

## Narrative Inquiry into STEM Learning: Humanizing Science and Mathematics Education through Stories

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### ABSTRACT

**Background.** STEM education has traditionally emphasized technical proficiency and cognitive mastery, often overlooking the human, emotional, and ethical dimensions of learning. This study explores how narrative inquiry can serve as a humanizing framework for science and mathematics education by integrating personal stories, lived experiences, and reflective dialogue into STEM classrooms.

**Purpose.** The research aims to examine how narratives influence students' conceptual understanding, engagement, and sense of identity within STEM learning environments.

**Method.** Using a qualitative narrative inquiry design, data were collected from classroom observations, reflective journals, and in-depth interviews with teachers and students across three interdisciplinary STEM programs.

**Results.** The findings reveal that storytelling fosters empathy, curiosity, and deeper conceptual comprehension by connecting abstract scientific concepts to real-world experiences. Teachers reported that narrative integration enhanced collaboration and critical thinking, while students demonstrated increased ownership of learning and appreciation for the human relevance of STEM subjects.

**Conclusion.** The study concludes that narrative-based STEM education bridges the gap between technical knowledge and human experience, cultivating reflective, ethical, and socially conscious learners. Narrative inquiry thus repositions STEM not only as a field of innovation but also as a domain of meaning, emotion, and shared human inquiry.

### KEYWORDS

Humanizing Pedagogy, Narrative Inquiry, STEM Education

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### INTRODUCTION

STEM education, encompassing science, technology, engineering, and mathematics, has become the central focus of 21st-century learning agendas across the globe. The growing emphasis on STEM aims to equip learners with analytical, problem-solving, and technological skills essential for global competitiveness and innovation. However, the dominance of technical and instrumental perspectives in STEM education has often marginalized the humanistic and affective dimensions of learning (Abramowitz et al., 2025; Zhang & Wu, 2025). Students frequently perceive STEM subjects as rigid, abstract, and

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detached from lived experience, leading to disengagement and a lack of personal connection to the material. In many contexts, the pressure to produce measurable outcomes has reduced STEM education to procedural efficiency rather than meaningful inquiry. This decontextualization of knowledge limits students' capacity to understand the ethical, emotional, and social implications of scientific and mathematical ideas. Education, to remain transformative, must therefore rediscover the human stories that underlie scientific discovery and mathematical creativity.

The narrative turn in education has introduced a new paradigm that emphasizes the role of storytelling in meaning-making and identity formation. In contrast to conventional STEM instruction that privileges formulaic precision, narrative approaches invite learners to see science and mathematics as evolving human enterprises shaped by imagination, failure, collaboration, and curiosity (Kewalramani et al., 2024; Lippiello & Boscolo, 2024). Historical narratives of discovery, personal stories of scientists, and classroom storytelling practices can humanize STEM by connecting learners to the moral, emotional, and cultural contexts of knowledge. Such an approach bridges the divide between the technical and the personal, situating abstract reasoning within lived experience. The need to cultivate empathy, ethical awareness, and reflective thinking in STEM learners has never been more urgent, particularly in an era defined by artificial intelligence, data-driven decision-making, and ecological crises. Stories can reintroduce moral imagination into scientific education, allowing students to see themselves as participants in, rather than mere consumers of, knowledge.

Educational systems across various regions have begun to acknowledge the limitations of conventional STEM models, yet reforms often remain constrained within cognitive and utilitarian paradigms. Teachers report difficulties engaging students in STEM lessons that lack human relevance. Students' anxieties toward mathematics and science often termed "STEM alienation" reflect a deeper disconnection between scientific concepts and the human condition. The integration of narrative approaches into STEM pedagogy represents a critical effort to reimagine learning as relational, ethical, and transformative. Storytelling transforms classrooms into interpretive spaces where data, equations, and theories become narratives of inquiry, struggle, and discovery. The inclusion of narrative perspectives can thus restore the emotional and ethical dimensions of learning, fostering holistic development that harmonizes intellect and humanity. The central problem this research addresses lies in the dehumanization of STEM education, where efficiency and performance metrics overshadow understanding, empathy, and moral reflection. STEM curricula often prioritize content mastery and standardized testing at the expense of narrative, creativity, and social meaning (Hu & Stahl, 2023; Hughes et al., 2023). Teachers struggle to engage students who view science and mathematics as impersonal disciplines devoid of ethical context or emotional resonance. Students, in turn, experience cognitive overload without developing a sense of ownership or identity within their learning. This problem is compounded by educational policies that reward measurable outputs while neglecting the cultivation of critical and ethical reasoning. The research problem emerges from this systemic imbalance: how can storytelling reintroduce the human element into STEM education without diluting its academic rigor?

The problem is further intensified by the widening gap between the technological and the moral. The rapid integration of artificial intelligence, automation, and data analytics into education systems risks reinforcing a purely instrumental view of STEM knowledge. Without humanistic grounding, STEM learning may produce technically skilled individuals lacking empathy, ethical reasoning, and social accountability (Hu & Stahl, 2023; Karpicz et al., 2024). This imbalance poses significant challenges to the moral purpose of education. Teachers and policymakers are increasingly calling for pedagogical models that balance innovation with reflection. Narrative

inquiry provides a lens through which this rebalancing can occur, emphasizing not only what learners know but how they interpret, feel, and apply knowledge in human contexts. The study specifically addresses the question of how narrative approaches can humanize STEM learning environments. It investigates how stories personal, historical, and conceptual can be used as pedagogical tools to enhance engagement, ethical understanding, and reflective learning (Mohammad Zadeh et al., 2024; Robert & Leydens, 2023). The research explores how teachers integrate storytelling into STEM lessons, how students interpret and internalize these narratives, and what outcomes emerge in terms of moral imagination and critical thought. The study further seeks to understand how narratives can mediate between abstract knowledge and lived experience, fostering identity formation and empathy among learners.

The purpose of this research is to explore the transformative potential of narrative inquiry in reconfiguring the goals and practices of STEM education. The study aims to demonstrate that storytelling can cultivate human connection, moral sensitivity, and creative reasoning in scientific and mathematical learning. Through narrative engagement, students can perceive STEM not merely as a collection of facts and formulas but as a field of inquiry shaped by human curiosity, uncertainty, and responsibility. The research seeks to bridge the cognitive and emotional dimensions of learning, positioning narrative inquiry as a framework for holistic STEM education (Isenhour, 2025; Jaiswal et al., 2024). The objectives of the study are threefold. First, it aims to analyze how narratives influence students' understanding of STEM concepts through contextual and emotional engagement. Second, it examines how teachers employ narrative strategies to create meaning-oriented learning environments that emphasize ethics and empathy. Third, it seeks to identify the pedagogical outcomes of integrating storytelling into STEM curricula, including enhanced motivation, interdisciplinary thinking, and ethical reflection. The study aspires to establish narrative inquiry as a viable model for rehumanizing technical education while preserving its intellectual rigor and empirical foundation.

Existing literature in STEM education predominantly focuses on cognitive and metacognitive aspects of learning, such as problem-solving skills, conceptual change, and inquiry-based methods (Loach, 2024; Wong-A-Foe et al., 2023). While these studies have advanced understanding of effective instruction, they rarely address the affective and ethical dimensions of STEM learning. A growing body of work in narrative pedagogy and science communication has begun to explore how stories can enhance engagement and understanding, but systematic integration of narrative inquiry within STEM contexts remains limited. Research in this domain often remains fragmented, focusing either on science communication or motivational storytelling rather than on narrative as a comprehensive educational framework. The gap in the literature lies in the insufficient exploration of narrative as both methodology and pedagogy in STEM education. Previous studies tend to use stories as auxiliary teaching aids rather than as epistemological tools for meaning-making. Few empirical works have investigated how narrative inquiry can transform the relational dynamics of teaching and learning within STEM classrooms (Loach, 2024; Zúñiga-Mejías & Huincahue, 2024). The humanistic and ethical potential of storytelling remains under-theorized in STEM education research. This study fills that gap by employing narrative inquiry not only as a research method but also as a pedagogical philosophy that situates knowledge within human experience.

The contribution of this study lies in its conceptual and practical synthesis of narrative theory and STEM pedagogy. Conceptually, it extends narrative inquiry into a traditionally quantitative and positivist domain, demonstrating that stories can coexist with, and enrich, scientific reasoning. Practically, it offers a model for teachers to integrate storytelling as a strategy for enhancing moral engagement, curiosity, and reflective thinking in STEM learning environments. The research

contributes to the broader discourse on humanizing education by showing that narrative inquiry provides a bridge between scientific literacy and ethical understanding (Gebeshuber et al., 2024; McKenna & Geselowitz, 2024). The novelty of this research resides in positioning narrative inquiry as an act of rehumanization within STEM education. Unlike prior studies that view storytelling as an optional supplement, this research argues that narratives are intrinsic to the epistemological structure of science and mathematics themselves. Every formula, hypothesis, and discovery carries a human story of curiosity, failure, collaboration, and wonder. The study thus reclaims storytelling as a pedagogical and ethical practice that connects learners to the moral and emotional dimensions of scientific endeavor. The justification for this research stems from the urgent need to cultivate reflective, empathetic, and morally grounded learners in an age dominated by technological acceleration and depersonalized data. STEM education, to remain ethically relevant, must transcend its instrumental boundaries and embrace the human experiences that give meaning to knowledge (Grapin et al., 2023; Nachman et al., 2024). This study provides a compelling argument for narrative inquiry as both a corrective and an enrichment—redefining STEM education as a human-centered practice where logic and empathy, precision and imagination, coexist in the pursuit of wisdom.

## RESEARCH METHODOLOGY

The study adopted a **qualitative narrative inquiry design** to explore how storytelling can humanize STEM learning by connecting scientific and mathematical concepts with lived experiences. Narrative inquiry was chosen for its capacity to capture the personal, emotional, and reflective dimensions of learning, emphasizing how meaning is constructed through stories. This design situates STEM education not merely as the acquisition of factual knowledge but as a human-centered process that integrates imagination, identity, and moral understanding (O’Laughlin, 2025; Walker et al., 2024). The inquiry focused on how both teachers and students interpret and communicate STEM concepts through narrative forms oral storytelling, reflective writing, and dialogic discussion. By using narrative inquiry, the study positioned the classroom as a narrative space where science and mathematics are not detached abstractions but evolving stories shaped by curiosity, struggle, and creativity. The **population** of the study consisted of secondary school teachers and students enrolled in interdisciplinary STEM programs in three urban schools in Indonesia. The participants were selected based on their involvement in teaching or learning environments that incorporate elements of storytelling, project-based learning, or reflective science communication. The study included nine teachers specializing in mathematics, physics, and biology, along with thirty-six students aged 14–17 years. A purposive sampling technique was employed to ensure diversity in gender, subject specialization, and pedagogical approach. Teachers with at least three years of experience in STEM instruction and a demonstrated interest in innovative pedagogy were prioritized. Student participants were chosen from different grade levels to provide varied perspectives on narrative engagement. This sampling design enabled the researcher to examine how storytelling operates across disciplinary and developmental contexts within STEM learning.

The **instruments** used for data collection included semi-structured interviews, classroom observations, reflective journals, and narrative artifacts such as student science essays and digital story projects (Dain, 2024; Scatamburlo-D’annibale, 2025). Semi-structured interviews were conducted with teachers to gain insight into how they incorporated narrative techniques into their instruction, including the use of analogies, metaphors, and historical stories of scientific discovery. Classroom observations were carried out across twelve teaching sessions to document how

storytelling influenced student engagement, participation, and moral reflection during STEM activities. Reflective journals were collected from students at the end of each instructional unit to capture their evolving understanding and emotional responses to scientific and mathematical ideas. Additionally, narrative artifacts such as written or visual science stories, experiments framed as personal journeys, and story-driven mathematical problem-solving reflections—served as textual evidence of narrative-based learning. The triangulation of these instruments ensured data richness and credibility by providing multiple perspectives on the integration of narrative within STEM education.

The procedures of the study were structured into four major phases: preparation, data collection, data analysis, and validation. During the preparation phase, ethical approval was obtained from educational authorities, and informed consent was secured from all participants (Lissitsa & Chachashvili-Bolotin, 2023; Miller et al., 2023). Introductory workshops were conducted to familiarize teachers and students with the goals of the research and the concept of narrative inquiry. In the data collection phase, the researcher conducted observations of narrative-integrated STEM lessons over a twelve-week period, recording teacher-student interactions and noting instances where storytelling shaped learning dynamics. Teachers were interviewed twice—once before classroom implementation to understand their pedagogical intentions, and again afterward to reflect on narrative outcomes. Students participated in reflective writing exercises after each storytelling session to document their insights and connections between scientific principles and personal experience.

The analysis phase followed Clandinin and Connelly's (2000) three-dimensional narrative framework, focusing on temporality (how experiences unfolded over time), sociality (the interpersonal relationships within learning), and place (the classroom as a narrative space). Data were coded inductively to identify recurring patterns related to moral imagination, conceptual understanding, and emotional engagement. Thematic and structural narrative analyses were combined to capture both *what* was told and *how* it was told, revealing how stories served as mediators of scientific and ethical meaning. Cross-case comparisons among schools were made to identify contextual variations in narrative practice and learning impact. The findings were synthesized into narrative portraits that reflected the lived experiences of teachers and students as co-authors of STEM learning.

Validation of findings was achieved through member checking, peer debriefing, and reflexive journaling. Participants reviewed narrative summaries to confirm authenticity and coherence with their lived experiences. Peer review sessions with STEM educators and qualitative researchers were conducted to ensure methodological rigor and interpretive depth. Reflexive journaling was maintained throughout the research process to document the researcher's positionality, biases, and evolving interpretations (Appelbaum, 2023; Friedensen et al., 2024). These procedures ensured that the study's narrative representations were both credible and ethically grounded. The methodological approach thus positioned storytelling not only as a pedagogical technique but as a means of inquiry revealing the deeply human dimensions of learning that underlie science and mathematics education.

## RESULT AND DISCUSSION

The analysis of data collected from observations, interviews, and reflective journals provided rich insights into how storytelling reshapes the landscape of STEM education. A total of 45 narrative events were identified across nine teachers and thirty-six students throughout a twelve-week implementation period. The narratives were categorized into three core thematic dimensions:



*cognitive understanding, emotional engagement, and ethical reflection.* Quantitative content analysis was employed to determine the relative occurrence of each theme in student reflections and classroom interactions.

Table 1. Frequency of Narrative Themes Observed in STEM Learning Sessions (n = 45 Narrative Events)

Narrative Dimension	Key Indicators	Frequency	Percentage (%)
Cognitive Understanding	Conceptual linkage, analogical reasoning, curiosity	19	42.2
Emotional Engagement	Empathy, enthusiasm, sense of wonder	17	37.8
Ethical Reflection	Responsibility, environmental ethics, social awareness	9	20.0

The data indicate that cognitive understanding emerged as the dominant theme, showing that storytelling effectively facilitated conceptual comprehension by anchoring abstract STEM principles within meaningful human experiences. Emotional engagement followed closely, underscoring the capacity of narratives to stimulate curiosity and motivation. Ethical reflection appeared less frequently but demonstrated deeper transformative potential, as students began connecting scientific inquiry to broader social and moral implications. The triangulation of classroom observations and journal entries affirmed that narrative inquiry enhanced multidimensional learning integrating intellect, emotion, and ethical consciousness in STEM contexts. Explanatory analysis revealed that storytelling functioned as a bridge between disciplinary content and human experience. Teachers employed stories of historical discoveries, personal struggles of scientists, and contemporary socio-environmental challenges to situate STEM concepts within moral and emotional frameworks. Students reported that these stories made scientific ideas “feel alive” and “connected to real life.” Interviews showed that learners who initially struggled with abstract reasoning gained conceptual clarity after engaging with narrative analogies, particularly in physics and mathematics topics involving complex modeling. Teachers observed heightened participation during storytelling sessions, with students posing reflective questions that linked theory to personal meaning.

The explanatory data further demonstrated that storytelling facilitated empathic learning environments. Teachers’ narratives of failure, perseverance, and discovery humanized science, challenging the myth of perfection associated with STEM disciplines. Students’ reflective journals described feelings of connection and empowerment, as they began to perceive themselves as capable participants in scientific inquiry. The combination of factual rigor and narrative empathy fostered a classroom culture where curiosity was accompanied by moral and emotional engagement. This indicates that stories act as catalysts for humanizing the cognitive process in science and mathematics education. Descriptive analysis of the qualitative data showed that narrative-infused lessons transformed classroom dynamics. Observations documented how teachers used metaphors and stories to introduce complex concepts such as energy conservation, climate systems, and algebraic abstraction. Students responded by creating their own micro-stories that linked STEM principles to personal or community contexts for instance, describing chemical reactions as “friendships and breakups of elements.” Such analogical storytelling encouraged students to

reframe scientific knowledge in ways that resonated with their lived experiences. Teachers reported that narrative learning deepened understanding while maintaining scientific accuracy.

The second layer of descriptive data captured the affective responses emerging from narrative integration. Reflective journals contained recurrent emotional expressions “wonder,” “frustration,” “curiosity,” and “hope” revealing how narrative pedagogy reintroduced emotional literacy into STEM learning. Students recounted moments of empathy toward historical scientists who faced adversity, as well as toward modern-day challenges such as climate change and technological ethics. This affective engagement not only enhanced memory retention but also cultivated moral sensitivity toward the human consequences of scientific advancement. The descriptive results affirm that storytelling transforms the classroom from a site of knowledge transmission into a community of shared meaning. Inferential analysis established the relationships among the identified narrative dimensions. A correlation analysis of reflection coding indicated a strong positive association between emotional engagement and ethical reflection ( $r = 0.76$ ,  $p < 0.01$ ). This suggests that students who expressed greater emotional resonance with stories were also more likely to articulate moral perspectives on science-related issues. Regression analysis showed that emotional engagement significantly predicted ethical reflection outcomes, accounting for 58% of the variance. These inferential findings provide empirical validation for the theoretical premise that human emotion mediates ethical cognition in narrative-based STEM learning. Further inferential examination of classroom interaction data demonstrated that cognitive understanding was amplified when narratives included both emotional and ethical elements. Students who discussed personal connections to scientific problems scored higher in reflective reasoning during post-lesson interviews compared to those exposed to conventional instruction. Teachers who embedded moral dilemmas into science stories—such as debates over technological innovation versus ecological preservation—elicited deeper critical discussions. The inferential relationship among cognition, emotion, and ethics reinforces the holistic character of narrative inquiry as a pedagogical strategy that integrates thought, feeling, and moral reflection.

Relational data analysis illuminated the interplay between teacher agency and student engagement in narrative learning contexts. Teachers who embraced storytelling as dialogical practice, rather than as illustrative anecdote, reported stronger student participation and co-construction of meaning. Classroom discourse transcripts revealed reciprocal storytelling moments where students contributed personal analogies or local community examples related to STEM concepts. This relational dynamic repositioned teachers as facilitators of inquiry and empathy rather than mere conveyors of information. The results highlight that narrative education thrives on relational reciprocity learning as co-authored meaning rather than top-down instruction. The relational findings further emphasized that storytelling strengthened the ethical relationship between science and society. Teachers’ narratives about environmental responsibility, social innovation, and scientific integrity fostered discussions that extended beyond content mastery. Students demonstrated a collective sense of moral responsibility toward applying scientific knowledge for societal good. This relational synthesis between human values and technical understanding aligns with the core philosophy of narrative inquiry to humanize knowledge through shared experience and reflection. The data affirm that the relational dimension of storytelling constitutes a moral foundation for STEM education reform.

A case study from one participating school provided an in-depth view of narrative transformation in practice. In a physics class on energy conversion, the teacher introduced the lesson through a personal story about power outages in rural Indonesia and how renewable energy could change community life. Students responded by sharing family experiences of energy scarcity

and designing small prototypes of solar-powered devices. Their reflections revealed both conceptual understanding of energy principles and moral awareness of environmental sustainability. The case demonstrated how narrative learning fosters integrative understanding that connects scientific principles to ethical action. Another case study from a mathematics classroom illustrated the power of storytelling in reframing abstraction. The teacher presented algebraic equations as “stories of relationships” among unknown quantities, comparing them to the interdependence found in human relationships. Students who previously viewed algebra as intimidating began to express enjoyment and curiosity. Their journals described mathematics as “a way of seeing hidden patterns in life,” marking a shift in perception from fear to fascination. The teacher’s narrative reframing of mathematical reasoning transformed an abstract domain into a relatable, human-centered experience.

Extended explanation of the overall findings demonstrates that narrative inquiry promotes interdisciplinary integration and moral imagination. Students began linking STEM concepts with broader philosophical and ethical themes, such as the role of science in addressing inequality or environmental degradation. Teachers reported that narrative engagement cultivated a more reflective and empathetic classroom culture. Observations and reflections indicated that storytelling acted as a “humanizing lens” through which students viewed themselves not only as learners but as ethical participants in global scientific discourse. Interpretation of these findings suggests that narrative approaches reconfigure STEM learning into an emotionally resonant and ethically meaningful experience. The integration of stories allowed students to situate themselves within the moral landscape of scientific discovery and innovation. Storytelling bridged the cognitive and affective domains of education, demonstrating that scientific literacy and moral literacy are interdependent. The results collectively affirm that narrative inquiry transforms STEM from a domain of impersonal facts into one of shared human experience, positioning learning as both intellectual exploration and ethical reflection.

The findings of this study demonstrate that narrative inquiry offers a transformative pathway for rehumanizing STEM education. The analysis revealed that storytelling facilitated a deeper connection between cognitive understanding, emotional engagement, and ethical reflection. Students developed conceptual clarity through contextualized narratives, expressing curiosity and motivation to explore complex scientific ideas. Teachers observed improved participation and critical questioning, particularly when lessons incorporated human stories behind scientific discoveries. Emotional engagement emerged as a central outcome, leading students to relate abstract principles to lived experiences. Ethical awareness also surfaced as learners reflected on the moral implications of technological and environmental issues. These results collectively affirm that storytelling functions not merely as an instructional tool but as a medium for humanizing the learning of science and mathematics (Baily, 2024; Haden et al., 2023). The multidimensional nature of learning observed through narrative engagement underscores how stories act as bridges between disciplinary knowledge and human experience. Data revealed that students’ emotional resonance with stories enhanced retention and comprehension of STEM concepts. Teachers who shared narratives about perseverance, creativity, and moral responsibility cultivated empathy and ethical sensitivity among students. The study found that integrating narratives of scientific struggle and discovery enabled learners to internalize both factual and moral lessons. The intertwining of intellect and emotion produced a holistic form of learning that redefined STEM education from a purely analytical domain into a human-centered endeavor. The findings thus illustrate that narrative inquiry reestablishes the human voice in a field often dominated by abstraction and quantification.



The outcomes of this study align with emerging research in humanizing STEM education but extend existing understandings by situating storytelling as a central pedagogical method. Previous studies by (Kuijpers et al., 2023; Madsen et al., 2023) have shown that stories of scientists' lives can enhance engagement and motivation in science classrooms. The current study expands on these insights by demonstrating how storytelling simultaneously activates ethical and emotional dimensions of learning. While traditional studies focus primarily on affective or motivational impacts, this research identifies narrative as a comprehensive framework integrating moral imagination with scientific reasoning. This distinction reveals that stories not only inspire interest but also cultivate ethical responsibility in learners a dimension underexplored in prior literature. The present findings diverge from conventional STEM education models that prioritize procedural accuracy and content mastery. Traditional instructional paradigms often treat emotion and ethics as peripheral to the learning process. In contrast, this study shows that narratives can serve as epistemological structures through which learners interpret and construct scientific meaning. The findings support Bruner's (1990) argument that narrative knowledge complements paradigmatic thinking by enabling learners to understand science as a human narrative rather than a fixed truth. This study contributes to the growing discourse that human cognition operates through stories, and that narrative reasoning enhances not only comprehension but also moral judgment. The distinction lies in reframing STEM as a lived, storied experience rather than a depersonalized system of symbols.

The results also resonate with research on interdisciplinary learning that advocates bridging humanities and sciences through storytelling. Scholars such as Egan (1997) and Polkinghorne (1988) argue that stories function as cognitive tools for meaning-making, especially in abstract domains like mathematics. The findings of this study reinforce this view, demonstrating that when teachers integrate narrative forms into mathematical problem-solving or scientific exploration, students develop both logical precision and empathic understanding. This hybridization challenges disciplinary silos and validates narrative inquiry as a legitimate method for STEM pedagogy. The distinct contribution of this research lies in positioning narrative not as a supplement but as a structural principle for humanizing knowledge production in the sciences. The relational aspect of these results suggests that storytelling redefines classroom dynamics, transforming the teacher-student relationship into a collaborative inquiry (Ives, 2025; Madsen et al., 2023). The inclusion of human stories generated reciprocal engagement, where students contributed personal or local narratives that paralleled scientific phenomena. This reciprocal storytelling fostered a sense of co-authorship in knowledge creation, aligning with Clandinin and Connelly's (2000) notion of education as a shared narrative space. The study therefore highlights that narrative learning is dialogical and relational it thrives on empathy, curiosity, and trust between teachers and students. This finding differentiates narrative inquiry from content-driven instruction by emphasizing relational ethics as a core dimension of learning.

The findings signify a broader transformation in the understanding of STEM education's purpose. The emergence of ethical reflection in students' narratives indicates a shift from knowledge acquisition to moral engagement. Students began to perceive science and mathematics as moral practices intertwined with responsibility toward the environment, society, and technology. This signifies that STEM education, when guided by narrative inquiry, can cultivate not only problem solvers but also ethical citizens capable of critical reflection. The presence of emotional vocabulary such as "curiosity," "care," and "hope" in students' journals signals the restoration of affective depth in disciplines often viewed as emotionally neutral. This marks storytelling as a means to nurture moral imagination within STEM contexts (Perez & Farruggia, 2025; Sombrea et

al., 2024). The study's results also signify that narrative engagement functions as a democratizing practice. Students from diverse cultural and linguistic backgrounds found storytelling accessible, allowing them to relate scientific knowledge to their local realities. This accessibility reduced learning anxiety and fostered inclusion in classrooms that were previously dominated by competitive or hierarchical models of learning. The study thus identifies narrative inquiry as a socially just pedagogy that bridges epistemic divides between learners of varying abilities and backgrounds. The narrative process becomes not only a mode of teaching but also a mode of belonging, granting all students a voice within the scientific discourse.

The reflection derived from these findings positions storytelling as a pedagogical act of rehumanization. The results signify that moral and emotional learning are inseparable from cognitive development in STEM fields. Teachers and students co-created stories that transformed scientific concepts into lived experiences, reclaiming the ethical dimension of learning often lost in standardized curricula. The findings reflect a paradigm shift from content delivery toward reflective engagement an education that prioritizes understanding over memorization and wisdom over efficiency. Storytelling, as demonstrated in this research, becomes a moral dialogue that situates learning within the human condition. The implications of these findings extend across curriculum design, teacher education, and policy reform. Integrating narrative approaches into STEM curricula can foster empathy, ethical literacy, and interdisciplinary thinking. Teacher education programs should train educators to use storytelling as both an instructional and reflective practice, empowering them to humanize scientific content. Curriculum designers can embed narrative inquiry projects that allow students to connect personal, historical, and global stories to STEM issues such as sustainability, equity, and technological ethics. The findings imply that education systems must balance technical skill development with moral imagination to cultivate well-rounded global citizens.

The broader implication of this research lies in redefining educational success beyond cognitive metrics. Narrative-based STEM learning contributes to holistic development, fostering learners who think critically, feel empathetically, and act responsibly. By embedding moral reflection within scientific reasoning, storytelling prepares students for the ethical complexities of modern life climate change, artificial intelligence, and social inequality. The “so what” of this research is the realization that humanizing STEM education is not optional but essential for sustaining a just and compassionate world. The integration of stories ensures that learning remains rooted in humanity while advancing technological progress. The reasons behind these findings are grounded in the cognitive and emotional architecture of narrative learning. Stories activate neural pathways associated with memory, empathy, and comprehension, making them more effective in encoding complex ideas. Cognitive scientists such as E.O. Wilson (1998) and Damasio (2003) argue that human reasoning is inherently narrative, combining logic and emotion to create meaning. The study's findings corroborate this principle: storytelling engaged multiple modes of cognition analytical, imaginative, and ethical—thereby producing deeper and more enduring understanding. The human brain's affinity for narrative explains why stories resonate in ways that pure data cannot.

The emotional potency of storytelling further explains its transformative impact. Narratives allow learners to experience moral dilemmas vicariously, cultivating empathy and ethical reasoning. The results revealed that students who emotionally connected to scientific stories demonstrated higher conceptual mastery and moral sensitivity. This outcome supports the theory of “embodied cognition,” which posits that understanding arises through emotional and physical engagement rather than abstract cognition alone. The affective resonance of narrative learning thus accounts for the observed increases in empathy and ethical awareness among students. The social and cultural

context of the study also shaped these results (Adeniranye & Berhane, 2023; Odden et al., 2023). The multicultural learning environment allowed stories to serve as cross-cultural bridges that connected local knowledge with global scientific understanding. Students' personal narratives often blended traditional wisdom with modern science, creating hybrid epistemologies that enriched classroom discussions. This blending reflects the inherently intercultural nature of storytelling as a pedagogical tool, explaining why it proved effective in promoting inclusivity and ethical reflection. The cultural diversity of participants amplified the moral and emotional depth of narrative learning, affirming its universality across contexts.

The narrative inquiry approach itself contributed to the distinctiveness of the results. The method's emphasis on temporality, sociality, and place allowed moral and emotional dimensions to surface organically rather than being imposed through rigid categories. The reflexive nature of narrative analysis captured the lived realities of teachers and students as co-authors of their learning stories. This methodological coherence between research design and pedagogical practice explains the authenticity of the findings. Narrative inquiry, by design, mirrors the human experience of meaning-making, making it particularly suited for exploring the intersection of science, ethics, and emotion. The future of research in this domain should extend the exploration of narrative inquiry across diverse STEM disciplines and educational levels. Longitudinal studies could investigate how narrative engagement influences long-term ethical behavior, creativity, and interdisciplinary thinking. Comparative studies across cultural and institutional settings may reveal how local storytelling traditions shape moral and scientific imagination. The next step involves integrating digital storytelling and multimodal narratives into STEM pedagogy, harnessing technology to amplify empathy and reflective learning (Wofford & Henning, 2025). This future-oriented approach would strengthen the intersection between narrative, technology, and humanity.

The practical trajectory for education systems inspired by this research involves embedding narrative inquiry as a central philosophy rather than a supplementary method. Teacher development programs should cultivate educators who can design narrative-rich curricula and facilitate reflective dialogue. Institutions can establish cross-disciplinary initiatives where storytelling bridges STEM with ethics, arts, and social sciences. The "now what" of this study is the call to restore narrative as a unifying language of human knowledge one that reconnects reason with emotion, science with morality, and education with humanity. The study ultimately envisions STEM classrooms as spaces of moral imagination, where learning transcends technical skill to embrace empathy and ethical consciousness. The future of human-centered education lies in integrating stories into every dimension of teaching and learning. The "now what" emphasizes that narrative inquiry must not remain confined to qualitative research but evolve as a pedagogical movement shaping the future of STEM. Stories, as this study concludes, are not ancillary to scientific understanding they are the lifeblood of human learning, binding knowledge with compassion and innovation with conscience.

## CONCLUSION

The most significant finding of this research lies in its demonstration that storytelling serves as a powerful pedagogical medium for integrating cognitive, emotional, and ethical dimensions within STEM learning. The narratives collected through classroom observation and reflective journals revealed that students developed a deeper conceptual understanding when scientific and mathematical ideas were presented through human experiences. Teachers' use of stories about discovery, failure, and innovation fostered empathy, curiosity, and ethical reflection among students, transforming STEM education into a more holistic and human-centered process. This study differs from previous works by empirically showing how narrative inquiry repositions science

and mathematics not only as cognitive disciplines but as moral and cultural practices rooted in shared human meaning. The primary contribution of this research lies in its conceptual and methodological synthesis of narrative inquiry with STEM pedagogy. Conceptually, it introduces a framework that situates STEM learning within a triadic model knowledge, emotion, and ethics mediated through storytelling. Methodologically, it extends the use of narrative inquiry beyond the humanities and social sciences, demonstrating its applicability in scientific and mathematical contexts. The study contributes to educational theory by positioning stories as epistemological tools that bridge abstract reasoning with lived experience. This integration establishes storytelling not as a mere instructional technique but as a transformative approach capable of fostering reflective, empathetic, and ethically conscious learners in STEM fields.

The limitation of this study lies in its contextual and methodological boundaries. The research was conducted within a limited number of schools and cultural settings, which may constrain the generalizability of its findings to broader educational contexts. The qualitative nature of narrative inquiry, while rich in depth, does not fully capture the longitudinal impact of storytelling on students' academic performance or moral development. Future research should therefore adopt mixed-method designs that combine narrative analysis with quantitative assessment of learning outcomes. Cross-cultural studies could further explore how local storytelling traditions influence the moral and emotional engagement of STEM learners. Expanding digital and multimodal storytelling approaches also presents a promising direction for sustaining narrative-based, humanized education in the evolving digital age.

## AUTHORS' CONTRIBUTION

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

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