

Using Personal Storytelling, Narrative Structure, and Critical Incident Techniques to Examine Transformative Shifts in Graduate Student Self-beliefs of STEM Fit

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Abstract

In this full-length method paper, we introduce a narrative research approach designed to elicit and interpret meaning from graduate student lived experiences in STEM education. Jerome Bruner theorized a uniquely human mode of understanding, wherein knowing comes from retrospectively joining events and actions into stories. According to Self Determination Theory (SDT), long-term success in any field depends on the development of disciplinary and/or role-based identities (*autonomy*), feelings of belonging (*relatedness*), and beliefs about one's *competence* in relevant knowledge and tasks. In our NSF-funded collaborative project, we are implementing a co-curricular storytelling intervention designed to enhance graduate student self-beliefs and perceptions of STEM fit and improve graduate student retention in STEM. Analyses of non-narrative Year 1 and 2 project data (i.e., participant survey responses and semi-structured interview transcripts) establish that core activities of our storytelling intervention—writing, sharing, and refining personal stories—enable graduate student participants to reflect on and derive transformative meaning from their experiences in STEM.

In this paper, we introduce the analytic process developed to interpret narrative project data (i.e., written stories) generated by participants. We posited that our ability to *interpret within* the holistic complexity and richness of these stories requires a theoretically informed approach able to identify and examine the interplay of narrative structure and meaning beyond identifying plots and ordering events. Thus, we frame our approach using Critical Incident Techniques (CIT), identifying key events by tracing the emotional arc of each narrative. This approach enables identification of common structural patterns, while maintaining the narrative meaning participants derive from their journeys that we interpret considering SDT constructs.

We share our collaborative process, detailing each step using an example from project data. We present three preliminary insights from our nine participants stories. First, the deeply layered stories reveal the interwoven nature of SDT constructs of identity, belonging, and competence. Second, active meaning-making illustrates how participants constructed and interpreted the importance of their own resilience in relation to turning-point moments. Third, use of CIT and emotional arcs supports a systematic process to sort and synthesize narrative themes while retaining the richness and uniqueness of each story.

We recognize limitations of our approach, namely a potential for social desirability bias to affect story construction. While most stories analyzed end as redemptive stories (i.e., positive arc), they also describe emotional 'ups and downs' wherein participants show themselves as vulnerable and flawed and make their storied journeys realistic, relatable, and compelling. Because we encourage participants to share "scars not wounds", narratives tend to reflect growth and transformation, moving beyond the simplest redemptive narrative structures. Despite limitations, our approach enriches narrative qualitative inquiry in STEM, providing a framework for identifying turning points and positive responses to support graduate student STEM journeys. Additionally, our approach enhances organization development (OD) efforts and planned change processes by communicating critical-event driven change at the individual (storytellers') level to inform systematic institutional-level STEM interventions.

Introduction

In this full-length method paper, we introduce a theoretically informed approach using personal narratives, constructed by science, technology, engineering, and mathematics (STEM) graduate students through an organized reflective process of oral and written storytelling, to evoke and interpret meaning made through lived experiences in STEM. Graduate student well-being and thriving is critical to their retention in any field. According to Self Determination Theory (SDT) [1], intrinsic motivation, individual flourishing, and long-term success in any field requires development of disciplinary and/or role-based identities (autonomy), feelings of belonging (relatedness), and positive beliefs about one's competence in relevant knowledge and tasks.

As part of a multi-year, collaborative NSF-funded project [2], [3] in conjunction with the nonprofit organization The Story Collider [4], we are developing a co-curricular educational intervention—a personal storytelling workshop—to positively influence these vital mindsets and self-beliefs among graduate students, and, ultimately, support their retention in STEM. Currently, we are implementing the workshop and assessing subsequent shifts in self-beliefs and perceptions of STEM fit via pre/post surveys and one-on-one, post-workshop interviews with STEM graduate student participants at two public universities in the western United States. In prior work, we reported on mixed methods data generated across two project years and four workshops (including more than one hundred graduate student participants) that provide empirical evidence that workshop activities produce many intended outcomes [5], [6]. Thus, we find it appropriate to examine the workshop artifacts (i.e., personal stories) to identify and interpret the narrative meaning participants make in the context of graduate STEM education.

Purpose. In this work, we focus on the development of a narrative research method for identifying and interpreting the *narrative meaning* intrinsic to the workshop's unique artifacts—the stories written by participants. Grounded in theories of narrative cognition [7], [8], narrative structure (i.e., narratology) [9], emotional story arcs [10], and critical event analysis [11] / critical incident techniques [12], [13]), our approach enables us to identify relationships between events occurring over time via narrative plot and structure, and to closely examine the interplay between plot, structure and the (co-occurring, value-based) emotional arc of each story/storyteller. Examining this interplay, we (a) identify critical incidents (using the changing activation or valence of storyteller emotions) and their antecedents or triggers, (b) extract the meaning participants make about these critical events within in the written narratives, and (c) use SDT constructs to synthesize and interpret story arcs, lessons learned (i.e., meanings made), and topical themes across all narratives to generate broad implications for graduate STEM education at the individual and organizational levels. We guide our work with the research question:

What are thematic and structural characteristics of the personal narratives of graduate students about their STEM experiences, and how do these characteristics influence development of their (a) professional identity, (b) sense of belonging, and (c) feelings of competence in STEM?

Significance. Our work puts forth use of personal storytelling and narrative structure, combined with critical event analysis/CIT, as a promising approach for uncovering the meaning that graduate students develop by recounting their experiences in STEM. Given a generalized critique of narrative research conducted outside the humanities as “not being theoretical enough” [14, see also 15], this method paper is significant for a few reasons. It represents a substantial effort to construct and detail a theoretically informed approach for using personal narrative as a research tool in the context of graduate STEM education. In this way, our work supports theoretically

grounded implementations of narrative in STEM and engineering education research more broadly. Our work also supports the advancement of current interest in academic emotions [16], [17], [18] in engineering education, adding to what little is known about the interplay of emotions and events on identity and skill competency development in STEM fields [19].

Theoretical Foundations

Narrative cognition. Educational psychologist Jerome Bruner [7], [8] theorized a human mode of understanding distinct from the logical, rational, and deductive form of understanding commonly synonymized with human cognition (i.e., the computer model of the human brain). To Bruner, this other kind of cognition is “a narrative kind of knowing”; Bruner posited that both forms of human cognition are fundamental and cannot be replaced by, or reduced to, the other [7]. Adopting Bruner’s theory, we espouse an epistemological stance that knowledge as meaning—as opposed to rationalist truth [8]—is constructed by retrospectively considering the ordering and unfolding of (what may seem to be random and chaotic) life events and human actions into plots, as is done during storytelling and story writing [7], [20]. In a global sense, narrative cognition enables us to study and interpret the ways in which human experiences are lived and told through personal stories [11].

Narrative plot and structure. Narratology, known in the humanities as the theory of narrative and the science of storytelling, is defined as the “the study of the logic, principles, and practices of narrative representation” [9]. Two important categories of narrative representation are *narrative plot*, the sequence of unfolding events and actions, and *narrative structure*, the organizational framework and order used to present the plot. Narrative structure can be used to organize story elements into recognizable sequences that influence how the brain organizes information [21] and make stories more memorable. Since plot and structure are not necessarily identical or coincident, discernment of a story’s plot from within its structure is essential to understanding the story’s meaning.

Emotional arc. Beyond plot and structure, a third essential element of narrative representation is change—usually of the protagonist (in our case the storyteller)—over time. Simply put, a plot with structure but lacking change is not a story [9]. One approach for capturing change is to trace fluctuations in the emotional activation (i.e., valence) of the story/storyteller with the plot. This trace is often referred to as the emotional arc of the story [22], [see e.g., 18].



Fig. 1. Six common emotional arcs of narratives. Adapted by L. Neeley from Reagan et al. [10]

Research shows that stories written throughout history are dominated by six basic emotional arcs [10]. Three arcs (top row Figure 1) end at a higher emotional state than they begin and have

“happy” endings; three (bottom row Figure 1) conclude at a lower emotional state than at the start and are tragedies—stories with bad endings. It is important to note that the “fall” or “rise” movement on the arc is not always singular, and that graduated steps or gradients of rise (or fall) occur; we may call this occurrence “stacking” of emotional levels/states.

While emotional arcs do not offer direct information about narrative plots, structures, or meanings, they do provide (a) cues and clues as to how unfolding events are being experienced by—and potentially transforming—the characters, and (b) an affective impetus for continuing engagement with a story [10]. Thus, emotional arcs provide information about characters’ internal emotional journeys, indirectly supporting interpretations of the meaning and depth of a story and the gravity of its outcomes. Because we identify the internal journeys of characters using emotional arcs, the inflection points of emotional arcs highlight the most significant changes—when critical events/incidents occur—in the internal world of the storyteller.

Critical event analysis/Critical incident techniques. Webster and Mertova [11] proposed that experiential narratives can be used as “event-driven” methodological tools in educational research since “our memory of past critical events often leads us to adapt strategies and processes to apply to new situations.” These scholars defined critical events in narrative, saying, “...a critical event as told in a story reveals a change in understanding or worldview of the storyteller” [p.73]. Critical events are significant because they mark a fundamental change in the storyteller’s worldview or identity. Critical event analyses [11] and CIT [12], [13] encompass the determination of critical events/incidents; like events that repeat the context, method and resources of critical events with different characters; and other events occurring at the same place, time and context of critical and like events and intuitively informing critical events across triangulated data sources.

Filling a methodological gap. While we conduct non-narrative, mixed methods research methods (e.g., surveys, interviews) with participants to measure and characterize the outcomes of our storytelling intervention, non-narrative methods do not help us identify critical points in participants’ journeys or extract details of time-dependent processes of experiential meaning-making. Because our intervention (i.e., workshop) guides students in story building in a 20-hr mentored effort, we deemed it important to include in our approach “an analysis of the [meaning-making] process ... which is not possible using a thematic analysis only” [13, p. 396]. To undergird a narrative analysis [20] process to *uncover critical events through their connections to other events*, we draw from methods-based research on CIT and mechanisms of change, to enable a deeper understanding of “participants’ interactions with intervention contents” [13, p. 38] that prompt storying acts. Our work fills a methodological gap, enabling us to discern *how (the mechanisms through which) our intervention achieves its outcomes* by connecting plot, structure, and emotional arc of participants’ stories to interpret critical incidents as a meaning making channel.

Analytic Approach

In this work, we wanted to go beyond identifying common threads or themes, across the participants’ stories paradigmatically [20], by labeling and categorizing the contents or *text* of the stories (i.e., content or discourse analyses). We further recognized that narrative structure allows us to consider turns (of events) within and across stories, since individual stories echo stories of others in a common sociocultural world [11, 23]. Thus, before attempting to combine elements and meaning across narratives paradigmatically, we first took steps to identify how individual

change happened through unfolding events and the emotional arc of each story. Examining the plot, structure and emotional arc of each story individually, we paid special attention to the unfolding of connected elements, “which is neither one of logical consequence nor one of mere succession... [but meant] to display in what way occurrences represent actions” [11, p. 19]. The unfolding “is not required to be explanatory in the sense in which a scientific theory must show necessary [and hypothesized] connections among appearances” (p. 19). We followed a process of identifying the natural (“unforced”) unfolding of the plot elements that each story reveals prior to combining narrative elements and meaning paradigmatically across stories.

Narrative analysis process development. It is the retelling of events during the personal storytelling workshop that allows us to capture their narrative meaning making. Conflict between belief and reality of experience causes the storyteller to grapple with accommodating the change and, at times, generate new categories of knowledge [24]. Notably, temporal aspects of and reflections on experiences are especially important for understanding impacts of change. In that sense, we drew from the six steps of Kostamo’s et al. [13] framework for analysis of change using critical incidents [Tab. 2, p. 392]: 1) getting acquainted with the data assuming no particular perspective, 2) outlining data to find change descriptions, 3) summarizing participants’ descriptions of changes with regard to outcomes, 4) identifying critical incidents, 5) categorizing critical incidents, and 6) comparing change processes and critical incidents.

Guided by this framework, our team adapted the six steps to fit our data and goals through multiple and collaborative readings of three stories selected at random. Together, we adapted/expanded the six steps into the following nine step process:

1. **Gather, de-identify, and read** participant stories to identify the topic (what is this story about?)
2. **Immerse** in re/reading the story, categorize it as one of six basic emotional arcs
3. **Trace and refine emotional arc** using plot events and emotions of the storyteller, name emotional state at the STEM story start (name break between background and STEM story)
4. **Identify critical incidents** by examining emotional arc inflection points, plot, and structure
5. **Determine trigger(s)** of each critical incident by examining the event or action leading to or resulting in the critical incident(s)
6. **Determine the emotional change** by interpreting the emotional state and story arc stage of each critical incident.
7. **Identify meaning-making/lesson learned** (if provided) through each critical event as reflected on and told by the storyteller; include salient excerpts about meaning made
8. **Group data instances and excerpts** together across all stories by topic, arcs, triggers, critical incidents, and lessons learned
9. **Develop threads or themes** within groups and, as applicable, according to SDT constructs

The initial emotional state of the storyteller, which occurs at the start of the STEM journey, is discerned through background and context of the story. This initial state corresponds to the valence of the sentiments and feelings the participant experiences just before their STEM journey begins and prior to the first critical event in the plot. We depicted the valence of emotional states comparatively as low, moderate, or high. We plotted emotional arcs arising from plot and structure combinations from story beginning to end, following the fall and rise in storyteller sentiment [10].

Ensuring quality. To ensure quality in our process and trustworthiness in our findings, we relied on prolonged and repeated researcher engagement with each story by at least two team members, taking an emic perspective, using reflexivity in balancing what the participants narrated and what we interpreted, and building consensus on results of analytic tasks in early stages of development [25]. Initially, to develop the steps and format, each team member analyzed the same three stories to “test” and “calibrate” our interpretative process.

To formalize our procedure, we documented and systematized the nine-step process using an Excel-based form. On the one hand, this form enabled us to preserve the integrity and chronology of each story while making analytic decisions explicit and traceable based on their background information (Steps 1-7). On the other hand, the form supported cross-case comparison (Steps 8-9) and facilitated process validation through collaborative review.

We applied minor modifications to the excel form by repositioning columns, such as moving the trigger column next to the critical event and differentiating among low-medium-high emotional levels through close readings of the story and collaborative development. We found that the form helped us ensure consistency and repeatability of the relevant analytic steps. Our rich set of stories included a variety of participant perspectives. Salient quotations depicted in the process further represented “how the interpretations fit the data” [25, p. 578].

Once the basic process was developed using three stories, two members each read and analyzed an additional three narratives each (a total of six new stories) and the third member served as the second reviewer and analyzed all six. All three team members met and resolved a total of six disagreements related to clarifying triggers and events (the original agreement was about 90%), and reached a consensus. Analysis of the remainder of the forty-one stories collected over two project years is ongoing.

During process development, we noted that each of the participants’ stories were stories of redemption (positive endings), rather than stories of contamination (negative endings). Because we are employing storytelling as an educational intervention, this finding links favorably to the idea that “[p]eople who believe their lives are meaningful tend to tell stories defined by growth, communion and agency” [26, para. 4]. As McAdams [27] and McAdams and Bowman [28] suggest, it is important to note that these stories written by participants are not exhaustive but rather are constructed of narrative choices—the most extraordinary good and bad events, leading to good outcomes despite obstacles and regaining control of one’s life. Redemptive stories help craft a positive professional identity in STEM and promote a deeper sense of self and capacities.

Example of the Approach. To illustrate our method, we present findings of Steps 1-7 applied to one participant’s narrative (Table I). Findings from Steps 1-3 are presented in the “story information” column; results from Steps 4-7 are recorded in follow-on columns (Table I). Findings from Step 6 are reflected across two columns: “emotional change” captures the valence of each critical incident; valence change recorded in the “story arc stage” column clarifies fit within the overall emotional arc specified in the “story information” column during Step 1. The “lesson learned” and “excerpt” columns describe the storyteller’s meaning-making.

Our example narrative is a story of a mechanic who is deeply dissatisfied with his current ‘nuts-and-bolts’ job. After a difficult day and buoyed by the support of his wife, he decides to pursue his true passion for a career in computer science. Throughout his career transition, he faces and overcomes many challenges, forming a new professional identity and asserting computer science

competencies in the process. (Steps 8-9, related to discerning patterns across the stories, are described in a subsequent section.)

TABLE I
EXAMPLE OF STEPS 1-7

Story information STEPS 1-3		CI: <i>What happened?</i> STEP 4	Trigger: <i>What led to CI?</i> STEP 5	Emotional change STEP 6	Story arc stage STEP 6	Lesson learned STEP 7	Excerpt STEP 7
ID	S4-Y1	CI-1. Submits computer science job application to affect career transition from mechanical work	Dissatisfied with current job; wife's expression of support	L→H	↑	Identify your passion; choose a path to pursue it	"Then she asks me what I want to do and that she'd support whatever decision I make. I always knew I wanted to get into game design."
STEM story start	Tired mechanic, soaked and cold, comes home; wife asks about job satisfaction	CI-2. Receives multiple CS job rejections at end of undergraduate education	Competitive job market	H→L	↓	Unforeseen difficulties in entering the job market with the right passion	"Everywhere I apply I get rejected. When you're going through your undergrad as a Computer Science major you hear about how competitive the field is, but seeing it firsthand felt like running into a brick wall."
Initial emotional state	Low	CI-3. Emails a Prof and gets a suggestion to apply to the CS research team	Fear of returning to mechanic work; recalling father's advice on connections	L→H	↑	Networking can open doors	"As a shiver ran up my spine from the thought of going back there, I remembered one of the only things my father ever taught me, "Sometimes it's not what you know but who you know."
Topic	Negotiate professional identity through disciplinary or career transition	CI-4. Experiences Interview anxiety	Lack of relevant knowledge or skill; self-perceived inadequacy	H→L	↓	—	—
Emotional arc	Cinderella	C-I5. Receives CS job offer	—	L→H	↑	Opportunity can come unexpectedly; the value of tenacity	"All at once the feelings of not being enough, of wasting my time and money, of letting my amazing wife who believed in me down, all of these feelings melted away."

The story follows a chronological structure (timeline) and presents information, such as describing the storyteller's background and initial emotions (as described under the "Story information" columns in Table I). By isolating these initial characteristics, we anchor the participant's starting position prior to the occurrence of critical incidents; this grounding is essential for interpreting subsequent changes and the overall emotional arc (which is curvilinear).

The first critical incident occurs when the mechanic applies for a computer science job. This first incident is the direct result of two triggers: his increasing job dissatisfaction reaching a boiling point on a tough day, and his spouse's expressions of empathy and support for a career change. This first critical incident marks the beginning of the participant's identity reconstruction through an intentional career transition.

Subsequent critical incidents serve to complicate the emergence of the storyteller's computer science professional identity. Multiple job rejections following undergraduate degree completion in computer science are triggered by the competitive nature of the computer science labor market. Here, emotional change shifts from high to low, reflecting personal discouragement and self-doubt. A pivotal moment occurs when the participant emails a professor and receives encouragement to apply to a research team. This incident (sending the email) is triggered by the storyteller's fear of having to return to mechanical work, coupled with his recalling of parental advice emphasizing the power of social capital. The story culminates in the mechanic receiving an offer in computer science after participating in an interview that he thought was not entirely successful. This final moment highlights the participant's reconstructed identity, wherein he replaces feelings of inadequacy with affirmation and a renewed sense of belonging in the computer science field.

Along with each critical incident, we determined the direction of the emotional shift and identified the lesson that the participant learned. Importantly, not every incident resulted in a lesson or discrete meaning-making event (the same is true for triggers). Some lessons emerged incrementally after reflection, thus allowing identity, belonging, and impostorism to be inductively linked through the participant's meaning-making, rather than imposed deductively.

5. Preliminary Findings

We present preliminary findings of our approach from the analysis of nine stories, conducted by at least two team members and confirmed through consensus. After completing Steps 1-7 using Table I for each of nine stories, we moved to Steps 8-9, grouping and patterning topics, critical incidents (CI), triggers, and lessons learned across the nine stories. Findings provide a profound understanding of students' transitions, which can be used to support educators in their efforts to mitigate impostor syndrome and foster inclusive graduate level STEM environments.

Categorization of Topics. Across the dataset, we discerned three overarching topics related to how STEM graduate students experienced their academic journeys. The first topic focuses on *overcoming personal, physical, or emotional hardship* that negatively affects STEM graduate students' academic opportunity, participation, or completion. Stories in this category illustrate how obstacles outside of the participant's control, such as poverty, lack of resources, structural inequities, physical injury, or profound personal loss, initially constrained and destabilized their academic participation and progress, yet became sites of personal transformation. Through persistence, meaning making after trauma, reframing of purpose, and renewed motivation, students transformed adversity into a source of strength, thus enabling their success.

A second topic reflects participants' efforts to *negotiate or reconstruct their professional identity through disciplinary or career transition*. Rather than following linear academic or career pathways, participant stories revealed periods of uncertainty and change of path, often accompanied by self-doubt. These transitions required perseverance and an open mindset to deliberate through identity negotiation to achieve reconstruction.

The third topic centers on the *transitions of international graduate students to U.S. based graduate STEM programs*, including early adaptation challenges they face in the new culture and academic environment. These narratives emphasize the emotional shifts of relocating to a new country while simultaneously meeting the demands of STEM graduate studies. During the early stages of transition, initial experiences of isolation and/or imposter syndrome are often extremely amplified. However, growth occurs through increased self-reliance, support seeking, and the gradual formation of supportive peer, mentor, and academic communities. Collectively, these stories illustrate how adaptation is not merely a logistical concern, but is deeply intertwined with the development of identity, belonging, and confidence in one's academic capabilities.

TABLE II
RELATIONSHIP BETWEEN TRIGGER TYPES, CRITICAL INCIDENT TYPES,
AND LESSONS LEARNED ACROSS THE NINE STORIES

Trigger Type	CI Type	Lesson Type
Prior structural and resource constraints and /or sudden personal trauma	Failures related to scarce learning opportunities and /or disruptions to academic life	A mindset of perseverance, tenacity, hope, and resilience leads to resolution— growth through—constraints, adversity, and challenges (including personal trauma)
Professional identity tension and career dissatisfaction	Disciplinary or career transition decision	Personal change, transition (could be international/cultural transition) and identity development are interconnected phenomena
Vulnerability and emotional isolation during international transition to graduate STEM education	International travel crisis, communication crisis, or collaborative turning point	Belonging can occur through interpersonal collaboration, help-seeking, and support in professional relationships
Unfamiliar graduate STEM education environments and teaching methods	Academic struggle and performance challenge	Adaptation to teaching styles and resources, and strategic learning approaches (could be caused by international cultural changes, or advanced coursework) lead to... ... STEM competencies take time to develop in the wake of imposter syndrome due to the subject matter and nature of scientific research

Categorization of Triggers, Critical Incidents, and Lessons Learned. Next, as shown in Table II, we categorized triggers, critical incidents, and lessons that participants learned across the nine stories. We considered each of these elements to be sequential and interactive or relational components of participants' narrative sensemaking. Organizing these three elements in sequence, trigger → critical incident → lesson, allowed us to trace how personal, academic, and professional experiences unfolded from triggering events into moments of personal transformation. This structure also enables us to make analytic connections to identity, sense of belonging, and impostorism by examining the resultant meaning-making lessons using SDT.

6. Discussion and Implications

This methodological approach manifests how storytelling and CIT, when implemented together, can surface moments that shape STEM graduate students' experience and, potentially, influence their retention in the field. Beyond indirect survey or interview responses that provide information about the perceived effects of workshop participation, the deeply layered stories reveal the interwoven nature of identity, sense of belonging, and competence as experienced by participants during the STEM graduate education. Preliminary findings suggest that our multi-dimensional approach captures not only what happened—the experiences themselves—but also how students retrospectively made sense of those experiences through personal reflection and narrative meaning making. Such active meaning-making illustrated how students manifested resilience in relation to turning-point moments. As such, the integration of personal storytelling and CIT provided a framework not only for categorizing or systematically grouping of incidents linked to themes such as *identity*, *sense of belonging*, or *competence*, but also for understanding how those themes occurred and what they meant to the participant by incorporating the individuality (plot, structure, emotional arc) of each story into the analysis process.

Emotion and academic and professional development. Using personal storytelling to evoke and interpret participants' experiences, our results point to a suite of interventions with potential for improving retention in STEM education. For example, the role of emotion in personal and professional development of students is particularly interesting; it stresses the potential importance of storytelling as pedagogy in fields, such as STEM, driven by logic, objectivity, and rational decision-making. A more complete study of human experience includes the subjective emotional states of participants to serve as critical entry points into a field of study.

SDT links our work to the idea that the experience of difficult emotions, such as pride, empathy, struggle, and shame, can influence students' feelings of competence, improve the desire to attain academic and professional goals, and help students become more *determined* in the pursuit of STEM education and careers. In the process, reflection on lessons learned (i.e., consequences of critical incidents and how they resonate in present life) supports emotion management and recovery, building resilience and motivation often in a form of regained autonomy, as well as purpose, in a future profession. Students also connect to work/academic groups with similar experiences (social/professional identity). Each of these outcomes should be considered during development of educational interventions related to STEM students' academic and professional transitions, which could help educators envision unique interventions and/or comparison groups.

Change as a participatory process through ARM. Our preliminary findings, which demonstrate the transformation and change that can occur at the individual graduate student level, can also be translated to a group/systems level and applied in educational institutions in a

larger sense. Our workshop researchers (and, simultaneously, institutional leaders) are in a unique position to facilitate participatory efforts of the student-storytellers directly in the workshops and co-interpret lessons-learned informing future institutional interventions. Drawing from organization development and contemporary adaptations of Lewin's action research model (ARM) of planned change [29], we see how the model could work in marked congruence with our narrative storytelling intervention by positioning students as legitimate co-agents of change. Contemporary ARM guides change action through "member [narrator] involvement in the change process" [29, p. 26] and (potentially) intervention selection, in contrast to more traditional approaches wherein institutional experts (e.g., consultants, administrators, staff) do so alone. Change is viewed as a participatory process [30] that ARM guides through the stages of storytelling subject identification, broad participation and representation, data examination and developing intervention propositions, visioning – "what should be" in terms of new shared meanings of students' persistence in STEM, sense of belonging, and professional fit - forming action plans (with institutional leaders, faculty, staff, *and* student members), evaluating interventions and institutionalizing successful change programs [29]. Other career development interventions (e.g., conference presentations; communication trainings; cross-cultural adaptation interventions) are also made possible by the narrative method and critical incident identification.

7. Study Limitations

We recognize that our method, like all methods, has limitations. This method relies on the development of deeply personal, reflective written narratives of experience. The act of constructing these stories may introduce limitations related to the recall of actual events and the subjective reconstruction of narrative events, as well as personal preferences, likes, and dislikes.

A second limitation may be seen in the fact that all participant stories we have analyzed thus far are redemptive in nature. It could be that social desirability bias [31] interferes with the retrospective and reflective process of storytelling and story writing; participants may simply be reluctant to write and share stories that show them, their actions, behaviors, and decisions, in a negative light. However, along with positive endings, these stories also reveal descriptions of participant vulnerabilities, mistakes, failures, and emotional 'ups and downs' that tap into empathic responses from readers and help storytellers avoid social desirability bias for the purpose of making them more realistic and compelling. At the same time, participants are encouraged to share "scars rather than wounds" and to write narratives about experiences in the past, rather than ones that are still unfolding. Thus, the narratives are seen to move beyond simple redemptive arcs and reflect growth and transformation in hindsight.

Despite potential limitations, the study presents a promising approach for understanding the meaning participants make of their experiences by combining the interpretive power of storytelling, the order of narrative structure and the systematicity of CIT. Our approach enriches qualitative inquiry in STEM education, providing researchers, educators, and administrators with a framework to uncover turning points and facilitate positive triggers in the students' transition and development process in STEM fields.

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References

- [1] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *American Psychologist*, vol. 55, no. 1, pp. 68–78, 2000.
- [2] K. Pakala, A. Minichiello, U. Nguyen, A. Hamby, E. Jankowski and J. Pokimica, *IGE: Transforming STEM graduate education: Enhancing identity, belonging, and reducing impostorism through storytelling*, Proceedings of the 132nd Annual ASEE Conference & Exposition, June 2025, Montreal, Quebec, Canada.
- [3] K. Pakala, A. Hamby, J. Pokimica, A. Minichiello, E. Jankowski and U. Nguyen, *IGE: Narrative identity in STEM: Storytelling as a catalyst for graduate student success*, Proceedings of the 133rd Annual ASEE Conference & Exposition, June 2026, Charlotte, North Carolina.
- [4] <https://www.storycollider.org/> Accessed Dec 28, 2025.
- [5] A. Minichiello, K. Pakala, U. Nguyen, A. Hamby, E. Jankowski and J. Pokimica, *Actualizing graduate student identity, belonging, and feelings of competence in STEM via personal storytelling*, Proceedings of the 132nd Annual ASEE Conference & Exposition, June 2025, Montreal, Quebec, Canada.
- [6] A. Hamby, J. Pokimica, A. Minichiello, K. Pakala, and E. Jankowski, "Institutional storytelling as a catalyst for identity transformation and social change," *The Journal of Macromarketing*, vol. 46 no. 1, pp. 69–83, 2026.
- [7] J. Bruner, *Actual Minds, Possible Worlds*, Cambridge: Harvard University Press, 1986.
- [8] J. Bruner, *Acts of Meaning*, Boston, MA: Harvard University Press, 1990.
- [9] J. C. Meister, "Narratology", Paragraph 1. In: Hühn, Peter et al. (eds.), *The Living Handbook of Narratology*. Hamburg: Hamburg University. URL = <http://www.lhn.uni-hamburg.de/article/narratology> Retrieved Dec 28, 2025.
- [10] A. J. Reagan, L. Mitchell, D. Kiley, et al, "The emotional arcs of stories are dominated by six basic shapes," *EPJ Data Sci.* vol. 5, no. 31, 2016. <https://doi.org/10.1140/epjds/s13688-016-0093-1>
- [11] L. Webster and P. Mertova, *Using Narrative Inquiry as a Research Method: An Introduction to Using Critical Event Narrative Analysis in Research on Learning and Teaching*, Routledge/Taylor & Francis Group, 2007. <https://doi.org/10.4324/9780203946268>
- [12] J. C. Flanagan. "The critical incident technique," *Psychological Bulletin*, vol. 51, no. 4, 1954.
- [13] K. Kostamo, P. Jallinoja, K. M. Vesala, V. Araújo-Soares, F. F. Sniehotta, and N. Hankonen, "Using the critical incident technique for qualitative process evaluation of interventions: The example of the 'Let's Move It' trial," *Social Science & Medicine*, vol. 232, pp. 389-397, 2019. <https://doi.org/10.1016/j.socscimed.2019.05.014>
- [14] D. J. Clandinin and F. M. Connelly, *Narrative Inquiry: Experience and Story in Qualitative Research*, San Francisco: Jossey-Bass, 2000.

- [15] J. H. Kim. *Understanding Narrative Inquiry*, Sage Publications, Inc., 2016.
- [16] J. Lönngren, A. Bellocchi, M. Berge, P. Bøgelund, I. Direito, J. L. Huff, K. Mohd-Yusof, H. Murzi, N. Farahwahidah Abdul Rahman, and R. Tormey, “Emotions in engineering education: A configurative meta-synthesis systematic review,” *Journal of Engineering Education* vol.113, no. 4, pp. 1287–1326, 2024. <https://doi.org/10.1002/jee.20600>.
- [17] J. Walther, M. A. Brewer, N. W. Sochacka, and S. E. Miller. “Empathy and engineering formation,” *Journal of Engineering Education*, vol.109, no.1, pp.11–33, 2020. <https://doi.org/10.1002/jee.20301>.
- [18] N. Kellam, K. Gerow, G. Wilson, J. Walther, and J. Cruz. “Exploring emotional trajectories of engineering students: A narrative research approach.” *International Journal of Engineering Education*, vol. 34, no. 6, pp. 1–15, 2018.
- [19] E. Treadway, J. Swenson, L. Maykish, and S. Lape, “Influences of local affect on the development of engineering identity,” *European Journal of Engineering Education*, pp.1–25, 2025. <https://doi.org/10.1080/03043797.2025.2575763>
- [20] D. E. Polkinghorne. *Narrative Knowing in the Human Sciences*, Albany, NY: State University of New York Press, 1988.
- [21] H. J. Chu, J. Swaffar, and D. H. Charney “Cultural representations of rhetorical conventions: The effects on reading recalls," *TESOL Quarterly*, vol. 36, no. 4, pp. 511–541, 2017. doi:10.2307/3588239. JSTOR 3588239. [Retrieved Dec 28, 2025].
- [22] S. Zhong and D. B. Hitchcock, “Functional clustering of fictional narratives using Vonnegut curves,” *Adv Data Anal Classif*, vol.18, pp.1045–1066, 2024. <https://doi.org/10.1007/s11634-023-00567-1>
- [23] A. H. Dyson and C. Genishi, *The Need for Story: Cultural Diversity in Classroom and Community*. Urbana, IL: National Council of Teachers of English, 1994.
- [24] J. Fay, J. “A narrative approach to critical and sub-critical incident debriefings,” *American School of Professional Psychology*. Dec 30, 2025. [Online]. Available: Narrative Approaches, <https://narrativeapproaches.com/resources/academic-resources-2/145-2/> [Accessed Dec 30, 2025].
- [25] E. Nutt Williams and S. L. Morrow, “Achieving trustworthiness in qualitative research: A pan-paradigmatic perspective, *Psychother. Res.*, vol. 19, pp. 4-5, 576-582, 2009.
- [26] E. Esfahani Smith. “The two kinds of stories we tell about ourselves,” Jan 12, 2017. [Online]. Available: [Ideas.Ted.com](https://ideas.ted.com/the-two-kinds-of-stories-we-tell-about-ourselves/). <https://ideas.ted.com/the-two-kinds-of-stories-we-tell-about-ourselves/> [Accessed Dec 30, 2025].
- [27] D. P. McAdams, “The redemptive self: Generativity and the stories Americans live by,” *Research in Human Development*, vol. 3, no. 2–3, pp. 81–100, 2006. [Online]. Available: Taylor & Francis, <https://doi.org/10.1080/15427609.2006.9683363> [Accessed Jan 3, 2026].
- [28] D. P. McAdams and P. J. Bowman, “Narrating life's turning points: Redemption and contamination,” in *Turns in the Road: Narrative Studies of Lives in Transition*, D. P. McAdams,

R. Josselson, and A. Lieblich, Eds. Washington, DC: American Psychological Association, 2001, pp. 3–34, 2001. Available: <https://doi.org/10.1037/10410-001>

[29] T. G. Cummings and C. G. Worley, *Organization Development and Change*, 7th ed. Mason, OH: South-Western College Publishing, 2001.

[30] M. Elden and R. Chisholm, “Emerging varieties of action research: Introduction to the Special Issue,” *Hum. Relations*, vol. 46, no 2, pp. 121-42, 1993.

[31] N. Bergen and R. Labonté. “‘Everything is perfect, and we have no problems’: Detecting and limiting social desirability bias in qualitative research,” *Qualitative Health Research*, vol. 30, no. 5, pp. 783-792, 2020.