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Do Universities Still Need their Campuses?

Ian Winchester
University of Calgary

In the beginning, as with Bologna in 1108 or Oxford in the early 12th century or the medieval university of Paris, universities were places where students and teachers might congregate in buildings on a physical place of pleasant land. The great universities of today such as Oxford, Cambridge, the Sorbonne, Harvard, Stanford and their Canadian ilk all across the vast country of Canada like the University of Toronto, McGill, UBC, the University of Alberta (and the University of Calgary from where I am writing)all have remarkable and beautiful campuses with many useful buildings upon them.

The things taught today in all of these universities are much the same as they were when the European university movement began. Students wanted to learn about history, ancient and modern languages, philosophical questions, religious studies, the arts, practical and important disciplines relating to medicine, law, engineering. And after the advent of Galileo and Newton in the 17th century the whole array of modern sciences and their applications beckoned and became permanent parts of the university as and expanded kind of universal institution. And for all of these things we continue to need know there were since the beginning, older scholars wiling to teach.

Perhaps because the climate of the large part of Europe (a climate with spring, summer, autumn and winter requiring from time to time to be indoors and warm) all such places had buildings where students could eat, sleep, attend large classes, or intimate meetings with their tutors or teachers. All such universities necessarily had many buildings of many different kinds.

The question I wish to ask today is: Are such spaces and buildings still necessary in a world with many more possibilities for students to gather and teachers to teach? In other words do we still need campuses for universities?

I am thinking especially of the experience of the whole world during and after the universal presence of COVID 19, a plague that affected us all and killed many. For during and after covid we found ourselves having developed entirely new ways for students to gather

and to be taught by those who knew what they wanted to learn. For example such powerful ways of presenting many students and instructors simultaneously on computer screens as Zoom and Microsoft Teams were developed rapidly and almost universally used during that covid period.

The whole effort of that time was to keep people at a physical distance from one another so that they might not catch or spread this terrible plague, covid 19, to others. So we have some four or five years with total isolation of teachers and students. The only exceptions was where wearing masks and the being in special physical places was necessary such as in a laboratory, in a library, with a patient, working on building things together or in Engineering schools that required close human contact and the like.

We learned to teach K-12 school students living in their own homes and not going to school using computers connecting the teacher and the students on line. And the faces and voices of teachers and students could easily be present so that complete isolation was avoided or even superseded by another kind of necessary intimacy. One parallel development was that mothers and fathers were often also home to avoid unnecessary contact with others. So the home schooling movement expanded greatly and almost universally as a side effect of these generally new approaches to teaching and learning.

At the present time governments and businesses are now trying to bring back to their physical spaces, offices and laboratories many of the people who had been dispersed by the necessary protections for covid. Public schools have largely returned to the pre-covid ways with both students and teachers returning all week to their schools and playgrounds. But at many universities it has been possible to teach many courses entirely on line.

The most striking implication of this possibility is that many of the offices and lecture halls set aside for teachers and teachers are largely empty. International students even local students are now often able to take their degrees without having to pay for food and lodging and local travel in the town where their university happens to be located or at their university itself.

One example is the faculty where the Journal of Educational Thought is located, the Werklund School of Education. While from time to time the teaching faculty in a given specialization gather for

particular meetings, in general these university teachers in graduate programs there still largely work from home and teach their courses at the graduate level largely on line using Zoom and its ilk.

This means that our offices and teaching spaces for are largely empty. This seems to be largely true for the rest of this university with respect to the programs and the arts and wherever access to physical things (laboratories, civil engineering) or present people (medicine, kinesiology, teacher training).

Except for a very limited exceptions university teaching and learning could be done with Zoom like teaching and learning provisions. Our libraries are now possible to be digital facilities and not large rooms full of heavy books.

So the easy conclusion is that we might easily close down most if our physical facilities that make up our present university campuses. Or at least strongly reduce these.

What arguments might we then offer to instead maintain the present arrangements with large physical spaces and a multitude of splendid buildings that must be largely supported by our governments?

It seems to me that such arguments must be made by all the faculties in universities like the one where the Journal of Educational Thought is editorially found. So I would propose that the new editor of our journal arrange a special issue dedicated to the topic of the present necessity of maintenance of the physical campuses that are continuous with the entire history of the university movement.

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Postplagiarism and the Remaking of Education, 2000 to 2050

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Abstract: I have spent much of my career studying ethics and integrity in educational contexts, including plagiarism, contract cheating, and other forms of educational and scientific fraud. From where I sit in 2026, the half-century from 2000 to 2050 divides into two phases. The first (2000-2025), now a matter of record, was organized around detection of misconduct: institutions increased access to education while building ever more elaborate machinery to verify that student work was authentically human. The second half of this century, now beginning, rests on a different premise. Humans and machines write together, and policing where the human ends and the machine begins is not only difficult, it may well be an exercise in futility. In this, my first editorial as the incoming editor-in-chief of the *Journal of Educational Thought* (following in the footsteps of my colleague, Ian Winchester) I take a position. The detection paradigm has failed on its own terms, and the sooner we say so, the sooner we can build what comes next. I explore the postplagiarism era as an entry point to the second half of the first century in this millennium.

Keywords: postplagiarism, education, ethics, future, higher education, academic integrity, plagiarism, artificial intelligence, GenAI, academic misconduct, academic fraud

The Era of Detection, 2000 to 2025

The first quarter of the century was defined by scale. Enrolment in higher education rose from roughly 100 million students in 2000 to nearly 269 million in 2024 (UNESCO, 2026). International student mobility nearly tripled over a similar period, from 2.5 million students in 2002 to 7.3 million in 2023, a figure UNESCO projects will reach 9 million by 2030, though fewer than 3% of students ever study abroad

(UNESCO, 2026). Beneath the growth sat a single organizing logic: governments treated education as investment in human capital and national competitiveness (Spring, 2008).

The technology arrived in stages. For example, learning management systems (LMSes) moved the institutional centre online in the 2000s, open online courses promised wider access in the 2010s, and the COVID-19 pandemic compressed years of digital adoption into months, reshaping tertiary education and exposing access to devices and connectivity as a condition of participation rather than a convenience (UNESCO, 2026).

A defining contradiction of the detection era was not technical, but ethical. As students grew adept with networked tools, institutions answered with surveillance: text-matching software (erroneously called plagiarism detection software), remote proctoring, and algorithmic monitoring. Ian Winchester (2024) noted the "great fuss" that generative AI provoked in scholarly circles, yet the deeper problem preceded ChatGPT. Detection carried a cost, one which fell unevenly. Remote proctoring has been described as ableist, and AI-detection tools produce false positives that land disproportionately on neurodivergent students and on those whose first language is not the language of instruction, with documented psychological and material harm to the accused (Eaton, 2023). Institutions adopted these tools to protect the integrity of assessment. In practice, the tools penalized difference.

Postplagiarism

By 2025, we had crossed a threshold. Once human and machine routinely wrote together, the search for purely human text became futile. Muñoz-Cantero and Espiñeira-Bellón (2024) reached the same conclusion from medical publishing, noting that text produced through AI and machine translation evades the text-matching tools built to catch copied work. I began to explore postplagiarism in 2021 and developed it into a full framework in 2023 to name this shift (Eaton, 2021, 2023). Postplagiarism describes a period in which advanced technologies are integrated into everyday academic life so completely that technology cannot be decoupled from education, and in which humans are co-creators of knowledge alongside machines rather than sole authors. It is not the abandonment of

integrity. It is the recognition that integrity now has to be built on different ground.

I framed postplagiarism around six tenets (Eaton, 2023):

1. Hybrid writing, co-created by humans and AI, becomes the norm.
2. Human creativity is enhanced rather than threatened by AI.
3. AI lowers the language barriers that have long divided writers and readers.
4. Work can be offloaded to AI, but responsibility cannot. Humans remain accountable for what is produced.
5. Attribution remains important, understood as respect for those we learn from rather than as the technical mechanics of citation.
6. Inherited definitions of plagiarism, never universal to begin with, require rethinking.

These tenets carry the trends I take up through the rest of this editorial. They have also drawn objection, and I am well aware of it. Bali (2023) presses the third and fourth tenets in particular, asking whether machine translation can be treated as neutral and whether using a tool amounts to relinquishing control. I hold the fourth tenet as stated. Control over a process may pass to a machine, but accountability for the result does not.

The first tenet is about authorship. The fourth carries assessment. The fifth and sixth ask what academic integrity even means once detection stops working. Postplagiarism is not a separate topic appended to a discussion of education futures. It is the thread that runs through every change ahead.

Everything to this point is a record of what has occurred, supported by the figures and sources cited. What follows is projection.

What Can We Expect Between Now and 2050?

So what should we expect? No one has a crystal ball, and I cannot predict the future. What I can do is read the signals already visible and ask what they make probable (Eaton, 2025). In this editorial, I am influenced by the work of futurists whose work centres around reading signals (e.g., Dator, 2009; Gorbis, 2013; McGonigal, 2022).

The first projection rests on the first tenet and on early evidence. In a study of graduate students using generative AI, my colleagues and I found that students wanted to use these tools ethically and wanted agency over how they combined their own judgment with a tool's suggestions to produce original work (Eaton, 2025). A second study points the same way. In a qualitative case study of eleven undergraduate business students, Ramazanov (2026) found that students treated generative AI as both an aid to efficiency and a constraint on originality, and that they kept final judgment over the work. One empirical study on postplagiarism shows that post-secondary students' responses are complex and evolving (Kumar, 2025). We do not yet have sufficient insights into how students of the future will regard GenAI or writing or co-creation that is a product of human-AI collaboration. Having said that, I expect hybrid authorship to settle into routine across the sector through the 2030s, much as calculators and spreadsheets did before it. The basis for this projection is the behaviour students already report, not a forecast of technology that does not yet exist.

The second projection follows from the fourth tenet. If responsibility cannot – and should not – be offloaded even when work can, then assessment has to measure what the tools cannot supply: a student's reasoning, judgment, and capacity to work with ambiguity. UNESCO (2026) reports both the promise of AI for personalized learning and the reality of students using large language models to complete whole assignments. Detection cannot resolve such tensions. Wearable technology sharpens the point. Examining AI smart glasses, detecting a device cannot establish that unauthorized assistance occurred, nor whether it affected performance, because the assistance leaves no external trace (Corbin et al., 2026; Eaton et al., 2026). We could reasonably expect assessment to move from the surveillance of a finished product toward the documentation of a learning process, driven less by policy than by the failure of the alternative. Healy (2024) shows this shift already underway in K-12 contexts. He adapts the University of Sydney two-lane assessment model (Bridgeman et al., 2024) to secondary schools in Ontario, Canada, separating supervised, AI-free tasks from open tasks where human-AI collaboration is assumed. He frames the change as postplagiarism applied to K-12. Integrity built on epistemic plurality, rather than on detection and punishment, is a more inclusive path,

and it matters most disabled and neurodivergent students, as well as those with other cognitive differences (Eaton, 2026).

My final projection is the least certain, but it is worth our attention. UNESCO and others have begun to treat neurotechnology and brain-computer interfaces as signals worth watching for education, not because classrooms will adopt them soon, but because the ethical questions they raise (cognitive privacy, consent, and the integrity of a student's own thought) will need answers before the technology arrives rather than after (Eaton, 2025). Wearable AI is the leading edge, and it is in classrooms now. Examining AI smart glasses, my colleagues and I described technology that places cognitive assistance in a student's perceptual field while staying cosmetically discreet, a step along the path from external tools toward implantable and embeddable systems that I traced in earlier work (Eaton, 2023; Eaton et al., 2026). The current research on these interfaces sits in clinical and rehabilitation settings. As I have argued before, paying attention to emerging technologies and their possible uses (and misuses) in education, is not speculative, but rather, it is pre-emptive. Now is the time to pay attention to wearable AI technology and neurotechnology because they will almost certainly have an impact in the coming years and decades.

A New Social Contract for Education

UNESCO (2021) stated that the contract underwriting twentieth-century education, schooling exchanged for credentials exchanged for employment, no longer matches present conditions, and called for a new social contract built on the right to quality education throughout life and the defence of education as a common good. I concur with that diagnosis. A contract designed for an industrial economy cannot serve students who will learn across far longer working lives and who face the grave risks to the living planet that UNESCO (2021) speaks to. What we need most now is action, not a rhetorical shift. Education should be lifelong in practice and governed as a public good, capable of meeting economic change, and ecological strain.

Within that contract I place two commitments. The first is epistemic plurality, which treats diverse ways of knowing as a resource rather than a deviation to be corrected. The second is neurodiversity understood as an asset rather than a problem to be

accommodated. Both follow from the postplagiarism tenets, and both move assessment away from a single, surveilled standard of performance (Eaton, 2026). Rather than enforcing a single norm, assessment can be reimagined as a space where multiple ways of knowing, being, and doing, are valued and sustained.

Building Integrity Without Surveillance

The detection paradigm is not failing because educators lack resolve, but because the premise that underpins it, specifically, that human and machine output can be cleanly separated, no longer holds. Postplagiarism provides us with a way to name this. The changes of the next quarter-century, in authorship, assessment, integrity, and the slower (but almost certain) arrival of neurotechnology, all run through postplagiarism. The task ahead is not to decide whether to permit AI or how to rewrite an honour code, but rather to decide what exactly we are educating people to do in a world where knowledge is produced in partnership with machines. My answer is integrity built on accountability and judgment, not on surveillance. The students of 2050 and beyond will inherit the consequences of the decisions we make today. We owe them an answer that helps them become excellent stewards of the future.

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Triangular Ethnography: A Ludological Approach to Academic Motherhood

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Abstract: This study explores the complexities of professional and caregiving roles experienced by academic mothers through the innovative framework of Triangular Ethnography. Integrating feminist ethnography and ludology, the study employs memes as ethnographic prompts in a game-based methodology to illuminate the challenges, resilience, and humor of academic motherhood. Participants engaged in randomized storytelling rounds that revealed key themes: the unrelenting emotional labor of being the *default* parent, the blurred boundaries between work and home, the strategic use of humor as resistance, adaptive coping through strategic play, and the undervaluation of academic labor by family, society, and institutions. The findings contribute to feminist scholarship by offering insights into the lived realities of academic mothers while advocating for systemic reforms in institutional policies and academic culture. Methodologically, the study highlights the potential of ludological approaches for qualitative inquiry, emphasizing relationality, reflexivity, and the transformative power of play.

Keywords: Triangular Ethnography, academic motherhood, feminist ethnography, ludology, emotional labor

Introduction

The intersection of academic motherhood and feminist ethnography presents a compelling lens through which to examine the complex dynamics of professional and personal identities (Acker & Armenti, 2004; Mason et al., 2013). Women in academia often navigate unique challenges, balancing the intellectual rigor of their professions with the emotional labor of caregiving (Hochschild, 1983; Hokka et al., 2022). This dual burden is compounded by systemic barriers within academic institutions, where policies and cultures frequently fail to accommodate the realities of working mothers (Ward & Wolf-Wendel, 2016). The lived experiences of academic mothers offer valuable insights into broader sociocultural dynamics, yet these narratives are often underexplored or relegated to anecdotal reflections rather than rigorous inquiry.

Feminist ethnography provides a critical framework for examining these experiences, emphasizing relationality, reflexivity, and the systemic critique of power dynamics (Denzin, 2017). By centering the voices of women and challenging traditional hierarchies of knowledge production, feminist ethnography enables a nuanced exploration of how academic mothers navigate their intersecting identities (Haraway, 1988; Collins, 2000). In particular, the collaborative and dialogic elements of feminist methodologies align with the relational nature of storytelling, fostering a space where lived experiences can be shared, examined, and theorized collectively (Ellis et al., 2011).

Meanwhile, ludology, the study of games and play, offers a complementary perspective for exploring the strategic decision-making and coping mechanisms inherent in academic motherhood. Rooted in the concept of *meaningful play* (Salen & Zimmerman, 2004), ludology provides a unique methodological framework for simulating and reflecting on complex social roles (Bogost, 2007; Salen & Zimmerman, 2004). In this study, we integrate the emerging ludic scholarship (Zhu, 2026) with feminist ethnography to create a methodological approach: *Triangular Ethnography*, a relational and game-based framework that uses memes as ethnographic prompts. This proposed method not only captures the humor, struggles, and resilience of academic mothers but also engages with the intersection of individual and collective meaning-making.

This paper examines how the triangulated dialogue of three academic mothers, mediated through meme-based ludological interactions, illuminates the challenges and strategies of navigating academia and motherhood. Through this lens, we explore the lived experiences of academic mothers, contributing to a growing body of interdisciplinary scholarship that merges qualitative inquiry with playful and reflexive methodologies.

Research Questions

This study seeks to address the following questions:

1. How do academic mothers navigate the dual roles of professional obligations and caregiving responsibilities within the context of systemic and cultural challenges in academia?

2. What insights into these experiences can be revealed through a ludological exploration, where memes are used as playful yet critical tools for reflection and dialogue?

Triangular Ethnography: A Methodological Innovation

To explore these questions, we introduce *Triangular Ethnography*, a methodology that combines elements of feminist ethnography, ludology, and collaborative storytelling. This approach is rooted in three pillars:

Relational Dynamics. Drawing from feminist ethnography, it emphasizes the co-construction of knowledge through dialogic exchanges among participants, highlighting relationality and collective meaning-making (Ellis et al., 2011).

Game-Based Framework. Inspired by ludological principles, the study adopts a meme-centered game structure to simulate and reflect on the strategic decision-making and emotional labor inherent in academic motherhood (Salen & Zimmerman, 2004).

Interdisciplinary Triangulation. By engaging three participants (the triangular framework) in dialogue around shared themes, the methodology creates a rich, multi-voiced narrative that reveals nuanced perspectives and emergent patterns.

The triangular framework of this ethnography represents the three participants and embodies the intersection of individual experiences, shared reflections, and systemic critiques. This dynamic process fosters a layered understanding of the complexities academic mothers face, bridging personal narratives and broader institutional structures.

Interdisciplinary Relevance and Contributions

The interdisciplinary nature of this study contributes to multiple fields:

Feminist Scholarship. By foregrounding the lived experiences of academic mothers, it adds to feminist critiques of gendered labor and systemic inequities in academia (Acker & Armenti, 2004; Haraway, 1988).

Ludology in Qualitative Research. The integration of meme-based gameplay as a reflective tool offers a methodological innovation that expands the boundaries of qualitative inquiry (Bogost, 2007; Sutton-Smith, 1997).

Narrative and Collaborative Ethnography. The dialogic structure provides a model for small-group ethnographies that prioritize relational storytelling and collective theorization (Collins, 2000; Ellis et al., 2011).

Practical Implications for Academia. The findings have potential implications for institutional policies and cultural practices, advocating for more equitable support structures for academic mothers.

Methodology

Triangular Ethnography Framework

This study proposes *Triangular Ethnography*, a methodological framework designed to explore the lived experiences of academic mothers through relational, dialogic, and playful engagement. This approach integrates feminist ethnography, narrative inquiry, and ludology to investigate the intersection of caregiving and professional identities. The term "triangular" reflects both the three-participant structure and the methodological interplay between individual experiences, relational dynamics, and shared meaning-making. At its core, Triangular Ethnography emphasizes the importance of relationality in knowledge production. Rooted in feminist ethnography, this framework prioritizes collaboration and co-construction of meaning, recognizing that insights are shaped through the dialogic interactions among participants (Ellis et al., 2011). The triangular structure allows for a dynamic exchange where each participant contributes unique perspectives while collectively

engaging with shared themes, fostering a multi-dimensional understanding of academic motherhood.

Building on narrative ethnography, this methodology foregrounds storytelling as a means of reflecting on and theorizing lived experiences. Through structured dialogues prompted by memes, the study blends personal anecdotes, humor, and critical reflection, creating a space for participants to navigate the complexities of their dual roles (Riessman, 2008). The triangular model enhances this approach by embedding relational dynamics within the narrative process, capturing both individual agency and collaborative exploration.

Ethnography, Temporality, and Ludic Attunement

We acknowledge that *ethnography* is often associated with prolonged temporal immersion and sustained participation in participants' everyday lives. From this perspective, duration and waiting-with are central to ethnographic attention. However, Triangular Ethnography is not offered as a substitute for long-term fieldwork; rather, it articulates a *ludic mode of ethnographic attunement* in which ethnographic knowing emerges through *density, recursion, and relational saturation* within a deliberately designed, dialogic encounter. In this study, ethnographic attention is achieved through repeated rounds of meme-prompted storytelling, where participants return to lived moments from shifting angles, reconfigure meaning in response to others' narration, and make visible the institutional textures of academic motherhood as they surface through laughter, interruption, and collective sense-making. In this sense, temporality is present as *iterative narrative time* produced through cycles of play and reflection.

In addition, our use of ludic design as method aligns with our broader methodological program that treats play as a methodological engine for producing situated knowledge through rule-based interaction, improvisation, and relational co-construction (Zhu, 2026; Zhu & Duet, 2024). Triangular Ethnography therefore names a genre of ethnographic practice that is micro-temporal yet iterative, and intentionally designed to render visible the affective and institutional pressures that academic mothers navigate.

Memes as Ethnographic Prompts

Memes, as cultural artifacts, serve as playful yet potent tools for self-expression and social critique. Their succinct and humorous

format enables participants to engage with complex topics in an accessible and emotionally resonant manner (Shifman, 2014). In this study, memes functioned as ethnographic prompts, eliciting personal narratives and facilitating dialogue about the challenges and strategies of academic motherhood. By leveraging the universal appeal of humor and relatability, memes encouraged candid discussions while simultaneously bridging the gap between personal and systemic critiques.

The study utilized a curated set of 27 memes divided into three thematic categories: *academic life*, *motherhood*, and *self-care (or lack thereof)*. Participants took turns selecting memes, sharing personal reflections, and engaging in collective storytelling. This structured yet flexible process mirrored elements of gameplay, introducing a ludological dimension that simulated the balancing act inherent in academic motherhood (Salen & Zimmerman, 2004). The interplay of humor, vulnerability, and strategic dialogue enabled participants to critically examine their experiences while fostering a sense of shared solidarity. The use of memes enriched the data collection process as well as aligned with the study's interdisciplinary ethos. By integrating visual culture, ludic elements, and ethnographic inquiry, this approach captured the emotional, relational, and institutional dimensions of academic motherhood in a novel and engaging manner.

Game Design as Method

To explore the complex experiences of academic motherhood, we employed a game-based methodology rooted in ludological principles. This approach incorporated collaborative storytelling, randomization, and structured gameplay to reflect the unpredictability, negotiation, and relational dynamics of balancing professional and caregiving roles. The game's design facilitated both personal reflection and collective engagement, creating a playful yet meaningful environment for ethnographic inquiry.

Meme Selection and Categorization

Each participant individually selected nine memes that resonated with their experiences, divided equally across three thematic categories:

Motherhood. Highlighting caregiving challenges, emotional labor, and identity as a parent.

Academic Life. Reflecting professional responsibilities, systemic pressures, and workplace humor.

Self-Care (or Lack Thereof). Addressing personal well-being, resilience, or neglect in the pursuit of balance.

This personalized selection process ensured that the prompts were deeply relatable while maintaining thematic diversity.

Shuffling and Numbering

The curated memes were pooled, shuffled, and assigned unique numbers (1–27) to introduce an element of randomness. This shuffling mirrored the chaotic and often unpredictable intersections of academic and personal lives.

Randomized Storytelling Mechanics

Step 1: Determining the Storyteller. At the beginning of each round, a random number generator determined which participant (Mila, Sarah, or Jennifer) would share first. This added an element of chance to the turn-taking process.

Step 2: Selecting the Meme. A second random number (1–27) was generated to select the meme that would serve as the storytelling prompt.

Step 3: Storytelling and Reflection. The designated storyteller shared a personal narrative inspired by the selected meme, connecting it to her lived experiences in motherhood, academia, or self-care. The storyteller could reflect critically or humorously, setting the tone for subsequent dialogue.

Dialogic Exchange and Relational Dynamics

Following the initial storytelling, all participants were invited to:

Reflect. Share similar experiences or deepen the discussion.

Pose Questions. Encourage the storyteller to elaborate or explore new angles.

Challenge. Offer counter-narratives or alternative perspectives.

Dib the Meme. Claim the meme as more reflective of their own experience, adding a layer of playful competition.

The storytelling process emphasized relationality, as participants built on each other's narratives, fostering mutual understanding and collective meaning-making.

Strategic Turn-Taking and Completion

At the end of each turn, the storyteller selected the next participant, who then chose another numbered meme for discussion. This flexible structure allowed for dynamic, spontaneous exchanges

while ensuring that each participant completed three storytelling rounds by the game's conclusion. Over three rounds of gameplay, participants engaged with a total of nine memes, balancing the unpredictability of random selection with the intentionality of relational dialogue.

The design and implementation of the game-based methodology in this study reflect a convergence of philosophical and theoretical considerations, embedding Triangular Ethnography within a broader framework of relationality, play, and co-constructed knowledge. Below, we expand on its foundational principles:

Ludology as Relational Play

Ludology, the study of games and play, informs this methodology by emphasizing the creative and reflective potential of structured play. According to Salen and Zimmerman (2004), play is a mode of engagement that creates "meaningful interaction within a rule-based system" (p. 83). The randomization of memes, strategic storytelling, and turn-taking in this study mirrors the game-like structures academic mothers often navigate in their dual roles, where rules (academic expectations, caregiving demands) intersect with improvisation (decision-making in unpredictable contexts). The structured randomness of the game reflects the chaos of balancing these roles, yet the gameplay's intentional relationality allows participants to co-create meaning from their shared experiences. By transforming memes into ludological prompts, the study blurs the boundaries between play and inquiry, inviting participants to reflect critically while engaging in acts of spontaneous storytelling. This echoes Sutton-Smith's (1997) assertion that play serves as an adaptive response to ambiguity, a space where humor and creativity serve as tools for resilience and exploration.

Feminist Epistemology and Situated Knowledges

Feminist ethnography emphasizes the importance of situated knowledges (Haraway, 1988), recognizing that experiences are shaped by specific contexts, relationships, and power dynamics. The triangular framework of this methodology reflects Haraway's (1988) call for a "partial perspective" (p. 583) where each participant's narrative serves as both a unique vertex and a point of connection within the relational structure of the group. The dialogic exchanges encouraged by this methodology align with feminist epistemological commitments to relationality and reflexivity. In this context, memes

operate as what Haraway (2008, p. 4) might term “material-semiotic nodes”: cultural artifacts that encapsulate humor, critique, and shared cultural understandings. By engaging with these memes, participants collaboratively construct meaning, weaving individual stories into a collective narrative of academic motherhood.

Narrative Temporality and Iteration

This methodology also engages with the narrative temporality articulated by Ricoeur (1984), wherein stories serve as vehicles for reconfiguring lived experience into reflective understanding. The iterative nature of the storytelling rounds ensures that participants revisit and reinterpret their narratives in light of others’ perspectives. This recursive process mirrors the interplay of mimesis in Ricoeur’s hermeneutics: prefiguration (lived experience), configuration (storytelling), and refiguration (shared meaning). Through this lens, the game becomes a temporal and dialogic space where participants recount and reshape their experiences, identifying patterns and connections that might otherwise remain obscured. The storytelling process thus becomes an act of world-building, where academic motherhood is reframed as a site of both struggle and solidarity.

Emotional Economies and Affective Play

The emotional labor inherent in academic motherhood is central to the study’s use of memes as prompts. Drawing on Ahmed’s (2017) work on the cultural politics of emotion, this methodology frames memes as affective texts that provoke immediate, visceral reactions. These emotional responses, whether humorous or critical, serve as entry points for deeper reflection. The intertwining of humor and vulnerability in meme-based storytelling highlights the dual role of affect as both a source of connection and a site of critique. Moreover, the playful dynamics of the game allow participants to explore these affective dimensions without the constraints of traditional academic discourse. This aligns with feminist critiques of disembodied rationality, offering a more holistic and human-centered approach to understanding the lived realities of academic motherhood (Collins, 2000).

Co-Constructed Knowledge and Agency

Finally, the strategic turn-taking embedded in this methodology empowers participants to shape the flow and focus of the game. By choosing the next storyteller and meme, participants exercise agency, transforming the game into a collaborative act of knowledge

production. This reflects Freire's (1970) pedagogy of dialogue, where participants are co-creators of meaning rather than passive recipients of inquiry. The dialogic structure thus becomes both a methodological tool and a philosophical stance, affirming the value of shared agency and collective insights.

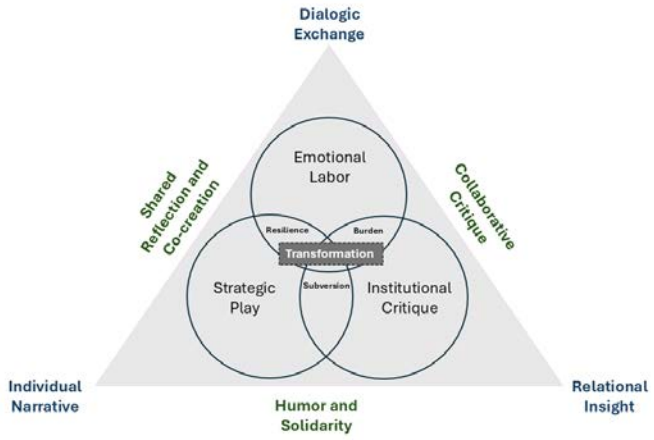


Figure 1

Triangular Framework of Reflexive Narratives: Emotional Labor, Strategic Play, and Institutional Critique

To enhance methodological transparency and comply with publication copyright constraints, Table 1 provides an overview of the meme cards used in the study, including their thematic categorization and representative content descriptions.

Table 1

Overview of Meme Cards Used in the Study

Meme ID	Theme	Representative Content Description	Function in Gameplay
1	Self-care	Tweet joking about needing coffee strong enough to "show up on a drug test."	Prompted discussions of exhaustion, caffeine dependency, and embodied coping.

Meme ID	Theme	Representative Content Description	Function in Gameplay
2	Self-care	Illustration stating "You're pretty demanding for a calming hobby."	Invited reflection on the irony of self-care expectations under constant pressure.
3	Academic Life	Text meme: "The audacity" as first noticed trait in others.	Opened dialogue on academic entitlement, boundaries, and emotional labor.
4	Academic Life	Tweet about explaining academic publishing and pay to a non-academic parent.	Triggered narratives about public misunderstanding of academic labor.
5	Academic Life	"Manuscripts can't be rejected if you don't submit" meme.	Facilitated humor around productivity anxiety and institutional pressure.
6	Academic Life	Post critiquing "basic biology" arguments about gender.	Sparked discussions of disciplinary authority and epistemic frustration.
7	Motherhood	Kermit meme about missing a planned time window by minutes.	Prompted stories about lost personal time and maternal scheduling collapse.
8	Motherhood	Image of mother interrupted by children	Highlighted constant maternal

Meme ID	Theme	Representative Content Description	Function in Gameplay
		even while in the bathroom.	availability and boundary erosion.
9	Motherhood	Meme juxtaposing children refusing food with dramatic starvation imagery.	Generated humor-inflected discussion of caregiving frustration.
10	Academic Life	Classroom meme joking about existential despair in philosophy courses.	Invited reflection on teaching affect and performative seriousness.
11	Academic Life	Meme portraying an introductory philosophy classroom where existential dread is humorously framed as pedagogy	Prompted discussion of disciplinary affect, academic humor as initiation ritual, and the normalization of existential exhaustion in academic cultures.
12	Academic Life	Tweet about explaining a dissertation to family and legal inadmissibility.	Prompted stories of translation labor and intellectual invisibility.
13	Academic Life	“Escape room but you must finish writing your paper” meme.	Framed writing as entrapment and survival challenge.
14	Academic Life	Error dialog stating “I have no idea what you want me to do.”	Anchored narratives of supervisory ambiguity and affective confusion.

Meme ID	Theme	Representative Content Description	Function in Gameplay
15	Self-care	Meme referencing desire for fantasy-level financial rescue (Grey's Anatomy).	Opened ironic discussion of economic precarity and wishful thinking.
16	Self-care	Image of elaborate sand sculptures dismissed as wasted effort.	Reflected undervalued creative labor and invisible care work.
17	Motherhood	Joke about intellectualizing curly fries as "rotatoes."	Opened lighthearted reflections on identity blending.
18	Motherhood	Meme about grocery substitution replacing milk with an absurd item.	Prompted stories of logistical chaos and cognitive overload.
19	Motherhood	Meme stating going out requires wedding-level planning.	Anchored discussion of maternal logistics and lost spontaneity.
20	Motherhood	Image depicting maternal authority when "checking with the wife."	Sparked dialogue on default parenthood and decision burden.
21	Academic Life	Split-image meme contrasting the joy of "Manuscript Submitted" with the subdued reaction to "Manuscript Accepted."	Anchored narratives about temporal lag, emotional anticlimax, and the affective rhythms of academic publishing.

Meme ID	Theme	Representative Content Description	Function in Gameplay
22	Academic Life	Meme about professors replying instantly to 2am emails.	Invited reflection on blurred work-life boundaries.
23	Academic Life	Meme contrasting desire to escape to woods vs. academic career.	Prompted narratives of burnout and fantasy withdrawal.
24	Motherhood	Meme depicting a visibly exhausted mother captioned with attempting to excel professionally, parent well, maintain social life, exercise, sleep, and "remain sane."	Prompted discussion of cumulative overload, impossible ideals of balance, and the affective toll of simultaneous role expectations.
25	Motherhood	Image of a smiling mother with caption "When your kids keep telling a story and it won't end."	Anchored narratives of attentional labor, emotional regulation, and the endurance required in everyday caregiving interactions.
26	Motherhood	*The Lion King* still captioned "Everything the light touches is your job description."	Functioned as a metaphor for maternal scope creep, default parenthood, and the normalization

Meme ID	Theme	Representative Content Description	Function in Gameplay
			of total responsibility.
27	Self-care	Meme contrasting motivation to be productive with collapsing into bed upon arriving home.	Generated reflections on exhaustion, deferred self-care, and the gap between intention and embodied capacity.
28	Self-care	Futurama meme questioning whether one is practicing self-care or procrastinating.	Invited critique of wellness discourse, moralization of rest, and blurred boundaries between care and avoidance.
29	Self-care	Meme celebrating checking off a single item from an overwhelming to-do list.	Prompted ironic discussions of productivity metrics, small wins, and survival-oriented accomplishment.

Note. These memes were contributed by participants and selected for affective resonance rather than analytic representativeness; their function emerged through gameplay and dialogic interpretation.

Data Collection: A Relational Approach

Recording the Dialogues as Ludic Interactions

Data collection was conceptualized as a co-created game, with participants engaged in playful yet meaningful storytelling. Each session was structured as a series of interactive 'rounds', blending spontaneity and strategy. These sessions were conducted virtually to

maintain flexibility and ensure a sense of comfort for participants. The storytelling *game* was recorded using secure tools, and transcripts were enriched with annotations capturing laughter, tone shifts, and moments of silence, all integral to understanding the relational dynamics at play.

Triangular Coding and Analysis

The analysis process reflected the triangular ethos of the methodology by integrating the individual, relational, and collective dimensions of meaning-making:

Vertex-Level Coding (Individual Narratives). Initial codes were assigned to personal stories, focusing on themes like emotional labor, humor, and institutional critiques. This phase centered on each participant's unique *voice* and the personal resonance of the selected memes.

Edge-Level Coding (Relational Dynamics). The second phase analyzed the dialogic exchanges between participants, capturing moments of shared laughter, challenges to one another's narratives, and collaborative meaning-making. Codes here included *shared vulnerability*, *humorous resistance*, and *empathetic alignment*.

Interior-Level Analysis (Emergent Themes). Finally, the interplay between personal and relational data was synthesized to reveal the core emergent themes represented at the center of the triangular framework.

This multi-level coding process was complemented by a game-like annotation method, where transcripts were treated as "game boards" annotated with symbols (i.e., stars for humor, arrows for tension, and circles for collaborative moments). This playful approach mirrored the methodology's ludic ethos, highlighting the unpredictable and interactive nature of meaning-making.

Randomization and Humor as Methodological Catalysts

Randomization and humor were central to the data collection process:

Randomization as a Game Mechanic. The random number generator created an improvisational structure, encouraging participants to engage with memes outside their immediate preferences. This randomness disrupted expected patterns, mirroring the chaotic intersections of academic motherhood.

Humor as Relational Play. Humor acted as a dynamic force, softening difficult discussions and creating spaces for critical

reflection. Participants frequently used humor to subvert traditional narratives of motherhood and academia, reframing challenges as moments of shared absurdity and resilience. Together, these elements transformed the data collection process into an interactive and emergent exploration, aligning with the playful and reflexive nature of Triangular Ethnography.

Triangular Ethnography in Action: Relationality, Playfulness, and Reflexivity

The design and implementation of this study exemplify the core principles of Triangular Ethnography by embedding relationality, playfulness, and reflexivity into each phase of the research process. These elements work together to create a dynamic, interactive, and theoretically robust approach to exploring academic motherhood.

Relationality: Knowledge as Co-Creation

At the heart of Triangular Ethnography is the principle that knowledge is relational and emerges from the interplay of individual narratives, collaborative critique, and shared reflection (Haraway, 1988; Collins, 2000). The storytelling process foregrounded participants' unique voices as well as amplified the collective insights that arose through their interactions. Relationality was most evident in the dialogic exchanges that formed vertices of the framework, where participants co-constructed meaning by challenging, affirming, and deepening each other's stories. The study's structure transformed storytelling into an inherently relational act, where humor, empathy, and critique operated as tools for collective reflection. This underscores Ahmed's (2017) assertion that relational practices disrupt isolation and foster solidarity, particularly for those navigating marginalized identities like academic mothers.

Playfulness: Subverting Seriousness

Playfulness was a philosophical stance within this study. The game-inspired design, with its randomized meme selection and improvisational storytelling, infused the research process with spontaneity and creativity, echoing the ludic principles outlined by Salen and Zimmerman (2004) and Sutton-Smith (1997). The act of engaging with memes, a culturally rich medium, blurred the boundaries between "serious" academic inquiry and everyday humor, enabling participants to critique systemic pressures while laughing at their shared struggles. Sutton-Smith (1997) frames play as an adaptive response to ambiguity, a space where participants could

momentarily subvert the rigid structures of institutional norms. Playfulness also allowed participants to approach heavy topics, such as emotional labor and institutional burdens, with a sense of levity. Such an approach aligns with Bogost's (2007) notion of procedural rhetoric, "the art of persuasion through rule-based representations and interactions rather than the spoken word, writing, images, or moving pictures" (p. 3), where play serves as a mechanism for both engaging with and resisting oppressive systems.

Reflexivity: Iterative and Dialogic Praxis

Reflexivity in this study extended beyond individual self-awareness to encompass the iterative and dialogic exchanges that occurred during storytelling and analysis. The triangular coding framework emphasized how individual experiences, dialogic exchange, and relational dynamics (vertices) were shaped and reshaped through shared reflection, humor and solidarity, and collaborative critique (edges) to produce emergent and transformative insights (interior). This reflexivity aligns with Ricoeur's (1984) concept of narrative refiguration, where the act of storytelling allows participants to reinterpret and transform their lived experiences. By engaging in recursive storytelling rounds, participants reflected on their personal struggles while contextualizing them within broader systemic critiques.

Findings: Navigating Academic Motherhood through Triangular Ethnography

The findings from this study illuminate the multifaceted experiences of academic motherhood as explored through the playful and relational framework of *Triangular Ethnography*. By engaging in randomized, meme-inspired storytelling rounds, participants unearthed deeply personal narratives while collectively reflecting on shared struggles, triumphs, and critiques of institutional systems. Emerging from the iterative storytelling and dialogic exchanges are five key themes that capture the relational, systemic, and affective dimensions of academic motherhood. These themes weave together individual experiences with collective insights, offering a nuanced understanding of how academic mothers navigate overlapping roles and identities. Each theme is supported by vignettes from the

storytelling sessions, enriched by the humor, vulnerability, and reflexivity that characterize the triangular framework.

Theme 1: Emotional Labor and the Gendered Default Parent

The narratives shared during the storytelling sessions highlight the unrelenting emotional labor academic mothers shoulder, often as the *default* parent. This labor extends beyond physical caregiving to include the mental and emotional demands of anticipating, managing, and resolving family needs, even in co-parenting arrangements. Despite the presence of other caregivers, academic mothers often find themselves the primary point of contact for their children, embodying the societal expectation of maternal omnipresence.

Jennifer, for example, described waking up to a late-night text from her son, who was staying at his father's house, asking, "Mom, where's my inhaler?" She noted, "It doesn't matter where you're at or what you're doing… my kids will still all come to me, even if they're with their dad." This constant availability underscores the invisible labor of being the go-to problem solver, even when another caregiver is physically present. The assumption that mothers, rather than fathers, will handle every need, from locating items to providing emotional support, reflects entrenched gender norms that perpetuate maternal responsibility.

Similarly, Sarah reflected on societal critiques of her decision to work full-time while raising young children: "I've always heard, 'You don't spend enough time with your kids because you work full-time.' Especially when they were babies and I was breastfeeding and pumping… but they never asked my husband those questions." This commentary highlights the double standards academic mothers face, where professional ambitions are seen as *selfish* or *detrimental* to their children's well-being, while fathers are rarely held to the same scrutiny.

This emotional labor is not confined to the physical home but extends to digital spaces. Jennifer shared that even when her children are at their father's house, they reach out to her via text for routine concerns, like asking where items are or for advice: "There's just no escaping it. If I'm not physically available, then they'll text me." Such instances illuminate how technology, while intended to facilitate communication, often reinforces the maternal expectation of constant availability.

These vignettes reveal how academic mothers are often positioned as the *default parent*, expected to anticipate and meet their children's needs regardless of context or co-parenting arrangements. This phenomenon aligns with the concept of emotional labor, first articulated by Hochschild (1983), as the unrecognized management of feelings and interpersonal dynamics. For academic mothers, this labor is compounded by societal pressures that frame caregiving as an exclusively maternal domain. The persistence of these gendered expectations also reflects broader systemic issues. Ahmed (2017) argues that the affective economies of care disproportionately rely on women, reinforcing structures that demand constant emotional availability without acknowledgment or support. This creates a paradox where academic mothers must navigate their professional responsibilities while being perpetually on-call as caregivers, leading to significant emotional and cognitive overload.

Moreover, the narratives reveal the emotional toll of being perceived as "always on." The mental load of coordinating schedules, addressing needs, and absorbing societal critiques underscores the need for institutional reforms. These might include policies that explicitly recognize and mitigate the emotional labor associated with caregiving, such as flexible work arrangements and normalized co-parenting roles.

Theme 2: The Collapsing Boundaries of Work and Home

The narratives in our study reveal how academic mothers experience the blurred boundaries between professional and personal spheres, especially in remote or hybrid work contexts. The spatial and mental collapse of work-life separation creates a perpetual state of multitasking, where professional responsibilities intertwine with the immediacy of family needs. These overlapping roles lead to constant adjustments and significant emotional and cognitive demands.* *Mila humorously described her child's interruptions during remote teaching as living with an "8-year-old roommate." She explained, "I have to make a disclaimer at the beginning of every semester, letting them know that I still unfortunately live with an 8-year-old roommate, because he'll just randomly wander into the camera with no pants, saying, 'Mom, I pooped.'" While humorous, this anecdote highlights how caregiving responsibilities intrude on professional spaces, requiring academic

mothers to navigate these interruptions with both patience and adaptability.

Sarah reflected on the mental juggling act required to manage academic and familial responsibilities simultaneously: “I could slide over to my computer desk and type out a couple more paragraphs on that manuscript I’m working on, or I’ve got three students who really need a question answered… I have to kind of coordinate when the kids are home after school, making sure I’m paying attention a little bit because I can get caught up in my to-do list”. This constant toggling between roles underscores the challenge of prioritizing tasks in a space where work and home overlap, often without clear boundaries.* *Jennifer shared her frustration with societal misunderstandings of working from home, explaining how others often conflate “working from home” with simply “being home.” She noted, “There’s a misunderstanding. Working from home and being home are two very different things.” This misconception adds to the burden academic mothers face, as the flexibility of remote work is frequently mistaken for ease or leisure, minimizing the complexity of managing dual responsibilities.

The dialogues highlight how academic mothers perform a constant balancing act, moving fluidly between professional productivity and caregiving demands. This collapse of boundaries often leads to multitasking at the expense of mental well-being, with participants describing the struggle to find uninterrupted time for either role. As Ahmed (2017) notes, affective economies disproportionately rely on women to perform invisible emotional and logistical labor, making these blurred boundaries an additional layer of systemic inequity.* *This theme also exposes how institutional expectations exacerbate the challenge. The conflation of working from home with availability reinforces the undervaluation of academic mothers’ time and labor. As Hochschild (1997) observed, the* time bind* is particularly acute for working mothers, who face societal pressures to excel in both professional and caregiving roles while lacking structural support.

Moreover, the narratives reveal the dual necessity of humor and strategy in navigating these blurred boundaries. While humor offers a temporary release from the stresses of multitasking, strategic boundary-setting becomes critical for managing the competing demands of work and family. Mila’s ability to embrace humor during

Zoom interruptions and Sarah's deliberate efforts to coordinate tasks highlight how academic mothers employ creative solutions to mitigate the challenges of collapsing boundaries.

Theme 3: Humor as Resistance and Resilience

For academic mothers, humor serves as both a survival strategy and a subversive tool, enabling them to navigate exhaustion, overstimulation, and systemic expectations. Whether used to cope with daily challenges or to critique institutional norms, humor offers a means of reclaiming agency in the face of relentless demands.

Mila shared how she embeds humor into her teaching practices by sneaking references to Spongebob Squarepants into course content: "I will secretly embed a code in a random course recording. For example, Spongebob Squarepants in week 4. If they email me a meme or smartly incorporate Spongebob into their weekly reflection, I'll give them extra points. Students ask, 'Why Spongebob?' And I say, 'Because [her child] is a fan.'" This playful integration of her personal life into professional spaces not only amuses her students but also creates moments of joy and surprise that break up the monotony of academic routines. Humor, here, functions as both a pedagogical strategy and a personal outlet for creativity. Similarly, Jennifer recounted joking with her doctor about her caffeine consumption, a humorous acknowledgment of the physical toll of her daily responsibilities: "My doctor asked, 'Do you drink a lot of caffeine?' and I said, 'Oh yes, like on an IV.' She laughed, but when she suggested cutting back, I said, 'Probably not. What's my other option? I need coffee to survive.'" This lighthearted exchange illustrates how humor helps her manage the overstimulation and fatigue inherent in juggling work and motherhood.

Humor emerges as a critical form of resistance for academic mothers, allowing them to push back against the weight of systemic expectations and societal norms. As Sutton-Smith (1997) notes, humor and play serve as adaptive responses to ambiguity and adversity, creating spaces for individuals to navigate and critique the constraints of their environments. For the participants, humor functioned as both a coping mechanism and a relational tool, fostering moments of connection with students, colleagues, and even healthcare providers.* *Incorporating humor into professional and parenting contexts also reveals its transformative potential. By embedding Spongebob references into course content, Mila subtly

disrupts the rigid boundaries of academic professionalism, blending personal joy with pedagogical innovation. Similarly, Jennifer's self-deprecating humor about caffeine dependency highlights the absurdity of societal and institutional demands, reframing them with a sense of agency and defiance.

Ahmed (2017) argues that humor can be a radical act, transforming exhaustion into collective solidarity by allowing individuals to share and critique their experiences in accessible and emotionally resonant ways. In this study, humor enabled participants to reclaim their narratives, using laughter as a form of rebellion against the pressures of academic motherhood.* *Ultimately, for academic mothers, these small acts of playfulness and rebellion offer a means of preserving their well-being while challenging the systemic norms that perpetuate their struggles.

Theme 4: Strategic Play and Adaptive Coping

For academic mothers, strategic play emerges as a critical mechanism for navigating the overlapping pressures of caregiving and professional life. This adaptive approach reflects a blend of flexibility, creativity, and intentional boundary-setting, enabling them to sustain resilience while addressing emotional and physical overwhelm. The participants' narratives illustrate how small but deliberate acts, whether retreating to decompress or engaging imaginatively with their children, become vital tools for coping with the relentless demands of academic motherhood.

Sarah described how overstimulation often leads her to withdraw and reset: "When you've hit like you're overstimulated, like, how do you cope? And for me coping... I go by myself in a dark room, and that sounds really scary, but like I turn the lights out and go in a dark room. I usually go take a nap, like if I'm just overstimulated to the max." This act of retreating is not simply a withdrawal but a deliberate strategy to recharge, recognizing the need for moments of solitude in a context that often demands constant presence and engagement. Mila recounted an experience during a conference trip, navigating her child's interruptions with creative engagement: "He just randomly started talking about sharks, about Pokémon, about anything he's passionate about. And you just have to listen." While managing conference logistics and unfamiliar roads, she transformed her child's interjections into an opportunity for connection,

demonstrating the improvisational adaptability that defines academic motherhood.

The deliberate use of "strategic play" highlights the ways academic mothers navigate the emotional and cognitive demands of their roles. Ahmed (2017) frames such strategies as acts of *affective adjustment*, where individuals reshape their environments and interactions to better align with their capacities and needs. For Sarah, retreating to a dark room exemplifies the intentional boundary-setting required to manage overstimulation. This practice mirrors Sutton-Smith's (1997) concept of play as a means of creating order amidst chaos, offering a momentary escape from the unpredictability of academic and parental responsibilities.

Similarly, Mila's engagement with her child reflects the parallels between strategic play and improvisational gameplay. Salen and Zimmerman (2004) argue that play functions as a *meaningful interaction* within a rule-based system, a framework that resonates with the adaptive maneuvers academic mothers employ. By reframing interruptions as opportunities for connection, Mila demonstrates how strategic play can transform potentially stressful situations into moments of shared joy. These narratives also emphasize the importance of recognizing and respecting the limits of emotional and physical capacity. As Hochschild (1983) observed, emotional labor often involves suppressing or managing personal feelings to meet external demands. Strategic play, however, allows academic mothers to renegotiate these dynamics on their terms, integrating self-care and relational connection into their daily practices.

Ultimately, these strategies both mitigate the stresses of academic motherhood and align with the study's ludic framework, reinforcing the value of creativity, adaptability, and improvisation in navigating complex and overlapping roles. By embracing these practices, academic mothers carve out spaces for resilience and connection, even within the constraints of systemic pressures and personal responsibilities.

Theme 5: Perceptions of Academic Labor: Family, Society, and Institutions

The narratives from this study reveal the complex and often contradictory perceptions of academic labor, highlighting its undervaluation by family, society, and institutional structures. Academic mothers navigate these perceptions while balancing their

roles, often facing misunderstandings about the nature and rigor of their work.

Jennifer shared how her children viewed her publishing a book as a significant achievement compared to her academic articles: "They're completely astonished by that, like, 'Mom's going to have a book!' They don't care about the articles that I've written and published. To them, having a book just seems so prolific." This reaction underscores how academic labor, especially in education, is often seen as abstract or inaccessible, even by those closest to academic mothers. The tangible nature of a book provides a rare moment of recognition, yet it is accompanied by questions about its value: "They've asked, 'What do you get for that, Mom? Are they going to pay you?' And I have to explain that it's not like writing a bestseller at Barnes and Noble." At the same time, Jennifer noted that her children's exposure to her career had shaped their views on work-life balance and career aspirations. While they were proud of her accomplishments, they expressed no desire to pursue academia or education themselves: "They tell me, 'I just can't. I'm not that personality, Mom. I can't just pour into everybody else all the time.'" These mixed perceptions reflect the visible demands of academic labor, which may inspire pride but also serve as a cautionary tale for the next generation.

Sarah described societal judgments about her choice to work full-time while raising young children: "I've always heard, 'You don't spend enough time with your kids because you work full-time.' Especially when they were babies and I was breastfeeding and pumping… people asked, 'How could you leave your baby to go work?' But they never asked my husband those questions." This commentary reveals the patriarchal-centered double standards in how caregiving and professional ambition are judged, with women bearing the brunt of societal scrutiny.

The narratives illustrate the widespread misunderstandings of academic labor, both within the family and broader society. Academic work is often perceived as intangible or esoteric, its value diminished by its association with intellectual pursuits rather than material production. Such phenomena align with Ahmed's (2017) critique of institutional affective economies, where the emotional and intellectual labor of marginalized groups is systematically undervalued. Children's perceptions of academic labor as both

admirable and exhausting reflect the visible toll it takes on their mothers, whose professional and personal lives often overlap without sufficient institutional support. The narratives in this study highlight how these overlapping demands shape family dynamics, as children witness firsthand the sacrifices involved in academic careers. At the societal level, the double standards described by Sarah point to the gendered expectations surrounding caregiving and professional identity. While men's work is often presumed to coexist seamlessly with their roles as fathers, women are held to higher and conflicting standards, expected to prioritize caregiving without compromising professional excellence.

Discussion

This study set out to explore two central questions:

1. How do academic mothers navigate the dual roles of professional obligations and caregiving responsibilities within the context of systemic and cultural challenges in academia?

2. What insights into these experiences can be revealed through a ludological exploration, where memes are used as playful yet critical tools for reflection and dialogue?

Through the lens of *Triangular Ethnography*, this study illuminated the intricate balancing act academic mothers perform daily, as they negotiate the overlapping demands of work and home. The storytelling sessions, prompted by meme-based randomness and relational exchanges, revealed how participants adapt to systemic pressures, manage emotional labor, and maintain resilience through strategic play and humor. These narratives expose the deeply personal yet collective dimensions of academic motherhood, showcasing its complexity, challenges, and moments of solidarity.

The integration of a ludological framework provided unique insights into these experiences. By transforming storytelling into a playful and dialogic process, the study uncovered the ways academic mothers creatively navigate their dual roles. Memes served as accessible cultural artifacts that bridged personal and systemic critiques, offering participants a space to express vulnerability, humor, and resistance.

The findings of this study highlight the multifaceted challenges and strategies of academic motherhood, organized around five key

themes that reflect the relational, systemic, and affective dimensions of participants' experiences. These themes are interwoven with theoretical frameworks, offering deeper insights into the lived realities of navigating professional and caregiving roles.

Emotional Labor and the Gendered Default Parent. The participants' narratives underscore the unacknowledged emotional labor that academic mothers perform, perpetuating their role as the *default* parent. Despite shared caregiving arrangements, participants described being the primary point of contact for their children, even during their supposed off-duty hours. Jennifer noted, "My kids will still all come to me, even if they're with their dad," exemplifying the expectation of maternal omnipresence.

The Collapsing Boundaries of Work and Home. The shift to remote and hybrid work environments has exacerbated the already blurred lines between academic and caregiving responsibilities. Participants described a constant state of multitasking, where professional productivity was often interrupted by caregiving demands. Mila humorously referred to her child as her "8-year-old roommate" who frequently interrupted Zoom calls, reflecting the spatial and mental collapse of work-life boundaries. This theme resonates with Ahmed's (2017) analysis of affective exhaustion, further emphasizing the toll that such boundary collapses take on women. The narratives highlight the need for institutions to rethink their approach to remote work, addressing the misconception that working from home equates to flexibility or reduced effort.

Humor as Resistance and Resilience. Humor emerged as a recurring theme, serving as both a coping mechanism and a form of resistance against systemic pressures. Mila shared her practice of embedding Spongebob references into her course materials, using humor to surprise and engage students while creating moments of joy amidst the monotony of academic routines. Similarly, Jennifer joked with her doctor about needing caffeine on "an IV drip," using humor to navigate conversations about the physical toll of her responsibilities.

Humor as Generative Suspension and Speculative Rehearsal. Our analysis also suggests a more generative function of humor: it can temporarily suspend the gravity of institutional hierarchies, loosening the demand to perform professionalism-as-distance and opening a brief interval in which alternative relations become thinkable. In these moments, laughter does not merely "react" to the absurd; it

reconfigures the scene, enabling participants to rehearse different ways of being academic, being maternal, and being in community. Read through a ludic lens, humorous exchanges function as *micro-events of world-making*, a speculative space in which participants experiment with new pedagogical tones, re-author the meaning of interruptions, and imagine practices of care that exceed individualized resilience narratives. Thus, humor operates simultaneously as critique and creation, both naming what is untenable and momentarily generating what might be otherwise.

Strategic Play and Adaptive Coping. Participants described deliberate strategies for managing emotional overwhelm and overstimulation, highlighting the role of strategic play in sustaining resilience. Sarah described retreating to a dark room as a way to reset after reaching her sensory limits, while Mila engaged her child in imaginative discussions about their passions during conference travel, reframing interruptions as opportunities for connection. These strategies reflect the improvisational elements of gameplay, where individuals adapt to changing circumstances through creative problem-solving (Salen & Zimmerman, 2004). Ahmed (2017) frames such practices as acts of affective adjustment, where individuals reshape their environments to align with their capacities.

Perceptions of Academic Labor. The findings also reveal the complex and often contradictory perceptions of academic labor, both within families and broader societal contexts. Jennifer's children marveled at her book publication but dismissed her academic articles, viewing the former as a more tangible accomplishment. Meanwhile, Sarah recounted societal critiques of her decision to work full-time, highlighting the double standards faced by working mothers.

Implications for Practice and Policy

The findings of this study highlight actionable insights for institutions, academic culture, and methodological innovation, providing pathways to address the systemic challenges faced by academic mothers. Institutions must take proactive steps to support academic mothers, recognizing their dual roles and the systemic inequities they face:

Flexible Work Arrangements. Implement and normalize flexible scheduling, remote work options, and caregiving leave policies that account for the unpredictability of parenting demands.

Recognition of Caregiving Roles. Acknowledge caregiving as a legitimate component of academic labor, integrating it into performance evaluations and tenure considerations. This could include crediting the emotional labor and mentorship academic mothers provide to students and colleagues.

Equity in Professional Evaluations. Redesign evaluation criteria to reduce biases that penalize caregiving responsibilities, such as productivity gaps or limited travel for conferences, and emphasize holistic contributions to academia.

By addressing these structural barriers, institutions can foster a more equitable environment where academic mothers are not forced to choose between professional success and family well-being.

Cultural shifts are equally critical in creating supportive and inclusive academic spaces:

Normalize Caregiving Challenges. Promote open discussions about the realities of caregiving in academia, reducing the stigma associated with balancing family and professional roles.

Value Emotional Labor. Recognize and celebrate the emotional and relational contributions of academic mothers, from mentoring students to fostering collaborative environments.

Foster Solidarity. Encourage peer networks and mentorship programs for academic mothers, providing opportunities for shared learning, resilience-building, and advocacy.

Such cultural changes require intentional effort from leadership, faculty, and staff to create an academic community that values diverse lived experiences.

The study also demonstrates the potential of ludological approaches for exploring relational and emotional dimensions of lived experiences:

Innovation in Qualitative Research. The integration of memes, randomization, and storytelling as methodological tools highlights the value of playful, interdisciplinary approaches to qualitative inquiry.

Engaging Relational Dynamics. Ludological methods can uncover nuanced interactions and collective insights, making them particularly valuable for studying intersectional identities and systemic challenges.

Reframing Research Spaces. By incorporating humor and play, future research can create spaces where participants feel

empowered to express vulnerability, critique norms, and co-create knowledge.

These methodological contributions offer a model for expanding the boundaries of qualitative research, particularly in feminist and relational frameworks.

Concluding Reflections

This study sheds light on the lived realities of academic mothers through an innovative and playful lens, combining feminist ethnography and ludology to explore the complexities of caregiving and professional roles. By centering relationality, humor, and strategic play, the study highlights the resilience and adaptability of academic mothers as they navigate systemic and cultural challenges. The findings underscore the importance of addressing the structural inequities and cultural stigmas that persist in academic institutions. By valuing emotional labor, normalizing caregiving challenges, and implementing equitable policies, academia can move toward a more inclusive and supportive environment. These changes are beneficial for the broader academic community, fostering diversity, creativity, and collaboration. The methodological innovations in this study demonstrate the transformative potential of playful and relational research approaches. Combining ludology with feminist ethnography offers a powerful framework for uncovering the relational and emotional dimensions of lived experiences, paving the way for future research that is both rigorous and deeply human.

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Augmented and Virtual Reality Authoring: A Study of Educators

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Abstract: This study reports a collaborative self-study of five educators' experiences of teaching and learning augmented, virtual, and mixed reality (XR hereafter) in education. Specifically, it aims to examine educators' beliefs about XR applications and the design considerations when they are engaged in authoring educational XR applications. The analysis of data showed that the educators put the learning outcomes at the forefront of their design of XR applications. When considering the topics for XR applications, educators tended to focus on content customized to their local contexts. Important design

considerations also included curriculum and instructional design, equity, safety and other topics.

Résumé : Cette étude présente une auto-évaluation collaborative des expériences de cinq enseignants en matière d'enseignement et d'apprentissage de la réalité augmentée, virtuelle et mixte (ci-après XR) dans l'éducation. Plus précisément, elle vise à examiner les croyances des enseignants sur les applications XR et les considérations de conception lorsqu'ils sont engagés dans la création d'applications XR éducatives. L'analyse des données a montré que les enseignants placent les résultats d'apprentissage au premier plan de leur conception d'applications XR. Lorsqu'ils envisagent les sujets des applications XR, les enseignants ont tendance à se concentrer sur le contenu adapté à leur contexte local. Les considérations de conception importantes incluent également le programme et la conception pédagogique, l'équité, la sécurité et d'autres sujets. (Note: This French abstract was translated using Google Translate).

Keywords: AR/VR applications, learning design, beliefs, teacher authoring, engagement

Introduction

The rapid advancement of technology has brought a renewed interest in using immersive technology in education. Augmented reality (AR), virtual reality (VR), and mixed reality (MR) are examples of the emerging tools that can offer rich opportunities to enhance learning and teaching (Liu et al., 2017). In this study, extended/cross reality (XR) is used to include AR, VR, and MR. A literature review of the existing work shows that VR and AR can help promote constructivist learning (Bani-Salameh et al., 2017). Additional benefits of XR include, but not limited to, providing more exploration options for learners (Correia et al., 2016), improving learner performances (Chang et al., 2019), and increasing learner motivation (Bacca Acosta et al., 2014).

In fact, XR is considered as the fourth transformational wave of innovation in technologies into the society after the previous three waves, namely computers, the internet, and mobile devices

(Mystakidis et al., 2021). The digital literacy of educators, including teachers — that is, their competency in integrating emerging technologies — is critical for them to adopt best practices in teaching, improve their professional career, and most importantly prepare students to be competent future citizens in society and workplace (Michos & Hernández-Leo, 2020).

Although XR is not new, research on educational applications of these tools have been patchy, lacking empirical studies (Liu et al., 2017). Even fewer studies have focused on teachers with respect to XR. In addition, XR technology has improved drastically in recent years, making it much easier and more affordable to be used in educational settings. Evidently, efforts to help teachers integrate XR technologies in education is scarce (Mystakidis et al., 2021). This study, therefore, aims to bridge this gap by studlng practice educators' thoughts and experiences.

In this paper, five educators conducted a collaborative self-study that examined themselves, including their own actions and beliefs (Pinnegar & Hamilton, 2009) while teaching and learning XR in education. Specifically, the following research questions guide this research:

1. What are teachers' beliefs about XR in education?
2. What are the design considerations when educators engaged in XR application authoring experiences?
3. What are lessons learned?

Theoretical Framework

Enactivism, an emerging philosophical view, provides the theoretical grounding for this paper. Behaviorism, cognitivism and constructivism are the most prevailing theoretical perspectives in educational technology and related fields. Though looking very differently, these dominant theories in fact share similar assumptions (Davis et al., 2008). One of such similarities is the clear separation of mind and body (Davis & Sumara, 2002). Such Cartesian or dualistic view of mind and body is very popular. In such view, mental and

physical are two different and separable phenomena. While such beliefs are dominant in the field of education, it has been convincingly argued that they have shortcomings that may undermine educational practices (Davis & Sumara, 2002; Li et al., 2010). Thus, enactivism is proposed as a promising theoretical paradigm that offers a more encompassing framework than the current predominant perspectives.

At the core, enactivism stresses five interconnected ideas: autonomy, sense making, emergence, embodiment, and experience (Di Paolo et al., 2010). In this view, doing plays a central role for it is, rather than just the vehicle of, learning (Varela & Maturana, 1992). That is, cognition is grounded in action. The rich embodied experiences offered by XR through the illusion of body ownership and even body transfer, thus afford an ideal playing field for enactivist research. Enactivism also emphasizes on the inseparability of mind, body, and environment and considers that each of the three components carries equal weight rather than one subordinate the other (Proulx, 2004). Educator learning-through-designing/building thus offers a perfect breeding ground for enactivist research for it allowing the connection between learning to their environment, which included their teaching practices, personal beliefs, background as both educators and learners, and more. In this environment, the learners are asked to design and develop XR applications aiming at specific instructional topics. It is assumed that the educator-created XR applications would embody the cognitive processes of the designers (in this case, the educators) and the processes intended for students to apply when their XR applications are exploited.

Related Literature

Teacher Beliefs

Teacher beliefs related to XR highlight its encouraging and positive role in supporting student learning. Teachers believe that tools like XR can provide student-centered (Yildirim et al., 2020), experiential and inquiry-based learning (Cheng, 2022) through immersive and novel experiences that increase motivation and engagement (Cooper et al., 2019). It gives students autonomy and

teachers flexibility to observe student progress and be a facilitator in the classroom (Yildirim et al., 2020). XR can offer students unique opportunities and access to learning that would otherwise be unavailable or impossible to recreate (Cheng, 2022; Yildirim et al., 2020). For example, exploring distant places (Yildirim et al., 2020) and abstract concepts (Cheng, 2022), manipulating objects (Cooper et al., 2019), conducting experiments, and engaging in potentially dangerous situations (Seckin Kapucu et al., 2021). Thus, the literature shows that teachers believe the integration of ET has the potential to improve student learning through the creation of hands-on and student-centered experiences.

Despite the positive aspects of incorporating XR into teaching, teacher negative beliefs can hinder teachers' acceptance and intention to use AR/VR. These included a lack of technical knowledge (Bower et al., 2020), low self-efficacy (Cooper et al., 2019), low confidence in using ET (Yildirim et al., 2020), concerns about safety and monitoring students during AR/VR use (Yildirim et al., 2020). The time it takes for students to acclimate to new technologies, along with the potential for distraction, can make teachers hesitant to use XR (Seckin Kapucu et al., 2021). Perceived difficulties in managing the technology (Cooper et al., 2019) and anticipating technical problems (Cheng, 2022) negatively impacted teachers' beliefs and intentions to use XR. Teachers noticed that VR sensation required students to take breaks (Cheng, 2022). They worried that students' feelings of isolation from peers would decrease the time students collaborate (Yildirim et al., 2020). It is clear from the literature that if schools adopt XR, there must be teacher buy-in, institutional support (O'Shea & Curry-Corcoran, 2013), and stakeholder awareness of the benefits and barriers to integrating XR in the classroom (Seckin Kapucu et al., 2021).

Learning by Doing/Design

Learning by doing/design is not a new idea. Proponents of this approach have looked at its application in AR and VR to help teachers acquire needed skills. Abundant research (e.g., Buchner & Hofmann, 2022; Li et al., 2013) has shown that learning-through-building can be an effective means to help teachers gain the needed knowledge and skills to effectively integrating technology into classrooms. Teachers

who designed AR/VR experiences reported positive changes in their beliefs and attitudes toward using these technologies with students (Han & Patterson, 2020). They shared a better understanding of AR/VR and increased technical knowledge due to the design process allowing teachers to reflect on their skills, capabilities, and knowledge (Han & Patterson, 2020). The perceived benefits of learning how to design AR/VR included experiencing the successful use of the technology (Han & Patterson, 2020) and transferring acquired design skills to students (O'Shea & Curry-Corco, 2013).

For example, Han and Patterson (2020) explored the process of teacher learning through the design and implementation of technology-enhanced learning using virtual reality (VR) in an elementary school in South Korea. The study examined the teachers' learning through the design process and enactment of a VR-enhanced curriculum unit. Focusing on the external domain of resources and information about using VR, the personal domain about using VR, beliefs, and attitudes, the domain of practice of design and implementation of VR curriculum, and the domain of consequence of student outcomes and teacher outcomes. The results showed that the teachers learned about VR setup, curriculum alignment with VR content, and pedagogical strategies to use VR to enhance student learning. Teachers learned to redesign lessons incorporating VR technology to enhance student learning.

Another study (Buchner & Hofmann, 2022) compared the effectiveness of two different Synthesis of Qualitative Data (SQD)-based learning designs for in-service teachers' training on augmented and virtual reality. The study included a total of 45 in-service teachers who were divided into two groups. The first group was given an opportunity to design their own AR content, while the second group only explored the current environment. The findings suggested that designing their own AR content increased the teachers' confidence and willingness to integrate AR into their teaching practices. The results also indicated that the Will-Skill-Tool model (WST) predicted the teachers' use of technology, with a positive attitude and belief toward integration of technology, teacher readiness, and self-perceived confidence to use it. Overall, this study suggests that designing one's own AR content is a more effective method for

teacher training than merely exploring the current environment. The study by Doğan et al. (2022) explored learning through design in 3D multi-user virtual environments. Forty university students were tasked with designing a 3D MUVE using OpenSimulator software over one semester. Adopting a quasi-experimental design, the results showed that providing continuous feedback, clear and realistic goals, and adjusting challenge levels can lead to autotelic (i.e. intrinsically motivating) experiences in students.

Although teachers experienced positive benefits, they also reported barriers to designing AR/VR learning experiences. Design considerations reflected the need to ensure a clear purpose and expectations of the AR/VR experience, and any game elements used should match the lesson's goal (Lyk et al., 2019; Patterson & Han, 2019). Teachers suggested using a needs assessment to understand students' prior experiences with AR/VR, conducting a trial run of their design, and considering the set-up of the physical learning space (Patterson & Han, 2019). In the design process, teachers encountered challenges, including a lack of design experience and technical problems (Patterson & Han, 2019). Teachers reported insufficient technical knowledge, difficulties with programs such as Unity, and a lack of time to learn (Seckin Kapucu et al., 2021). They stated that they needed adequate ET design training through teacher preparation programs (Eutsler & Long, 2021) and applied professional development (Seckin Kapucu et al., 2021). Hence, teachers encountered second-order barriers when designing AR/VR.

In sum, the existing literature focused on teachers' intention to use these AR/VR with students (Bower et al., 2020; Eutsler & Long, 2021). These studies often relied on the evaluation of usability, ease of use, and usefulness as a measure of teacher intention to use AR/VR in their classrooms (Cooper et al., 2019). The limited studies on practicing educators focused on short-term training experiences or professional development sessions targeting STEM subjects (e.g., Bower et al., 2020; Cheng, 2022). Additionally, studies on teacher design mainly linked design to redesigning or enhancing their current lessons and curriculum using AR/VR rather than XR design (e.g., Eutsler & Long, 2021; Han & Patterson, 2020). The current study thus aims to bridge the gap by exploring beliefs and experiences of

educators who teach different contents and levels of education through XR design and development.

Methods

Framed in a qualitative, naturalistic research perspective (Creswell, 1998), this case study reports five educators' learning experiences focusing on XR design and learning. As a widely adopted research methodology, it provides a great tool to deepen our understanding of educational practitioners' experiences and thinking. The case was a graduate course taught by the first author in a university setting. The theoretical proposition, enactivism, guided the data collection and helped shape our focus on certain data rather than other irrelevant data as enactivism stresses that "when we analyze data, we not only observe, but modify what we turn our attention to as we make aspects of the data emerge through our reading at the same time, this changes us" (Maheux & Proulx, 2015, p. 212).

The case study design fits well with the enactivist viewpoint because both share the goal to conduct transformative research (Creswell, 1998). Further, case study approach provides a perfect methodology for enactivism because both regarding researchers and objects, such as the educators, being researched are interconnected and such connections are essential (Maheux & Proulx, 2015). Thus, the researchers and our participants, i.e., the practicing educators, co-emerged as we are observing, exploring, reflecting designing and building. The importance of doing from the enactivism viewpoint guided our attention to focus on the educators' act and different learning activities. Case study stresses that "the quality and utility of the research not based on its reproducibility but on whether the meanings generated by the researcher, or the reader are valued. Thus a personal valuing of the work is expected" (Stake, 1995, p. 135), which further fits into the enactivist view as enactivism assumes reality is inseparable from the perceiver, thus our perception and the reality are dependent on each other. In this paper, thus, multiple perspectives were taken (e.g., multiple ways to collect data, different researchers investigating the same data) which also help triangulate

data (Gay et al., 2011). Pseudonyms were used in this paper with participants selecting their own.

The Context and Participants

The context of this study was a seven-week graduate course aiming to provide students with a foundational understanding of XR technologies in education. The course was offered as a hybrid course, with two face-to-face sessions and the rest were offered online asynchronously. In the course, students were asked to review essential concepts, explore XR and examine examples of how XR has been exploited to bring about challenges in people.

Considering that many people would have limited experience interacting with XR tools, students were asked to explore various XR environments, and experiment with different XR technologies, such as VR headsets (e.g., Lenovo, Oculus). They then chose one XR tool either to evaluate based on what they believed to be the most appropriate criteria, or to integrate into a lesson plan/training module to teach specific content.

A key aspect of this course was the adoption of learning by designing/building. Students were asked to apply learning design and XR design principles to design and develop their own XR applications. Through such design and building process, students gain deeper understanding of the fundamental ideas, theories and design principles of XR in education. Since students enrolled in this course often had limited programming background, scaffolding XR development practices were intentionally built into the weekly exercises.

This course encourages educators to be reflective in their evaluation of AR/VR environments. For example, both self- and peer-evaluations were incorporated into the process. An iterative design approach was also employed integrating peer and instructor feedback-revising loop. Following their design creation of an AR/VR experience, educators in this course determine the usefulness of the designed products through testing and discussion.

The participants consisted of five practicing educators and were involved in the XR course. Amongst them, four were graduate students enrolled in a doctor program and the fifth one was the course instructor. Two of the students were enrolled in the course, while the other two served as graduate assistants helping with the course. Amongst the 4 doctoral students, three were K-12 school teachers (one was teaching at the elementary level, while two were high school teachers) and the fourth one worked in a higher education institution.

Data and Analysis

The data collected included: assignments completed by the enrolled educators for the course which also included their online communications and digital projects, researchers' notes and reflective journals. While this study focused on online interactions and reflective journals, other data provided the context information of this study and allowed triangulation of the results. A thematic analysis was used to analyze the data. Adopting a three-step process, the analysis started with open coding (Corbin & Strauss, 1990) of all written artifacts. In this phase, each researcher independently coded recurring and salient themes. The second phase discussing each other's results and later comparing these naturally emerging themes with the literature related to XR education. Such processes allowed us to examine the summarized data and create general categories from the full dataset. A matrix of merged themes was developed to support the overall interpretation of the data. In the third phase, we used matrices and other displays to further condense the data and draw comparisons (Miles & Huberman, 1994). Grouping the data under different codes allowed us to identify patterns and emergent themes. In such iterative process, a constant comparative approach (Corbin & Strauss, 1990a) was adopted to generate, refine, and recreate themes and codes (Miles & Huberman, 1994). Specific strategies were adopted to ensure reliability and accuracy, including data collection from multiple sources, independent analysis of data, and cross checking and discussion by all researchers (Yin, 2014). Further, the theoretical grounding shaped the data collection and analysis, and helped guiding presentation of the findings (Sibbald et al., 2021). The researchers discussed all the themes, with particular attention being paid to the ones with disagreement. The

discrepancies were articulated, debated, and revised until an agreement was reached.

Results

Beliefs

Using XR to solve authentic problems was at the center of all educators' consideration related to XR application in education. They believed that the immersive nature of XR could provide an ideal environment to situate learners in real world scenarios while promoting intrinsic motivation. This was best represented by Radha's articulation about how XR to be applied in firefighter training:

> This AR game is for students taking the Aerial Apparatus Driver/Operator course… Students in this course must learn how to drive and operate a heavy vehicle carrying long ladders and other equipment. A driver (in the front) and an operator (in the back) both drive this truck, so their coordination is crucial…They must navigate through an actual building on fire, search for the victims, communicate with their peers about the victims, search for safe passages, and report to the leader. [In this game] students can turn and move as if in an actual burn building (real-world settings)…this application aims to deliver a physiological immersion for students. [Radha]

Experiential learning was also favored as XR allowing visualization of abstract concepts and object manipulation. The educators discussed how content, particularly the abstract ones, could be experienced and lead to enhanced understanding of concepts. For example, Emery explained how XR could be integrated into her psychology course to enhance learner understanding:

> I think students truly seeing the structure of the organs will add a more realistic meaning to the content and allow students to engage deeper and really simulate the magnitude these various areas of function of the brain have. Students get a better understanding of the content if they could manipulate

> a VR brain and see real-life side effects that could take place. [Emery]

The cost related to XR application, both positive and negative perspectives, were shared. On the one hand, the educators believed that XR could provide a cost-effective way for content learning and skill building.

> Using a simulation to train firefighters in driving a firetruck is convenient, as it takes a lot of resources and planning to procure a fire truck. With the increasing fuel cost, simulated activities are cost-effective. It also helps reduce the pollution and the cost of other fire extinguishing resources. [Radha]

On the other hand, some worried that XR technologies were likely still too costly for K-12 education, and thus may perpetuate inequality:

> It seems as though many AR/VR products are quite costly (Oculus headsets, Co-Spaces subscriptions, etc.). [Violet]

XR was perceived as a useful means to help confidence building and decreasing apprehension. For example, Radha acknowledged how fire-fighter trainees could benefit from XR simulations: "Before entering an actual fire building, they can practice this activity until they become confident." Violet discussed how XR could help "reduce anxiety surrounding learning mistakes".

Design Considerations

What were considered the most important aspects when designing an XR environment or applications for education? Apparently, the educators treated learning outcomes as the most significant aspect. Here the learning outcomes related directly to the intended educational content and objectives for which the XR application was designed for. They agreed that the ultimate goal of any XR educational application should be to promote learning. Their discussions, both online and in person, reflected this recurring theme. During an in-person meeting, the educators had a vibrant conversation about XR as a useful means of delivering content for

learners to experience. They emphasized that learning outcomes should always be at the forefront of XR design consideration and go beyond entertainment.

> The most important aspects to consider when designing an educational AR/VR application is whether the technology is enhancing learning. Too often, technology is used to make learning more engaging, however, it does not reinforce or teach content in a meaningful way. When incorporating [XR] into instruction, the technology should complement learning goals and enhance mastery for students. [Violet]

> There is always a fear of these technologies becoming entertainment rather than educational tools for students [Radha].

Different philosophical and pedagogical perspectives guided the XR design. Constructivism was a popular framework employed.

> This simulated activity falls under a constructivist classroom design, which is a teaching style in which students can engage in the content through student-led assignments or projects that promotes them using creativity to construct a deeper understanding of the content. [Emery]

Some adopted situated learning and embodied cognition when designing, as demonstrated by Violet's design document of her VR game to teach computer science (CS).

> This game relies on situated learning and embodied cognition to increase student understanding of computer science and computational thinking. Research demonstrates that students who have acted out a scenario have better recall of the concepts learned within that embodied experience (Dede et al., 2017). The expectation is that because students are creating the code and then experiencing the robot act out the code, they will have an embodied experience to reflect on when they are coding at later times.

Other theoretical perspectives like backwards design also helped the educators when designing their own XR applications.

> This project is developed utilizing Backwards Design. In keeping with this method, objectives were selected first, then the summative activities were designed, then formative and smaller summative activities were created. [Radha]

The educators followed curriculum and instructional design principles to create their XR applications, keeping in mind various perspectives ranging from context, resources, to accessibility, to user-friendliness. For example, Radha's design document specified six critical perspectives, namely: audience, technology and resources, cost, accessibility, and ease of use/navigation. During an in-person meeting, the educators reflected on the type of learning content that could be effectively delivered through XR technologies, such as history and culture. Such discussion inspired them to further examine design principles and how instructional design could be applied to XR integration. For example, the topic of how to best present learning objectives, whether through an XR environment or teacher presentation, was perceived as an important design decision, and thus deserving careful consideration. Effective strategies for content delivery such as using good graphics and a realistic scale of objects were also explored.

When designing XR applications, educators tended to focus on content customized to their local contexts. In this course, students were encouraged to find real clients. All the educators turned to the people around them, either their own students or colleagues, whom they knew best about. They designed XR applications according to the specific target groups, content knowledge, specific XR genre and strategies. For example, as an instructional designer, Radha was interested in designing XR simulations for firefighter education. Targeting students of a firefighter rescue training course, she described how the students must:

> ...navigate through an actual building on fire, search for the victims, communicate with their peers about the victims, search for safe passages, and report to the leaders. The

> students must use the building map and communication signals while navigating through the building. While doing this exercise, the students will be fully equipped with a PPE kit, helmet, gloves, boots, and other required equipment. [Radha]

Radha's argument for the using of XR was powerful: "when it comes to training emergency responders, there are limitations to creating simulated exercises, such as a real fire and rescue exercise." She envisioned an XR integrated course to help firefighters learn content and build confidence in a cost-effective fashion.

Ethics and wellness considerations were regarded vital to address potential risks and ensure the wellbeing of learners. The educators depicted how we should prioritize ethical practices, including safeguarding user data and privacy, avoiding discriminatory content, and promoting inclusive experiences. Such discussions also included recognizing the possible impact of XR on mental and physical health of learners by incorporating appropriate measures to mitigate any adverse effects.

> While using the gaming application, students should not be harmed due to the equipment, poor design, cybersickness, etc. Disclaimers, warnings, and waivers must be included to avoid real-world mishaps. [Radha]

Equity was autonomously brought up multiple times and by different educators, often connected to a larger social context. Diversity in terms of language, culture, ability, etc. were all examined with the aim of cultivating an inclusive learning environment.

> Extended reality could be used to better promote equitable response in the field. For example, firefighters in simulation could be approached by people speaking a variety of languages and the simulation could allow firefighters to practice understanding and responding to various requests. I'm not sure if firefighters are under scrutiny like the police force for disproportionate responses to certain racial demographic groups, but in the event that there is racial disparity in response, simulations could help firefighters

> practice more equitable responses. I think this is a great idea and hope that the police force will consider using similar simulations to promote equity within their organization. [Violet]

> Making sure students with disabilities have the ability to manipulate the environment to fit their needs, such as closed captioning, motor skills assistance, etc. [Emery]

The educators also urged for careful consideration of additional benefits of XR beyond cognitive gain, such as social development, mental health, etc.

> There would be real benefit to scaffolding immersive firefighter rescue experiences to gradually increase from using only the visual to adding physical heat and realistic audio… this may ultimately desensitize firefighters to extreme situations and reduce post-traumatic stress disorder following intense rescues and experiences. [Violet]

> Cultural immersion can be achieved using ARVR technology. Sometimes, reading and seeing something is not enough until you experience it. [Emery]

Safety was also perceived as an important aspect for XR application. On the one hand, educators depicted how XR could offer a safe environment for learners to practice needed skills "in a safe space where danger does not exist but can be simulated while gaining practice and experience" [Emery], or help reduce possible emotional issues associated to learning as demonstrated by Violet's comment above regarding PTSD.

On the flip side, educators were fully aware of potential issues related to safety and student wellness. They stressed the importance for XR integration to recognize such safety related regulations and practices, including any possible harmful effects and behaviors, physically and beyond.

> While using the gaming application, students should not be harmed due to the equipment, poor design, cybersickness, etc. [Violet]

> Disclaimers, warnings, and waivers must be included to avoid real-world mishaps. [Radha]

During an in-person meeting, the educators experienced various XR tools such as Oculus and Lenovo headsets. The observation notes showed the need for each person to take breaks because of motion sickness during complete immersion in VR. This led to a dynamic discussion of various topics related to safety. For instance, one topic discussed was that factors minimizing movement and pacing with breaks could provide users with relief from possible motion sickness and other unsteady feelings, therefore demand careful consideration for XR design. Another idea was that when learners are immersed in VR environments, it is critical to remind users to sit down and utilize chairs that swivel, thus allowing learners to look around instead of moving around to avoid possible mishaps.

Lessons Learned

Several key insights emerged when considering the lesson learned from the course design and implementation in the context of XR application authoring experiences. Firstly, when a learning through doing approach was adopted, an iterative design process needed to be embraced. Differentiation with ample options was an important strategy to ensure successful implementation. Both the course design and the learners' artifacts reflected these ideas. In this course, the learners had opportunities to share their initial ideas and draft plans, receiving feedback from both peers and the instructor, and revising and refining their products. They also had the freedom to choose the outcome, software template, etc. to create their final products. Some learners adopted such an approach, as reflected below:

> Components of Rapid Prototyping were also included in an iterative approach to designing and refining the game. [Radha's design document]

Another lesson learned was the need for face-to-face interactions where various XR tools could be explored. Teachers needed exposure to a variety of XR tools, which would be challenging to realize at home or even in K-12 schools, to gain comprehensive understanding of how each tool could be best utilized and for what specific purposes. Additionally, the opportunities to meet face to face to experience firsthand the XR tools, to observe each other using such tools, and to discuss related topics were priceless. The educators articulated how their learning was greatly enhanced through such experiences, which would be difficult, if not impossible, through online exchanges only.

> It is important to go into the lab to use and experience the technologies so that we understood how they worked and how we might implement them in our projects [researcher journal].

> Building my own game in Unity reinforced my belief that teachers need explicit, in-person instruction to find success in coding experiences. [Violet]

A third lesson learned related to technological needs, both the need for adequate technical infrastructure and the skills to use those tools. During the course, Emery could not download the authoring tools provided due to tech limitations on her end. Even though she had the option and chose to use other tools, she was nonetheless frustrated: "I found the class super interesting and the content overall something I am going to use in the future but developing it myself was just awful, which is completely unlike me."

Others were able to implement their projects, yet still highlighted how coding such projects was time consuming and required some programming background, as exemplified by Violet's reflection: "The amount of time spent on editing this project would not normally be feasible for most teachers, especially those without any kind of a coding background. To address these challenges, we need more professional development surrounding AR/VR for teachers, however, getting teachers to participate would be a huge challenge in itself as many teachers self-select as not 'tech-savvy'."

Discussion

Everyone probably agrees that AR VR are powerful tools that can potentially transform education. The question of how to best utilize such tools to enhance learning remains to be answered. This study focused on educators' experiences and thoughts and several results from the data analysis are worthy of discussion.

This study presents uniqueness as it considers the beliefs of educators who teach different contents and levels of education. It involves educators engaging in a graduate course that asks participants to consider previous research in design considerations, such as best practices, theory, learning principles, and ethics. Through the design process, it invites educators to examine issues and questions about AR/VR design and its use in education. Educators use development tools like Unity and/or Adobe Aero, scarcely cited in other studies, in their AR/VR product creation.

In this study, the educators have learned XR systematically through examining theoretical groundings and exploring best practices, allowing the unification of ethical and educational aspects in their authentic designing process. As argued by Lee and Hu-Au (2021), considering ethical practices and effective learning in concert is vital for XR integration in education in order to help students grow to their fullest potential. The experience during the course has enabled the educators to fully understand the importance of equity and wellness. When designing their own XR applications, they attend to multiple perspectives related to these topics including ethics, inclusion, and safety. Their design of XR systems thus involves a conscious decision concerning different ways to promote equity and wellness of students. While we understand that teachers would not typically have chance to create their own XR applications due to practical reasons, the process of designing and developing such products, as demonstrated in this study, has helped educators deepen their understanding of educational applications of XR. It is worth noting that equity and wellbeing topics were autonomously brought up before the ideas were introduced formally. This led the instructor to organically bring it to the subsequent reflective practices and deep discussions. Such ideas were later integrated into the

educators' design and development processes when authoring their own XR application. Such experience has resulted in an enhanced understanding of the concepts and how theories connect with practices. This endorses the learning-by-doing approach and substantiates enactivism about how cognition is embodied. Emery's challenges such as her inability to download the software, have resulted in her strong emotional response about XR development. It is a good attest of enactivism emphasizing that "learning is fully embodied and fundamentally affective" (Maiese, 2017, p. 197).

A finding of this study is that the educators' XR design has been grounded in sound theories. This is not surprising since various educational theories were examined at the beginning of the course. The XR authoring process, thus, afforded the educators a good opportunity to apply the theories to their design and development. This, however, is contrasted to previous studies that only about one in three XR use cases follow learning theories (Stanney et al., 2023). Since educational theory guided XR applications have been observed as more effective than unstructured XR learning (Khan et al., 2019), it is critical that we stress the importance of theoretical grounding when XR integration is practiced.

This study shows that learning outcomes are placed at the center when educators design educational XR applications, confirming previous research (Meccawy, 2022) that putting educators in charge of designing helps assure pedagogical alignment so that learning would not be lost. At the same time, the educators tend to customize their XR design to local context. This is in accordance with enactivism which views our body, mind, and the environment are inseparable. As such, our actions, such as perceiving, creating, etc. are all influenced by our experiences and cognition. Thus, it is not surprising that the educators have chosen to address a relevant and timely instructional problem using an actual client, applying their context, and establishing goals for the design of their AR/VR experience.

Cost associated with XR is an interesting theme that has been discussed both positively and negatively. While noting that XR can provide a cost-effective means to enhance learning, the educators realize the relatively high cost of XR can cause inequality, thus

exacerbating disparities of haves and have-nots. Although more and more families are starting to purchase XR technologies, these families only constitute a relatively small percentage of households. Even for those who have the tools, it is very likely that they own limited types of XR tools. Thus, it is important to consider how schools can provide equitable access to such powerful tools for all students and their teachers for appropriate integration so that the great potential of these tools can be best harnessed.

In this study, the educators put safety as a top priority, while highlighting XR's ability to provide safe spaces for practicing skills without real-world risks and even helping with emotional struggles. They also regard issues like fair access and data security as critical factors for XR integration. As discussed in previous research (Dodds, 2021), how to ensure XR experiences available to everyone, protecting users' privacy, etc. are ongoing challenges we face. It calls for collaboration among educators, learners, and developers to shape XR into a positive and effective tool for education.

Conclusions

XR is gaining more and more attention in various fields, including education. The increased use and the great potential of XR technologies call for deep understanding of best practices for the development and utilization of XR instructional content. It is also imperative to prepare our teachers to gain solid understanding of the best integration of such tools. This study contributes to existing literature by exploring practicing educators' experiences and thoughts while engaging in authentic XR applications' design and development processes. As demonstrated in this work, XR authoring forced the learners into a situation where they must apply the knowledge learned during the course, and go through cycles of trying, making mistakes, reflecting, modifying, refining. Such a process makes learning personalized and authentic, thus leading to heightened motivation and knowledge retention. The lesson learned from the work can enhance our understanding of how to best help practitioners develop to effectively integrate XR into teaching and learning.

It is important to note that immersive learning and XR are not passing fads. Rather, they are significant developments that call for active educators' engagement. From an enactivist perspective, learning occurs through active, embodied action within dynamic settings. XR technologies offer unprecedented opportunities by expanding the contexts in which learners can engage in embodied experiments, whether in virtually or augmented setting. As such, XR holds great potential when learners, in this case educators, are actively involved in the design and development process. Ultimately, it is the responsibility of our society, including the researchers, educators, designers, and policy makers to ensure this powerful technology is used responsibly, with enactive principles of learning offering one useful lens for supporting authentic, embodied knowledge building so that our students can benefit the most from it.

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"How do I prove it?": A Narrative Inquiry into Advancing a Child's School Mathematics

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Abstract: This article celebrates Chen, a Grade 3 student who shows his lived curriculum in the context of his school. This narrative inquiry is grounded in student-centred curriculum making. We explore Chen's inherent curiosity about developing formal techniques to prove mathematical statements—a standard process performed by mathematicians. We share observations and transcribed excerpts of video conversations that demonstrate Chen's remarkable understanding of the following results: the role examples play in proving and disproving statements; the application of direct proofs; the structure of proofs by contradiction; and the structure of proofs by induction. Stavros's approach to Chen's math education has implications in how students transition from routine calculations to generalized and abstracted ideas to solving problems by agreeing upon a shared understanding of proof structures. We conclude with recommendations on *planning thoughts* and *action thoughts* as strategies to create educative experiences that support both the learning and identity making of children.

Keywords: narrative inquiry, gifted students, school mathematics, curriculum making, mathematical proofs

Introduction

"How Do I Prove It?"

My university Zoom lecture ran overtime, so I quickly switched to Microsoft Teams where Chen—a precocious eight-year-old in Grade 3—was waiting patiently. His face was mostly hidden behind a blue mask. This is our third year working together, and our second year navigating the pandemic. K-12 students have returned to school under strict physical distancing and masking guidelines. As a non-employee, I'm not allowed in the school, so I arranged with Chen's teacher to meet with him virtually.

Chen's eyes light up when he sees me. He's smiling beneath the mask. Scattered across my desk are notes of planned thoughts *for activities that may or may not be used, depending on where his playful curiosity takes us. I share my screen and show him Goldbach's Conjecture—one of the oldest and most infamous open problems in number theory. It proposes that every even integer greater than 2 is the sum of two prime numbers. It was Chen's idea to explore this last week, and I'd forgotten how captivating these problems can be. I ended up spending hours lost in it. Chen reminds me that playfulness is important.*

Last week, Chen began testing the conjecture himself:

$4 = 2 + 2;\ 6 = 3 + 3;\ 8 = 3 + 5;\ 10 = 5 + 5;\ 12 = 5 + 7;$ ...

I tell him about the largest number that's been tested, some heuristic results, and other interesting facts about the conjecture's history. He listens intently, calculating as we go. Then he looks up and asks, "All the examples I tried work so far. How do I prove it?" (Field text, October 2021).

Greetings, tansi, taanishi, bonjour. I am Stavros, working in teacher education and conducting educational research in the College of Education at University of Saskatchewan, located on Treaty 6 territory and homeland of the Métis. At the time of this project, I was collaborating with teachers and students in their mathematics classrooms. My primary focus was working with Indigenous teachers and students. I took on this project with Chen in addition to my regular responsibilities, ensuring that it did not compromise the time or financial resources allocated to my existing programming.

I am Shaun, also based in the College of Education at University of Saskatchewan on Treaty 6 territory and homeland of the Métis. My

background includes working as a primary school teacher and later as a professor teaching elementary mathematics methods. I joined Stavros in this project to bring together my expertise in teacher education with his academic background in mathematics.

Our professional work with children and youth is grounded in Connelly and Clandinin's (1988) concept of curriculum making. While 'curriculum' often refers to the mandated documents teachers use to plan lessons, Aoki (1993) encouraged researchers to consider the diverse *lived* curricula that emerge through student-teacher interactions. Working with Chen reminded us of the limitations of the mandated curriculum, which did not adequately support his educational needs or experiences. It was through Chen's enthusiasm and playful engagement with mathematics that we were able to discern the direction he wished to pursue. Centering curriculum making shaped both our research approach and our pedagogical stance to teaching mathematics.

In previous work (Stavrou & Murphy, 2024), we illustrated the experiences coming to meet Chen and the complexities around his lived curriculum as a strong mathematics student. He sometimes described his mathematics class as boring and lacking opportunities to build on what he already knew or was curious about. This sentiment was echoed by his teachers, who noted that he quickly completed assigned work, had prior exposure to concepts beyond the curriculum, asked questions that exceeded the teacher's content knowledge, and sought alternative methods for solving problems. Continuing in this direction, our study offers an example of how curriculum evolves in real time within the context of mathematics learning. Chen inspired us to design activities that allowed him to engage with mathematical processes that genuinely interested him—something that is difficult to achieve within the constraints of a mandated curriculum, especially in classrooms with diverse learning needs.

One teacher asked, "What do we do with him?" Her question points to the imperative of providing differentiated learning and additional supports to diverse students, as well as the challenges inherent to that. In this article, we share experiences that highlight Chen's spontaneous interest in learning and applying mathematical proofs—a formal logical structure central to mathematical problem-solving. Stavros's field texts illustrate Chen's grasp of key proof

strategies, including the role of examples in proving and disproving statements, direct proofs, proofs by contradiction, and proofs by induction. A recurring question Chen posed that guided the trajectory of our sessions was: "How do I prove it?"

The remainder of this article is organized as follows. First, we situate ourselves within the broader research landscape by describing mathematical proofs and examining the role of teachers in curriculum making and identity formation for children with exceptional needs. Next, we outline our methodological approach of using narrative inquiry (NI) to explore the lived experiences of Chen, as well as our own. We then discuss our findings through field notes that narrate our sessions, illustrating an approach to Chen's relational curriculum making and demonstrating how students move from routine calculations to abstracted thinking. The transition to abstraction is facilitated through a shared understanding of proof structures. Finally, we conclude with reflections on *planning thoughts* and *action thoughts* as strategies educators can use to create educative experiences that support both the learning and identity making of children.

Literature Review

Locating Ourselves in the Broader Research

We do not provide a comprehensive overview of the design and characteristics of differentiated tasks for students with gifted mathematical abilities, nor is this article concerned with evaluating research on teaching models. Rather, our research is an example of the trend towards qualitative studies demonstrating the value of recognizing, differentiating, and directing mathematically precocious students (Ozdemir & Isiksal Bostan, 2021) with particular attention to a Deweyan (1938) ontology of experience and the ways educative experiences enhance growth.

Proofs in Mathematics Education

The phenomenon of how proofs are perceived, taught, and applied in educational settings to validate mathematical statements and deepen understanding involves students' conceptual understanding, teachers' content and pedagogical knowledge, and instructional practices (Faizah et al., 2020; Lesseig et al., 2019). There

are challenges in distinguishing proof from justification, opportunities for developing argumentation, and adapting teaching methods to promote meaningful engagement by connecting formal reasoning with intuitive approaches (Herizal et al., 2019; Stavrou, 2014). Hanna and Knipping (2020) surveyed how the role of mathematical proofs in education has changed between 1980 and 2020, tracing its evolution from post-New Math backlash to modern digital tools that help with proof construction. They provided an historical context which emphasized axiomatic rigor but faced backlash in the 1950s-1970s, leading to a 1980s shift toward constructivism, heuristics from Polya and Lakatos, and informal proofs valuing understanding over formality. They noted that from 1980-2000, studies highlighted student proof schemes (e.g., empirical versus deductive) and roles of intuition, while 2000-2020 studies brought sociocultural views, software for conjecture-testing, and debates on the aims of proofs.

Most attention surrounds the difficulties students have understanding proofs (Epp, 2003). Largely due to the advanced nature and prerequisite knowledge of mathematical proofs, most literature describing its teaching and learning is centred around high school and post-secondary students. An exception by Er and Dinc Artut (2022) explored 25 fifth-grade Turkish students who were diagnosed as gifted and were administered tests through Balacheff's taxonomy to determine their levels of proof conceptualization and development.

This article uniquely considers a child in Grade 3. We were not interested in quantifying or qualifying his level of giftedness or producing a diagnosis. Rather, we were interested in identity making and navigating schooling contexts through a NI (Huber et al., 2003) that explored Chen's experiences receiving curricular supports. The successful results of Stavros's approach to Chen's education has implications in understanding how students transition from routine calculations to abstracted ideas required in solving problems by agreeing upon a shared understanding of proof structures. Proofs are not part of Chen's curriculum, and therefore the inclusion of it functions differently in his education.

Role of Educators in Differentiated Mathematics Instructions

In the broader research, Chen's experiences can be described in terms of differentiated mathematics instruction (Freiman, 2011) geared towards a talented student (Rotigel & Fello, 2004) in ways that

appropriately challenge and inspire his creative disposition (Boaler, 2015; Feldhusen & Kroll, 1991; Sheffield, 2017) and mathematical interests (Lampen & Brodie, 2020). As educators, our role is a form of cognitive apprenticeship in which we provide extrinsic and intrinsic supports, such as scaffolding and reflective meaning-making (Bouta & Paraskeva, 2012). Using Chen's curiosity, we attended to the necessity of exploring other areas of mathematics when considering a mathematical problem. Stavros's background doing mathematics research in algebra informed his understanding of how to explore branches of mathematics, which he imparted to Chen.

As educators, we must re-imagine ourselves as curriculum makers by considering the lives of our students, as we exemplified in this article. While expectations on teachers exist, lives—not mandated curriculum—need to be the starting point. Our intention is to show and tell the ways a child's school mathematics was re-shaped through his inherent curiosity. We argue that the significance of Chen developing the language and logic of mathematical proofs is that they are fundamental to describing and advancing mathematical phenomena in research and practice.

In terms of identity making, Chen made explicit that he wanted to be able to do mathematics every day like Stavros does. Chen was curious about problems that Stavros researches, and began to see himself as a mathematician who also solves problems. Through the relational curriculum they co-composed, Chen's identity as a *mathematical* person grew as he established the conventional discourse mathematicians use to discuss proofs.

Narrative Inquiry

The research in this article was constructed and conducted using a NI methodology (Clandinin, 2013). The commonplaces of NI—consisting of sociality, temporality, and spatiality—shaped our understanding of the field texts (Connelly & Clandinin, 2006). These commonplaces provided a context through which to view and understand the field texts. Individuals live storied lives on storied landscapes (Clandinin, 2013), and in this research we inquired into a research experience related to the teaching and learning of advanced school mathematics with Chen.

The teaching of mathematics is not only situated in an understanding of subject matter but also resides in issues of identity making. The understanding of curriculum as a course of life (Connelly & Clandinin, 1988) is a way of considering the complexity of curriculum beyond subject matter. The curriculum commonplaces of subject matter, learner, teacher, and milieu (Schwab, 1978) position curriculum as an interactive and dynamic event. This event can be understood as curriculum making, which implies that curriculum is involved in life writing and therefore, identity making (Clandinin et al., 2006). For example, when engaged in mathematics learning, children are also in the process of life-writing and their identity making. The involvement of university instructors providing differentiated learning for Chen is a response to his need for identity making, taking up a complex way of knowing and being in relation to mathematics education. According to Trumbull et al. (2002), "individual students construct an understanding of mathematics concepts on the basis of their experiences within a community" (p. 2). In our professional practice, community includes the involvement of university instructors in Chen's education.

Methods

Stavros met with Chen once a week during his regularly scheduled math class, through Microsoft Teams. The sessions were 40 minutes in length. Teams connected Stavros (working in his home office) with Chen (in a private resource room in an urban elementary school, located in a Western Canadian prairie province.) The timeframe highlighted in this research occurred from September 2021 to December 2021.

The data collected is in the form of field notes of observations made during math sessions with Chen; transcribed summaries of audio-recordings taken during math sessions; video recordings of Teams sessions; and artifacts such as lesson plans, curriculum resources, and university mathematics textbooks.

During their one-on-one sessions, Chen solved problems Stavros prepared ahead of time, but they also engaged in topics that emerged as Chen directed his attention to other problems that piqued his interest (e.g., problems he was given by his teachers or problems he learned at home while watching YouTube videos). The fragments of narrative throughout the article were composed either from Chen's

words, the solutions he provided to the problems Stavros posed, or from Stavros's interpretation of Chen's recorded "actions, doing, and happenings, all of which are narrative expressions" (Clandinin & Connelly, 2000, p. 79).

Stavros recorded the Teams sessions during the periods they were held. The purpose of recording the sessions was to summarize interesting discussions to share in this article. His parents and teachers did not ask to view the recordings because Stavros adequately summarized the important details of the overall progress and performance. There were no audio transcripts.

Monthly member checks throughout the school year consisted of conversations with Chen's parents and teachers. They gave Stavros autonomy and authority to direct Chen's learning, which was largely motivated by Chen's engagement and proclivities towards specific topics.

Shaun came alongside Stavros to collaboratively analyze the field notes. As narrative inquirers, we interpret Chen's classroom experiences by engaging with the stories he tells about his schooling within a three-dimensional inquiry space—considering time, social relationships, and place. Shaun listened to Stavros's and Chen's narratives, observing and co-constructing meanings alongside them, integrating personal, social, and cultural contexts (Kim, 2016; Wei, 2023). This process of reconstructing narratives to understand the complexity of Chen's lived classroom experiences involves considering how experiences are shaped by grand narratives (e.g., institutional, communal, and familial), deciding what stories are told, and the relational-ethical aspects of representing lives in the midst (Clandinin & Connelly, 2000; Clandinin et al., 2006).

Setting the Stage for Experiences with Chen

Stavros used *planning thoughts* and *action thoughts* (Clark & Peterson, 1986) to understand and shape his sessions with Chen. Planning thoughts are those that take place before or after lessons, when teachers can reflect or reassess in a quiet environment; whereas action thoughts emerge during classroom interactions, where immediacy and complexity are unavoidable as teachers and students engage with each other (Doyle, 1986).

Stavros engaged in planning thoughts during the time between sessions with Chen, which involved creating math problems with purposeful scaffolding, curating content that allowed Chen to explore

topics in breadth and depth, and designing activities with tasks requiring different levels of attention and structure.

Stavros shared with Shaun an instance when he did not have adequate time to prepare between sessions, where Chen said, "Maybe you should come prepared so that I don't have to wait." (Field text, May 2019). This comment—made early in their time working together—remained at the back of Stavros's mind, reminding him that preparedness shapes educative experiences.

Coleman (2014) explained action thoughts are quick, spontaneous, and critical to the successful implementation of a lesson in which there is little time for reflection. For example, if the solution to a math problem did not work out the way Stavros intended—causing a temporary disruption in their session—Chen sometimes made impatient remarks, perceiving the disruption of flow as Stavros's lack of preparedness, rather than an organic aspect of learning. By having a series of activities planned, Stavros can pivot. For example, as Stavros continued providing planned information on the Goldbach Conjecture, he noticed Chen became fixated on the concept of proving the 'simple' statement, which Stavros knew wasn't likely because of its status as an unsolved problem. Stavros used this opportunity to shift the direction of the session towards techniques of proving mathematical statements.

This inquiry drew our attention to the need for curriculum—understood as life making—to provide educative experiences (Dewey, 1938) for children. Results of this article included Chen's understanding of the role examples play in proving and disproving statements; the application of direct proofs; the structure of proofs by contradiction; and the structure of proofs by induction.

Findings

Direct Proofs and the Role of Examples: Interruptions in Chen's Thinking

A *direct proof* is a logical argument where one assumes the truth of the hypothesis and uses previously established facts to derive the conclusion without resorting to contradictions or contrapositions. For statements of the form 'if P then Q', a direct proof assumes P to demonstrate Q must be true through a sequence of logical steps. This

deductive practice is vital to developing students' mathematical reasoning (Miyazaki et al., 2022).

Stavros asked Chen to prove the statement, 'If x and y are even integers, then $x + y$ is an even integer.' Their conversation is summarized below:

> *Chen: That's an easy one. Adding two even numbers together gives an even number. Like, 2 plus 2 is 4; 10 plus 12 is 22; 30 plus 300 is 330.*
> *Stavros: You listed three specific examples that work; but that doesn't prove the general statement.*
> *Chen: Why not?*
> *Stavros: For example, if I ask you to prove the statement, 'Dividing two integers creates an integer.' If you give me examples like 2 divided by 2 is 1 or 300 divided by 30 is 10, did you prove the statement?*
> *Chen: No.*
> *Stavros: Why not?*
> *Chen: Because you only picked examples that work! So, 3 divided by 2 doesn't work because 1.5 is not an integer.*
> *Stavros: Exactly. You found a counterexample to disprove the statement, 'Dividing two integers creates an integer.' So, to prove the statement, 'If x and y are even integers, then $x + y$ is an even integer' using examples, you'd have to show that every possible example works—which you can't do because there are infinitely many even numbers.*
> *Chen: Okay I get it. What do we do?*
> *Stavros: What do you know about even integers?*
> *Chen: They are multiples of 2.*
> *Stavros: [The expressions are written on the whiteboard feature of Microsoft Teams. This feature is also available to Chen.]. Let 2m and 2n represent two arbitrary even numbers, where m and n are any integers. Now what?*
> *Chen [writes]: 2m + 2n = 2(m + n). Okay I get it now. The answer is a multiple of 2 no matter what integers m and n are.*
> (Field note, October 2021)

This field note demonstrates Chen's understanding of the role examples play in proving and disproving statements using properties

of integers. This nuance of understanding is foundational to the need to develop the formal agreed-upon structures of mathematical proofs to solve problems.

Stavros understood Chen's affinity towards applying theory to develop new ways to think about more generalized and abstract statements. Chen's engagement to the conversation confirmed the importance of designing dynamic curriculum that responds to the needs of a child through educative experiences (Dewey, 1938).

Chen drew our attention to the need for responsive curriculum making that considers and accounts for the life experiences of children. This example exceeds what teachers might reasonably do in classroom contexts, and we do not suggest such a level of differentiation for all children in all contexts. What we uncovered in this research is how an individual support person was able to facilitate a responsive curriculum. We know that mathematics teaching can often be fraught in terms of differentiation to accommodate high-level mathematics teaching (Ekstam et al., 2017; Prast, 2018). We came to see that the interactions between the child and Stavros had a significant impact on the child's identity making. One of the calls for NI is the social significance of an inquiry.

A Proof by Contradiction: Chen's Developing Flexible Thinking

Chen used examples, statements, and properties about integers that he understood fully as the mechanism to explore the abstract concepts of proving the statements. To prove statement P is true using the method of contradiction, the strategy is to assume P is false and then show this assumption leads to something false or impossible. Careful scaffolding is needed to overcome the pedagogical challenges fraught in this method, such as begging the question or relying heavily on concrete examples (Ko & Rose, 2022; Stavrou, 2014).

Below is a field text that informed our result about Chen's understanding of a *proof by contradiction* using a canonical example from number theory.

> *Stavros: Any real number belongs to one of two disjoint sets. What are the sets?*
> *Chen: The set of rational numbers or the set of irrational numbers.*
> *Stavros: Yes. If we choose any random number from the set of rational numbers, what form does it have?*

Chen: It's an integer or a fraction.

Stavros: Good. And don't forget that any integer can be written as a fraction by writing 1 in the denominator. Give me an example of an irrational number.

Chen: The square root of 2.

Stavros: Good. Let's use a proof by contradiction to prove the statement, 'The square root of 2 is irrational.' To start this, we are going to assume the opposite: the square root of 2 is rational. What does this mean?

Chen: It means the square root of 2 is a fraction.

Stavros wrote: $\sqrt{2} = \frac{n}{m}$*, where* n *and* m *are positive integers. Let's assume* m *isn't 0 and the fraction is reduced so that they don't share any common factors.*

Chen: Okay, because we can't divide by 0.

Stavros: To move to the next step, eliminate the square root.

Chen: Okay, so I have to square both sides:

$$2 = \frac{n^2}{m^2}.$$

Stavros: Now cross multiply.

$$2m^2 = n^2$$

Stavros: Is n^2 *even or odd?*

Chen: Even because it is a multiple of 2.

Stavros: Good. What about n*?*

Chen: Hmm… n *has to be even also because an odd number multiplied to itself is odd; but an even number multiplied to itself is even.*

Stavros: Good. We can rewrite n *as* $n = 2p$*, where* p *is a non-zero, positive integer. Substitute this into the equation you created and play around with it.*

Chen:

$$2m^2 = (2p)^2$$
$$2m^2 = 4p^2$$
$$m^2 = 2p^2$$

Chen: OH! That means m *is also even! OH! OH! But that's wrong!*

Stavros: Why is it wrong?

Chen: We said $\frac{n}{m}$ *is simplified—they can't BOTH be even at the same time.*

Stavros: Good! We reached a contradiction when we pretended that the square root of 2 is rational. Therefore, it must be irrational.

(Field text, October 2021.)

Chen can flexibly work through problems using symbols and variables without getting confused by the abstraction. Stavros knew this, which helped scaffold Chen through the proof. Proving the irrationality of $\sqrt{2}$ is standard in post-secondary algebra courses. Stavros recalled learning the proof for the first time as an undergraduate student in a third-year number theory course. Stavros felt ill-prepared to deal with proofs because the foundational concepts were not appropriately scaffolded, leading to issues integrating proofs across various topics when his instructors taught advanced mathematics operating under the assumptions that students had the requisite knowledge. Stavros stated, "I encountered unnecessary struggles and barriers in my undergraduate and graduate courses because of this. I recall telling my master's supervisor that our undergraduate program requires a discrete math course for examining proofs. I was ignored, but such a course now exists." (Field note, December 2021).

This was a narrative thread in the stories of Stavros's experiences learning post-secondary mathematics that made him more attuned to instructional strategies that explicitly model proof construction. Stavros makes clear that the relational understanding of NI implies that the experiences of the researcher shape both the unpacking and experience of the research (Clandinin & Connelly, 2000).

Proofs by Induction: Stavros's Miseducative Experiences = Chen's Educative Experiences

A proof by induction verifies that a statement holds true for natural numbers. The first step of induction is the base case, where the statement is shown to be true for an initial value, such as $n = 1$. Next, the inductive step assumes the statement holds for $n = k > 1$ (called the inductive hypothesis) and then shows it also holds for $n = k + 1$.

Research shows that students often fail to recognize the importance of the base case; confuse the inductive hypothesis and the statement to be proven, leading to circular reasoning; rely excessively on empirical data; and struggle with the symbolic notation and algebraic manipulations during the inductive step (Michaelson,

2008; Norton et al., 2023). Stavros's planned thoughts reflected his own struggles learning proofs by induction, which shaped the statements he chose to present to Chen. "In my first year of university, I learned to prove the statement, 'For any natural number n, the sum of the first n natural numbers is equal to $\frac{n(n+1)}{2}$. I remember doing countless examples until I was convinced it worked; but, for me, the proof did not explain *why* it worked, so proofs by induction often didn't feel intuitive." (Field text, October 2021). Stavros relied on the empirical data of examples to support his understanding, but he never truly felt he made the conceptual leap to understanding the connection between mathematical induction and the result.

Reflecting on his own miseducative experiences guided Stavros to present Chen with intuitive, explanatory proofs by induction, such as the one used to verify the Heavy Coin Problem, a classic logic puzzle where you must identify a counterfeit coin. The task involves 3^n identical-looking coins, one of which is slightly heavier, with the challenge to identify the heavier coin using no more than n weighings on a balance scale. Stavros also chose this problem because Chen has an affinity to working with multiples, exponents, and large numbers. His conversation with Chen is summarized in the following first-person narrative:

> *"Chen, I need your help with a very important problem," I said as soon as we connected through Teams.*
>
> *"Okay, I guess I can try," Chen replied, beaming through his mask. "What's the very important problem?"*
>
> *"Did you remember to bring your chips? Pretend they are like my coins." I showed him a handful of plastic coins I had purchased last week.*
>
> *"Okay. I can pretend. It would be easier if you could come here," Chen said, referring to Covid precautions.*
>
> *I shared a fictitious story about being a coin collector and needing his help determining an efficient way to locate counterfeit coins by comparing their weights. I had an interactive balance scale shared on our screens. "If I have 3 coins, can I determine the counterfeit coin by using one weighing?"*

Chen quickly realized how one weighing would determine the counterfeit coin: place one coin on the left side of the scale, one coin on the right side, and leave the third coin on the table. If the scale is balanced, the coin not weighed is heavier; otherwise, the scale reveals the heavier coin. This demonstrated the base case: $n = 1$.

I applauded him for understanding that not every coin needs to be directly weighed to determine the heavier coin, hoping it would prompt him to apply this strategy when I added 6 more coins to the pile (i.e., $n = 2$ *involves* $3^2 = 9$ *coins). I asked, "Can we find the heavier coin in 2 weighings?"*

Chen shuffled coins around, murmuring ideas softly, his voice muffled by the mask he wore. Eventually, he stacked 3 coins on the left side of the scale, 3 on the right side, and 3 on the table. He giggled—which I knew to mean he had an aha! *moment—and said, "I know which pile has the heavier coin. Okay, so let's just pretend it's in the pile of coins on the table and that's why the scales balance. Then I can take the 3 coins from the table and split them up the way we started."*

Now I was the giddy one. I asked, "Let's pretend the number of coins I have is 3^k*, where* k *represents any number bigger than 1. What if* $k = 168$*? That's a big number because—"*

"Well, 168 isn't that big but 3^{168}*is more atoms than the whole universe."*

"What? How do you know that?"

"Well. You told me there are, like, 10^{80} *atoms in the universe."*

(Field note, October 2021)

This field note demonstrates the complexities of planned thoughts and action thoughts: Stavros's plan to teach induction proofs involved spontaneous decisions to discuss tangential ideas that Chen considered. If Stavros had responded to these movements away from the central problem as if they are disruptions to the main task, he will not have noticed that Chen was making comparisons with

what he already knew by integrating prior knowledge. Furthermore, these brief digressions to examples and prior knowledge are strategies to manage the cognitive load and improve problem-solving performance (Gupta & Zheng, 2020).

The conversation turned into Stavros having more coins than atoms—an absurdity that made Chen laugh. Eventually, they returned to the proof. Building off the base case, using examples ($k = 1, 2, 3$) as empirical evidence, and utilizing prior knowledge about multiples of 3 allowed Chen to see the crux of the problem: he could always locate the pile with the heavier coin on the first weighing by creating 3 equal piles—one on the left of the scale, one on the right, and one on the table—and then iteratively creating 3 equal piles until there are 3 coins left. This demonstrated the inductive assumption: when there are 3^k coins, we can assume it takes k weighings to locate the heavier coin.

Stavros asked, "If I give you 3 more coins, what can you conclude?"

"It would take one more weighing because I can split them evenly on my 3 piles," Chen answered after a brief pause.

"This is the inductive step: we can weigh 3^{k+1} coins $k+1$-times to locate the heavier coin. This completes the proof that if we have 3^n identical-looking coins, one of which is slightly heavier, we can locate it in no more than n weighings." (Field note, October 2021)

Discussion

Concluding Reflections: Planning Thoughts and Action Thoughts

Planning thoughts are integral to preparing for activities by reflecting upon what works and doesn't. Time constraints affecting preparation and activities that fail to captivate both mean sessions might have a trial-and-error dimension. Stavros's expertise in math and education provided him the competence (Creecy, 2020) to deliver specialized topics that Chen would otherwise not encounter until high school or beyond.

We recommend that educators approach planning thoughts as a process of posing questions with loose yet intentional goals, rather than setting rigid objectives that may lead to mis-educative experiences (Dewey, 1938). Stavros admitted to sometimes forcing activities because he already consumed varying amounts of precious

time and did not want to see it go to waste. Flexible planning thoughts is a recursive approach to adapting to student needs and maintaining a coherent trajectory—or embracing inevitable decoherence and then pivoting.

We recommend educators develop capacities for action thoughts so that they are better prepared for the spontaneous decisions and responses inherent in complex classroom interactions (Coleman, 2014). Keeping in mind our role to co-compose curriculum with Chen in ways that support his identity making as a mathematician (Stavrou & Murphy, 2024), Stavros facilitated sessions by learning Chen's behavioural cues and responding appropriately to various in-the-moment instances that might undermine the progress of the session.

Conclusion

Effective teaching with precocious students involves a nuanced interplay of planned and spontaneous thinking. In terms of identity making, the result of this was a series of interactions in which Chen developed rigorous mathematical skills and competencies that are integral to mathematicians endeavoring to verify statements using the agreed-upon logic system of mathematical proofs. As educators, we must balance the expectations of the mandated curriculum with the creative conditions of constructivism that support the thinking processes and needs of a child whose life is in the making (Huber et al., 2011; Zain et al., 2012).

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What's funny?

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Abstract: Science education sometimes seems quite dry and humourless; however, there are opportunities to add some entertainment to science in the classroom. The National Park Service often posts to social media a blend of science with the humour that comes from ordinary people, animals, photos captured at key moments, and popular culture. These posts can inspire curiosity and lead to discovery by those who delve into their topics. Both scientist and non-scientist views align to explain the popularity of these contemporary general science outreach efforts.

Résumé : Les cours de science semblent être sans bonne humeur; toutefois, c'est possible de discuter la science avec un peu de légèreté. Le National Park Service des États-Unis affiche à Instagram des publications pour renseigner tout the monde au sujet de leurs parcs nationaux. Mais ces publications sont composées d'un mélange de science et des contes amusants des gens ordinaires, des animaux, des photos, et des événements récents. Ces publications aux médias sociaux pourront attirer l'attention des lecteurs. Ensuite, c'est possible que les lecteurs sentent encourager de rechercher et de s'instruire au sujets des publications. Divers auteurs sont d'accord: un peu de bonne humeur rend ces publications de science d'Instagram très populaires.

Keywords: humour, science education, national park, Instagram, pen

We have probably all had the experiences of telling a joke that didn't 'land' properly for our audience and also of hearing a joke that didn't 'land' properly for ourselves. It was recommended to me by my mentors, and I continue to recommend to others, to generally avoid humour in educational settings. The general concern is that without

context, something we think is funny might not be appreciated by the recipient of our e-mail or by a student sitting in the classroom, and then we have a major problem on our hands – we have to find some socially acceptable way of backtracking or moving forward, despite or due to the power imbalance inherent in the classroom. Even without any hurt feelings or worse, humour might detract from the serious business of learning that is supposed to be happening (Sudol, 1981); for example, one might retain a clearer memory of one's professor throwing a chair across the lecture hall than of the course content that was covered that particular day. So it is generally considered best to just be serious in the sciences.

One of the more famous scientists of the 20th century, however, devoted an entire book to jokes. Isaac Asimov (1991) confidently stated on the very first page of his joke anthology "that the one necessary ingredient in every successful joke is a sudden alteration in point of view" (p. 1). At its foundation, Asimov (1991) believed that humour occurs when we put a new spin on something that is a given or taken for granted. For example, Asimov (1991) noted that we have a "natural progression of thought designed to make a solemn impression" (p. 4); for example, we tend to list in increasing urgency a number of unfortunate events (Asimov, 1991). What's more, however, is that Asimov's advice for his readers implies that the goal is ultimately connection. He clearly states that "[a] joke is a social phenomenon; an interaction among people ... it breaks down reserve, eases tension, establishes contact" (Asimov, 1991, pp. 2-3). Increasingly, however, there seems to be a decrease in society's consensus on what is seen as a natural progression, or what is a given. People within even a small friend group can have so many different priorities, practices, and backgrounds, any aspect of which can make someone's attempt at humour reinforce reserve, increase tension, and distance friends from each other.

Paul Feyerabend (1993) had harsh words for science education in general and the humour that accompanies scientific endeavours in particular. For example, Feyerabend (1993) referred to "the inbred and always rather nasty kind of jocularity one finds in specialized professions" (p. 11) in his reflections about education in the sciences. There is certainly a danger that those who have very narrow pursuits could be guilty of a sense of humour that excludes anyone without understanding of those same narrow pursuits. C. S. Lewis (2001),

possibly writing from the point of view as the academic he was, referred to flippancy as "the [j]oke is always assumed to have been made…every serious subject is discussed in a manner which implies that [the joke-teller and listeners] have already found a ridiculous side to it" (p. 56). Lewis' view of flippancy complements Feyerabend's view of scientists burrowed into their disciplines: outsiders could not possibly appreciate the intricacies of a discipline and therefore are also excluded from enjoying its jokes. While we might dismiss both Feyerabend's and Lewis' views since these men are not, strictly speaking, scientists, Asimov (1991) manages to make things worse by recommending that, among other things, in telling jokes "[t]he general rule is: [l]et stereotypes work for you." (p. 13) Wait…what?!

The National Park Service (NPS) on Instagram first came to my attention circa 2023, with a post featuring a pen on the left and a snake, the latter somewhat coiled but approximately pen-sized, on the right (National Park Service, 2023f). The written part of the post begins by describing the pen, then breaks the fourth wall with the realization that the post ought to have been about the snake. The post then provides actual snake-related information before reverting to jokes about the pen, even completing its post with a list of hashtags ending with "#pen". This social media post is a perfect match for Asimov's description of what humour is; namely, handling a scientific image in an unexpected way with the focus on the pen and not the snake, and it even ends as Asimov recommends, with the hashtag pen anticlimax (Asimov, 1991). Better yet, it avoided the worst of Feyerabend's concerns since the NPS made their post the way Feyerabend (1993) saw and believed the history of science should be: "as complex, chaotic, full of mistakes, and entertaining as the ideas it contains, and these ideas in turn [are] as complex, chaotic, full of mistakes, and entertaining as are the minds of those who invented them" (p. 11).

This NPS post inspired me to create an in-class scientific writing assignment. To begin, my exercise asked students to list the "things" in the image, then to suggest the main reason for the photograph being taken. Once students committed to their own scientific views of the image, I provided them with the text of the NPS post itself. It should come as no surprise if students assumed that the pen is in the photo to put the size of the snake in perspective – in fact, it would be surprising if a student wrote a pen-centred analysis of the photo in a

science classroom setting. My questions continued by asking students to guess at what is fact and what is fiction in the post – and even what is scientific or not. For example, the post's assertion that the "pen [is] capable of writing continuously for one mile" (National Park Service, 2023f) is scientifically measurable and therefore could be established – or not – as fact, as is "when the weather gets warmer, more snakes may start to make an appearance" (National Park Service, 2023f). This latter fact is almost a public service announcement, for anyone visiting a national park yet wishing to avoid an encounter with a snake. Tangentially, the statement "the pen ... belongs to the park, not the snake" (National Park Service, 2023f) is also factually true, but is not really relevant from a scientific point of view. In contrast, the statement that the snake is writing a book is certainly fiction (National Park Service, 2023f). Instagram members' comments about the post were fodder for further scientific analysis in the classroom setting. For example, the comments section gives a perfect example of a circular argument (Weston, 2017) when one Instagram member asked "How big is the pen?" (National Park Service, 2023f) and another member's response was "about one snake long" (National Park Service, 2023f). In contrast, useful park visitor information was obtained from yet another Instagram member's question "[a]t what size does a Danger Noodle upgrade to a Nope Rope?" (National Park Service, 2023f), when the NPS responded "[a]bout five pens" (National Park Service, 2023f).

There are many reasons to fear or dislike snakes – perhaps someone who has been bitten in the past has no wish to encounter snakes again under any circumstances, even in an online image. Therefore, it is entirely possible that anyone with an antipathy towards snakes could simply scroll past this post, perhaps even taking a moment to unfollow the NPS to prevent future online snake encounters. However, it is also possible that someone who had enjoyed other NPS posts might take the opportunity to give snakes a second chance, thanks to the humour involved. Other NPS posts feature a collection of entirely black images as if photos had been taken inside caves (National Park Service, 2023d), a photo of a banana as a non-metric unit of measurement (National Park Service, 2023b), a poster admonishing visitors not to "pet the fluffy cows" (National Park Service, 2022) i.e. bison, and one requesting visitors not break up (their relationships) while on a guided tour within a national park

(National Park Service, 2023a). In each case, there were many, many comments demonstrating people's enjoyment of and building on these jokes, jokes about the science, safety, or history associated with various national parks. The NPS is on to something: the natural world provides an endless amount of entertainment, between the animals, the locations, and the people who visit them. Add a touch of popular culture or current events and suddenly a porcupine – an animal you may have never seen before in person – is forever linked to Weird Barbie in your mind (National Park Service, 2023c). The many responses to NPS posts speak to Asimov's assertion that jokes are "a social phenomenon; an interaction among people" (Asimov, 1991, p. 2). And yet even as they draw people together online using humour, the NPS knows that not all topics are humorous; for example, the post accompanying a photo of a fawn curled up in the shadow of a tombstone at Andersonville reflected on military service and recognized veterans (National Park Service, 2023e), with none of the humour that characterizes most of its other posts.

It is also worth exploring why we intrinsically see a pen as a non-metric measuring device and the snake as the focus of the NPS post image (National Park Service, 2023f). Pens don't really seem sufficiently scientific, perhaps, or snakes are more dangerous and more worth exploring. Or maybe studying the sciences has conditioned students to see a pen as a static, controlled variable and a living thing such as a snake as a responding variable, capable of growth and change. Therefore, perhaps a snake is immediately seen as something from a biology class, whereas a pen is at least one engineering step removed from a chemistry class. And yet, we usually see pens made of metal, plastic, or both, and their inks would be a carefully compiled mixture of chemicals, and some of these materials are considered sufficiently dangerous to merit a Safety Data Sheet. For example, a green marker pen reviewed by Ambersil warns users about the ortho-xylene and titanium dioxide in the pen's ink, should that ink be encountered *en masse*; the pen itself is not of concern (Ambersil, 2024). Alternately, a ballpoint pen refill's Safety Data Sheet (Pilot, 2017) specifies benzyl alcohol and 2-phenolyethanol, with additional chemical components implied but listed as trade secrets. Would the average viewer's concern about the pen exceed that of the snake if people knew the pen contained secret chemical ingredients?

Anyway, to complete my preparations for the snake/pen/Instagram in-class exercise this year, I started to build a slide deck to introduce the topic of visuals in scientific writing. I found myself searching for a supposedly famous quote by Isaac Asimov that runs along the lines of 'science is rarely about people running down the street shouting "Eureka!" but more about someone noticing something odd and saying "that's funny"', where 'funny' means in odd, unusual, or unexpected in this context. Turning to the internet for help, one of the first hits the algorithm gave me was Quote Investigator, who informed me that there didn't seem to be any attribution of a quote of this type to Isaac Asimov (O'Toole, 2023). Instead, O'Toole (2023) found a similar line in Science Journal, by Gordon Rattray Taylor. The quote is as follows:

> THE POPULAR PICTURE of the scientist is of a man who is visited by a flash of insight and cries, in effect, "Eureka!" Or, more modestly, as a man who notices something others have ignored and mutters "That's odd."
>
> To be realistic, however, the successful scientist often seizes on a new tool or a new technique and applies it sooner than anyone else. (Taylor, 1965, p. 32)

The bottom line is that in building a few introductory slides to introduce a scientific humour activity to my students, I learned that a line commonly-attributed to a famous scientist was in fact never his (O'Toole, 2023). Moreover, the entire point of the original supposed quote was that scientific endeavour tended to build from the oddities that people noted, when instead the point of the actual quote is quite different in that it attributes success to early application (Taylor, 1965). I found the quote attribution tables had been turned on me while I was writing an exercise designed to turn the scientific visual data tables on my students. And if this isn't funny, I don't know what is.

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