is graduates who can contribute meaningfully to society not just through their professional skills, but through their capacity for compassionate leadership, collaborative problem-solving, and ethical decision-making.

Assessment and Evaluation

Traditional standardized testing inadequately measures solidarity, tolerance, empathy, and mindfulness. Hence, traditional formative (continuous in-course) and summative (end-course) assessment methods should be improved to assess the humane-centered skills of the learners. Accordingly, in the formative approach: peer reviews, reflective sessions and mindfulness check-ins can be used. Also, in the summative approach: community impact portfolios, cross-cultural exchange projects and Ethical dilemma case studies can be used.

Most importantly, assessments should focus on humanity and sustainability rather than the market value of the final output. This approach represents a fundamental shift in evaluation philosophy from measuring economic utility to assessing human and planetary well-being. Instead of asking "How will this skill increase earning potential?" or "What market value does this competency create?", human-centered assessment asks, "How does this learning contribute to human flourishing?" and "What impact does this have on sustainable future?"

In order to effectively assess solidarity, tolerance, empathy, and mindfulness, a carefully designed assessment rubric can serve as a guiding framework within the human-centered STEM paradigm. Such rubric shifts the focus of evaluation away from narrow, market-driven outcomes and instead emphasizes learners' ability to collaborate meaningfully, respect and engage with diversity, demonstrate compassion and understanding, and cultivate mindful awareness of themselves, others, and the environment. By embedding these humane-centered values into both formative and summative assessments, the rubric not only evaluates academic growth but also nurtures the qualities essential for human flourishing and sustainable futures.

The following assessment rubric[11] suggests an exemplary model (which can be further developed and varied based on the subject or the discipline) for evaluating process in the h-STEM model.

Pillar / Skill	Excellent (4)	Good (3)	Moderate (2)	Weak (1)
Solidarity (Commitment to collective well-being, cooperation, and shared responsibility)	Demonstrates consistent commitment to group success; actively supports peers; contributions show strong collective responsibility.	Works collaboratively with minimal conflict; shows awareness of shared goals.	Participates in group but contribution is inconsistent; limited sense of shared responsibility.	Struggles to engage with peers; focuses mainly on personal outcome over group needs.
Tolerance (Respect for diversity, openness to different views, patience with differences)	Actively engages with diverse perspectives; demonstrates respect and patience in all interactions; embraces intercultural understanding.	Generally respectful of differences; open to considering new viewpoints.	Shows partial respect; sometimes dismisses or overlooks different perspectives.	Demonstrates intolerance or resistance to diverse perspectives; disrupts inclusive environment.
Empathy (Understanding and responding to others' emotions, needs, and experiences)	Consistently demonstrates deep understanding of others' perspectives; actions reflect compassion and supportive responses.	Shows understanding of others' emotions; usually responds with care and support.	Occasionally acknowledges others' perspectives but responses lack depth or consistency.	Rarely recognizes or responds to others' emotions or perspectives.
Mindfulness (Awareness of self, others, and the environment; reflective presence)	Consistently demonstrates self-awareness and reflection; mindful of impact on others and environment; integrates awareness into actions.	Shows awareness of personal actions and their impact; reflects periodically.	Limited mindfulness; occasional reflection but inconsistent in practice.	Lacks self-awareness or reflection; unaware of impact on others/environment.

Table: 1 – Model assessment Rubric for h-STEM model

Teacher Development

Educators implementing human-centered STEM require different preparation and ongoing support. Most importantly, the development of attitudes is more significant than equipping teachers with traditional trainings. Before educators can cultivate solidarity, tolerance, empathy, and mindfulness in students, they must first embody these qualities themselves.

Traditional teacher training emphasizes pedagogical techniques, subject matter expertise, and classroom management skills, essentially the "how" of teaching. In contrast, human-centered education demands a deeper transformation in the educator's inner orientation, shifting focus toward the "to whom" and "why" of teaching. Accordingly, teachers must develop attitudes of genuine care for student well-being over performance metrics, commitment to social justice over competitive achievement, and dedication to long-term human flourishing over short-term academic gains.

Professional development must therefore prioritize attitude transformation through contemplative practices, social-emotional learning, community engagement strategies, and interdisciplinary collaboration skills. This

[11] Brookhart, S. M. *How to Create and Use Rubrics for Formative Assessment and Grading*. (Alexandria, VA: ASCD, (2013).

includes developing educators' capacity for self-reflection, emotional regulation, cultural humility, and systems thinking. Only when teachers genuinely embody human-centered values can they authentically guide students toward becoming compassionate, mindful, and socially conscious human beings.

The pyramid below shows us how teachers need to adapt to the new h-STEM model.

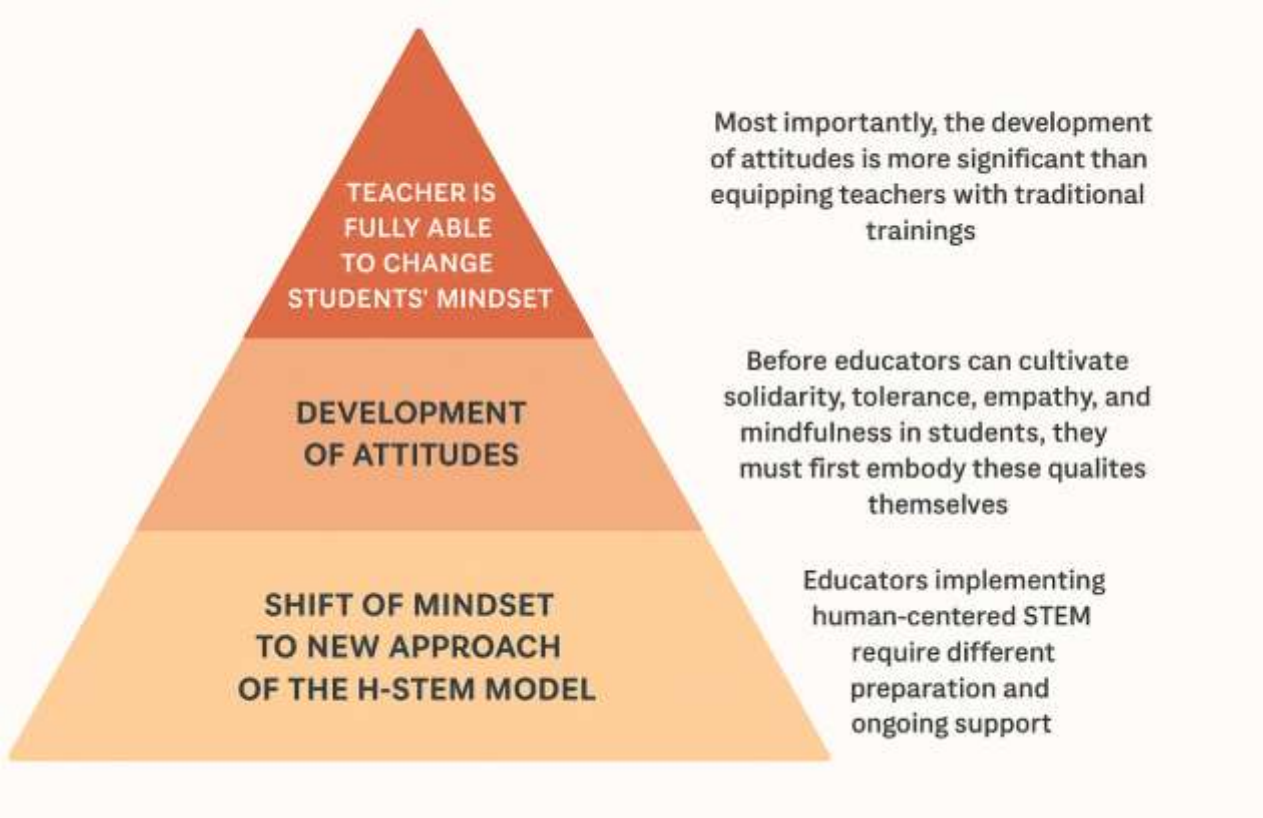

Figure 1 – Teacher's development pyramid for h-STEM model

Institutional Change

Educational institutions adopting this framework must examine their fundamental purposes and practices. Most critically, the structural framework of educational institutions should prioritize academic and thinking freedom of the scholar. Without intellectual freedom, students cannot develop genuine empathy, thoughtfulness, or authentic solidarity. These human qualities require the liberty to explore diverse perspectives; question established norms and think independently.

Current institutional structures often constrain thinking through rigid curricula, standardized expectations, and fear-based compliance systems. Human-centered education requires institutional courage to create spaces where students and educators can engage in free inquiry, express dissenting views, and pursue knowledge that serves humanity rather than merely market demands.

Structural changes include governance structures that prioritize human development over economic metrics, partnerships with community organizations that expand learning beyond institutional walls, and evaluation criteria that measure social impact alongside academic achievement. Most importantly, institutions must protect and cultivate environments where scholarly freedom enables deep thinking, ethical reasoning, and creative problem-solving necessary for addressing complex human challenges.

Future Directions

The proposed alternative reading of the STEM education emphasizing Solidarity, Tolerance, Empathy, and Mindfulness offers a pathway toward more sustainable, inclusive, and ultimately effective educational practice. This approach addresses the limitations of market-driven education while maintaining rigorous academic standards and practical applicability.

The applicability and effectiveness of the new h-STEM initiative should be tested further in both pedagogical[12] and andragogical[13] approaches. Also, future research should examine specific implementation strategies, develop appropriate assessment tools, and evaluate outcomes of human-centered educational approaches.

The urgency of global challenges from climate change to social inequality to technological disruption demands educational approaches that cultivate both technical competence and human wisdom. The alternative STEM framework proposed here offers one contribution to this essential educational transformation. Therefore, redefining STEM as Solidarity, Tolerance, Empathy, and Mindfulness will be a paradigm-shift in education.

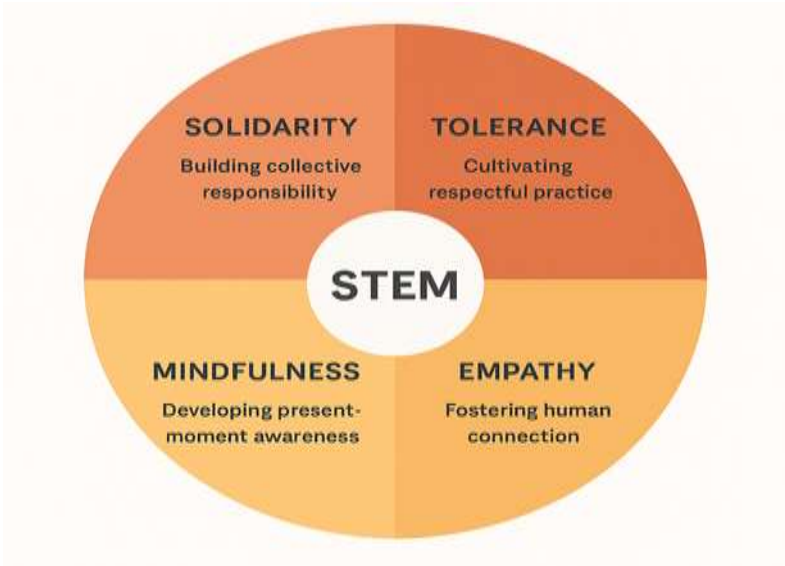

Figure 2 – The h-STEM model

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[12] '*Merriam-Webster defines it simply as "the art, science, or profession of teaching.*'
Norm Friesen, *What Is Pedagogy? Discovering the Hidden Pedagogical Dimension*, (Educational Theory 73(1), 2023)
[13] '*Andragogy learning style is the instruction technique adult learners prefer in higher education settings*.'
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