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Learning Targets in an Early Elementary Classroom: an Agential Realist Examination

Courtney Hartnett
Georgia State University

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This dissertation, LEARNING TARGETS IN AN EARLY ELEMENTARY CLASSROOM: AN AGENTIAL REALIST EXAMINATION, by COURTNEY L. HARTNETT, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education & Human Development, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chairperson, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty.

_____
Ryan Ziols, Ph.D.
Committee Chair

_____
Natalie Davis, Ph.D.
Committee Member

_____
Janice Fournillier, Ph.D
Committee Member

_____
Teri Peitso-Holbrook, Ph.D.
Committee Member

_____
Date

_____
Gary Bingham, Ph.D. Chairperson,
Department of Early Childhood &
Elementary Education

_____
Paul A. Alberto, Ph.D.
Dean, College of Education &
Human Development

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Courtney Lee Hartnett
Department of Early Childhood & Elementary Education
College of Education & Human Development
Georgia State University

The director of this dissertation is:

Ryan Ziols, Ph.D.
Department of Early Childhood & Elementary Education
College of Education & Human Development
Georgia State University
Atlanta, GA 30303

CURRICULUM VITAE

Courtney L. Hartnett

ADDRESS: 131 North 4th Avenue
Decatur, GA 30030

EDUCATION:

Ph.D.	2023	Georgia State University Department of Early Childhood & Elementary Education
M.A.T.	2014	Piedmont University Early Childhood Education
B.S.E.	2005	Georgia State University Early Childhood Education

SELECTED PROFESSIONAL EXPERIENCE:

2007-Present	Gifted Program Specialist Oakhurst Elementary School
2018-2019	Program Evaluation Principal Investigator Woodruff Arts Center & Fayette County Public Schools Partnership
2017-2019	Instructor Dept. Early Childhood & Elementary Education Georgia State University
2016-2017	Data Analyst Alliance Arts for Learning Institute
2015-2016	Program Facilitator Decatur Makers Maker-Scholars Program
2005-2007	General Education Teacher Oakhurst Elementary School

SELECTED PRESENTATIONS AND PUBLICATIONS:

Hartnett, C. L. (2022, May). *Eavesdropping at the intersection of Covid-19, teaching, our other lives, and just trying to make it.* 18th International Congress of Qualitative Inquiry, Urbana, IL.

Hartnett, C. L. (2022, March). *Learning targets: An agential realism examination.* LSU Curriculum Camp 2022, Baton Rouge, LA.

Hartnett, C. L. (2019, October-November). *Convergences and divergences among Indigenous and Western relational ontologies*. 27th Annual International Reconceptualizing Early Childhood Education Conference. Las Cruces, NM.

Holbrook, T., Hundley, M., Pendergrass, E. Self, E., & Hartnett, C. (2018, November). *Caring for students through children's nonfiction texts representing disability*. National Council of Teachers of English. Houston, TX.

Hartnett, C. L. (2016). *Daily routines for high leverage practices*. Georgia Mathematics Conference. Eatonton, GA.

Meyers, L., Baiden, F., & Hartnett, C. (2016, November). *Lights! Camera! Advocacy! Teachers and young learners co-create stories that matter*. National Council of Teachers of English. Atlanta, GA.

Hartnett, C. L. (2011). *Inquiry-based learning in the outdoor classroom*. Farm to School Summit. Atlanta, GA.

Hepler, S., Cannon, S. O., Hartnett, C. L., & Peitso-Holbrook, T. (2019). Undoing and doing-with: Practices of diffractive reading and writing in higher education (Viewpoint). In C. A. Taylor & A. Bayley (Eds.), *Posthumanism and higher education: Reimagining pedagogy, practice, and research* (pp. 141-151). Palgrave Macmillan.

SELECTED PROFESSIONAL SOCIETIES AND ORGANIZATIONS

2023	Abolitionist Teaching Network
2023	Georgia Association of Educators
2023	National Council of Teachers of English

LEARNING TARGETS IN AN EARLY ELEMENTARY CLASSROOM:

AN AGENTIAL REALIST EXAMINATION

by

COURTNEY L. HARTNETT

Under the Direction of Ryan Ziols, Ph.D.

ABSTRACT

Learning targets and other forms of stated learning goals are commonly used instructional components of outcome-based education models and indicators of classroom or teacher quality. When utilized as scripted by classroom teachers, learning targets are the intended vehicle through which standards and measurable expectations are delivered to students so that they can succeed on achievement assessments. This review and research dissertation makes use of new materialist theories and contributes to educational scholarship that acknowledges the complexity of elementary classroom environments and the sociomaterial forces that continuously shape the events and realities that emerge. The review chapter introduces diffraction as a novel methodology before examining current empirical scholarship to illustrate its diverse applications. The re-

search chapter examines learning targets, a form of stated learning goals, and their related practices beyond the commonly help convictions that such usage results in higher student achievement. The research manuscript presents a study that incorporated observational and video-recorded data from a 2nd grade classroom to explore what else learning targets co-produced other than student achievement and high marks on teacher rating scales. Considerations for the potentializing effects of learning target practices and related pedagogy are discussed.

INDEX WORDS: Learning Targets, Diffraction as a Methodology, Elementary Education, Agential Realism, Stated Learning Goals, Teacher Quality, Quality Instructional Practices

LEARNING TARGETS IN AN EARLY ELEMENTARY CLASSROOM: AN AGENTIAL REALIST EXAMINATION

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FOREWORD

Countless influences are enfolded into this dissertation, some of whom are named in the acknowledgements section and many others from encounters within elementary education environments during my years of teaching. One important motivator shaping this dissertation is the need for educational research that addresses the situatedness and complexity of teaching and learning to cultivate more just educational practices. Kumashiro (2000) claims "oppression plays out differently for different people in different contexts…the multiple and intersecting identities of students make difficult any anti-oppressive effort that revolves around only one identity and only one form of oppression" (p. 30). Hlebowitsh (2012) argues that research has shaped constructions of teacher quality and one-size-fits-all movements, such as *best practices*, based on theoretical ideas and representational statistics from afar, disconnected from the unique contexts of teaching and learning. Drawing from the work of Joseph Schwab, Hlebowitsh (2012) articulated implications:

> [W]hen theory is disengaged from the lives of the people, it yields 'unreal' abstractions (about students, teachers, schools, teacher education and so forth)--- all painted sloppily with a broad brush that makes no effort to find inherent qualitative distinctions. The result is the pursuit of over-reaching principles and procedures of curriculum development and the formulation of universal rules and widely generalizable teaching methods and models (p. 9).

This dissertation aims to contribute to educational scholarship that accounts for the situated messiness constituting early elementary classrooms. The dissertation is organized into two chapters. The first chapter is a review of research of diffraction as a methodology. Diffraction is a novel methodological approach that is accountable and responsive to the unique micropolitics

of education. The review of research serves to characterize diffraction as a methodology based on how scholars from multiple disciplines have defined and utilized the approach over recent years. The second chapter illustrates diffraction as methodology within an empirical study examining the use of learning targets and their associated practices in a 2nd grade elementary classroom. The investigation into the ubiquitous practice of learning targets was inspired by my experiences teaching young children. The aim of the study was to look beyond academic outcomes to explore taken-for-granted assumptions and productions as by-products of the learning target structures in the 2nd grade classroom. My hope is that more pragmatic attention is paid to the nuanced differences that exist and how those differences potentialize differing realities and possibilities for children in the care of our educational institutions.

1 DIFFRACTION AS A NOVEL METHODOLOGY

Introduction

Scholars, especially those within feminist science studies and standpoint theory, have raised concerns over theoretical assumptions and consequences of Western scientific practices (see Collins, 1990; Haraway, 1997; Harding, 1995; Smith, 1990; Stengers, 2010). The scientific ideals and practices under question, like objectivity and measurement, are often taken for granted as universal standards of rigorous science and empirical truths, divorcing them from their social constructions and denying the role of power in knowledge claims. Importantly, critiques of scientific objectivity challenged the representational assumption that it is possible for neutral humans to make pure descriptions of a world that is separate from their knowledge production practices (Haraway, 1997).

The disruption of this subject-object dualism and other anthropocentric positions contribute to a proliferation of theoretical developments that work against reductive modes of thought and practice, such as linear cause-and-effect, measurement, and representationalism, toward a science of embeddedness and emergence (Weaver & Snaza, 2017). From this purview, the world is of unknowable complexity through which humans are among a plethora of other entities that co-create shared existences through socio-material relations. These diverse, and sometimes incompatible, theories contest that researchers can be taught techniques to learn about a world that is independent from them as ontologically separated phenomena (Murris & Bozalek, 2019). The theoretical incommensurability with conventional Western research methodologies has enabled a reimagining of social science inquiry (St. Pierre, 2011).

This literature review study examines one such inquiry approach appearing in multidisciplinary scholarship, a diffractive methodology (see Dejmanee, 2016; Fox & Alldred, 2021; Gullion, 2018; Langout, 2016; Murris & Bozalek, 2019; Sayal-Bennett, 2018; Ulmer, 2016; Uprichard & Dawney, 2019). As an alternative to representational types of thinking and predicated on a relational ontology, a diffractive methodology does not ascribe to a framework or list of aligned methods (Barad, 2007). Because the approach is unspecific, a review of literature is helpful to outline the ways in which diffractive methodologies are applied. Additionally, possibilities and considerations for research practices are examined as well as concerns and challenges posed by the novel approach.

By reviewing the work of influential scholars and research studies utilizing diffractive methods, this investigation will explore the possibilities of a diffractive methodology by addressing the following questions:

1. How does a diffractive methodology theorize the empirical in ways different from more traditional qualitative research methodologies?
2. How are scholars applying diffractive methodologies in their research?

In the following section, I begin by tracing the emergence of diffraction as a methodology. There are countless contributors to the conceptualization, but Donna Haraway and Karen Barad are frequently cited as the seminal scholars in research literature (see Bozalek & Zemblyas, 2017; Fox & Alldred, 2021; Udén, 2018). Therefore, I draw primarily from their work to explain how diffraction as a critical methodology emerged as an alternative to knowledge practices grounded in a metaphysics of individualism and representationalism. Barad is credited with reconfiguring the optical phenomenon of diffraction as a methodological approach for Barad's larger conceptual framework, agential realism (Barad, 2003, 2007). On account of this, I draw

directly from Barad's writings and interviews to articulate an explanation of diffraction as a transdisciplinary methodology that accounts for the entailing ethical responsibilities of agential realism's relational ontology. I then synthesize a review of recent studies utilizing diffractive methodologies. The purpose of the review was to explore the ways diffraction as a methodology is taken up and to what end. Importantly, I conclude with implications for research– the affordances, limitations, and future possibilities.

Emergence of Diffraction as a Methodology

Diffraction as a methodology was introduced by feminist science studies scholar Donna Haraway (1992, 1994, 1997) as a tool for feminist research and an alternative to the practices of reflection and reflexivity. Reflection and reflexivity are common practices that assume a position of researcher exteriority, resting on a representational ideology (Lyons, 2010; Woolgar, 1988). Like the optical phenomenon of reflection that produces a "mirrored" representation, when used metaphorically in practice, reflection assumes one is able to engage in a mental state in which they can see and, therefore, better understand themself and their life. Reflexivity goes further in that it is considered a critical practice of reflecting while contemplating changes for improvement or, as part of research methodology, to acknowledge the ways in which a researcher influences the knowledge being produced (Bozalek & Zembylas, 2016)[1].

Diffraction refers to various wave phenomena that have been studied and employed in science fields since the 17th century (Gribben, 1984). Diffraction takes place whenever waves encounter an obstacle of any sort, for example, ocean waves and boulders on a coastline or light

[1] My intention is not to undermine the values of reflection and reflexivity, but to convey their misalignment with a relational ontology and limitations for knowledge-production. Focusing specifically on what is commonly referred to as the social sciences, there are important distinctions in the different ways that reflection and reflexivity are taken up, and the multitude of forms are productive in nuanced ways (e.g., Friere et al., 1997; Mezirow, 1997; Pillow, 2015; Schön, 1983).

waves and clouds. Depending on the type of obstacle and the characteristics of the wave, the diffraction results in different interference patterns. The wavelength and direction change in novel, unexpected ways in relation with the obstacle. The interference patterns show the effects of the differences produced.

Engaging with feminist, post-colonial theorist Trinh Minh-ha's (1986) idea of "inappropriate/d others" and her diffractive conceptualization of identity and difference as relational and affirmative, Haraway (1992) proposes diffraction as an interrupting analytical technology. Thinking diffractively is seeing and thinking differently with a "critical consciousness" from within, departing from fixed, essentialized representations (Haraway, 2018, p. 273). This approach enables a "subtle vision" to be more attuned to how differences are created and the effects they produce in the world (Haraway, 1992, p. 300).

Although diffraction and reflection are both physical phenomena that can be employed metaphorically, reflection produces representations of sameness through illusions of mirroring, what Haraway refers to as displacing "the same elsewhere" (Haraway, 1997, p. 16). Diffraction, on the other hand, produces patterns of difference through interference (Barad, 2007; Haraway, 1992, 2018). Haraway (2018) argues that diffraction as a material-semiotic enactment is more useful than reflection and reflexivity in that it produces and attends to small, but consequential differences in the constitution of worlds. Whereas reflection and refraction assume knowing subjects apart from their objects of knowing and invite "the illusion of essential, fixed position" (Haraway, 1992, p. 300), diffraction accounts for situated knowledges that "record the history of interactions, interference, reinforcement, difference" that open up spaces to see constitutive forces as "heterogeneous history" (Haraway, 2018, p. 273).

Diffraction as an epistemological model was further developed by feminist theorist and

theoretical physicist, Karen Barad (2007). Barad extends Haraway's concept of diffraction through the insights of quantum physics. For Barad, diffraction is a physical phenomenon and a materializing enactment that produces differences of epistemological, ontological, and ethical magnitude.

In her 2007 text, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Barad illustrates examples of physical diffraction using ocean and light waves to show the wavelike behavior in the classical sense of diffraction and then quantum experiments to aid readers in understanding the fundamental role diffraction plays in demonstrating epistemological-ontological inseparability. Notably, the diffraction patterns observed from two-slit experiments in which electron particles and light waves are sent through diffraction grating devices (i.e., two parallel openings in a flat surface) to recording screens "makes the downfall of classical metaphysics explicit" (Barad, 2007, p. 72). In the classical understanding, diffraction only occurs with waves as they combine when they overlap, bending and spreading when they encounter an obstacle. Particles, on the other hand in classical physics, are material entities that cannot occupy the same point in space at the same time, and therefore overlapping is impossible. These experiments demonstrate that light and quantum particles can display characteristics of both classically defined waves and particles depending on how the quantum particle or light is observed. The two differing results of wave and particle are contradictory in the classical sense, frustrating efforts to specify any true ontological nature (Barad, 2003). This is referred to as wave-particle duality in quantum mechanics (Gribbin, 1984).

In 1927, Danish physicist Niels Bohr, from whom Barad significantly draws, resolved the wave-particle duality paradox by concluding that the phenomenon of light is not an inde-

pendently existing entity, but interacts (or intra-acts, to use Barad's neologism that more accurately entails ontological inseparability) with the experimental circumstances to *perform* wave behavior or particle behavior (Barad, 2007, 2014). Bohr regarded the duality paradox as a fundamental fact of nature that different apparatuses draw different distinctions, what Barad refers to as agential cuts (Barad, 2003, 2007). It makes explicit the inseparability, or rather entanglement, of the observed phenomenon from the research apparatus (Barad, 2007). This epistemological-ontological entanglement is vital to diffraction as a methodology that breaks with representationalism and "thinking in terms of separate entities, fixity, and givenness" (Juelskjær et al., 2021, p. 152).

Although perhaps not as visible to the human eye physical phenomenon, diffraction as a methodology attends to the entanglements of ideas and other materials in ways that acknowledge that knowing is never done in isolation but is always affected by different forces coming together. As Barad (2003, 2007, 2014) illustrates in the quantum experiments and with insights from physicist Niels Bohr, phenomena are indeterminate until constituted, bounded in form and meaning, in relation with the experimental arrangement or measuring apparatus, which includes the researcher. With a diffractive methodology, the researcher is entangled with the phenomenon, not standing at a distance and representing what is purportedly known from the inquiry (Barad, 2003).

Diffraction as a methodology does not fix what is the object and what is the subject in advance; it takes into account that knowing comes from "a direct, material engagement with the world" (Barad, 2007, p. 412). Therefore, a diffractive methodology does not have a prescribed framework because researchers are *of* the world in which they seek to inquire and ontologically

inseparable (Barad, 2007; Murris & Bozalek, 2019; St. Pierre, 2016). Prescribed frameworks assume an a priori reality to which scientific practices reveal what is already there. Explained by Barad, a diffractive methodology is

> a method of diffractively reading insights through one another, building new insights, and attentively and carefully reading for differences that matter in their fine details, together with the recognition that there intrinsic to this analysis is an ethics that is not predicated on externality but rather entanglement. (Dolphijn & van der Tuin, 2012, p. 50)

Diffraction as a methodology *is a product of a diffractive methodology*. The conceptualization of diffraction as a methodology emerged from Barad's diffractive reading practices (Barad, 2007; Juelskjær et al., 2021). I will use this example of the diffractive methodology as a diffractive production to illustrate and flesh out Barad's explanation of a diffractive methodology quoted above. First, I use an interview published in Juelskjær et al. (2021) to construct a brief retelling of how diffraction as a methodology emerged in response to Barad's pursuit of justice in science research and practices, showing how ethics has always been integral as the foundation and mobilizing force. Then, I highlight characteristics of a diffractive methodology that resonate with some of the diverse readings undertaken by Barad to exemplify how purposeful intra-actions of this scholarship reconfigured diffraction as a methodology.

Diffraction as a Methodology in Pursuit of Justice and Response-ability[2]

In Juelskjær et al. (2021), Barad described how diffraction as a methodology evolved over many years since she was in graduate school. Aware that physics is implicated in "the mili-

[2] Barad's (2007) neologism, response-ability, indicates the ethical responsibility of the researcher to enable conditions that render the other capable of response and the researcher to be sensitively attuned to listening.

tary-industrial complex, colonialism, imperialism, classism, racism, and other forms of oppression," Barad contemplated very early on in her career what it would mean to be responsible for that which she loves: physics (Juelskjær et al., 2021, p. 119). As a young assistant professor in physics, still preoccupied with questions of justice and commitments to responsibility, Barad sought conversations with other faculty members in the humanities and social sciences by organizing and participating in faculty reading groups and sitting in on courses colleagues offered that centered on questions of justice. She became aware of how her disciplinary training had produced certain forms of ignorance. Barad found it difficult to communicate across academic divisions and recognized that she had to learn how to be intelligible to the nonscientists she needed to be in conversation with to deeply consider these questions of justice and responsibility. Barad explained the undertaking: "This turned out to entail nothing short of teaching myself a range of scholarship in the humanities, social sciences and the arts, which meant building entirely new skills of reading and thinking with others" (Juelskjær et al., 2021, p. 120).

Diffraction as a methodology began congealing as Barad addressed "the burning question of how to think ideas from different knowledge formations together in a way that would do justice to the different knowledges and insights that [Barad] was aware needed to be in conversation with one another" (Juelskjær et al., 2021, p. 120). Reading insights from "scientific and social theories, including quantum physics, feminist theory, science studies, critical race theory, postcolonial theory, (post-)Marxist theory, and poststructuralist theory," through one another produced new insights that contributed to the conceptualization of diffraction as a methodology (Barad, 2007, p. 25).

The diffractive methodology is a boundary-crossing productive amalgamation of these theoretical contributions. Diffraction as a phenomenon in physics demonstrates relationality and

differences from within and as a means of becoming (Barad, 2014). Consider the indeterminate nature of when and where one ocean wave begins and another ends and the multiplicity of effects interfering with the everchanging wave formations. Diffraction articulated as a methodology does not undo the relational ontology put forth by quantum physics and acknowledges the plurality of entities that interfere as part of the experimental conditions through which material-discursive phenomena emerge (Barad, 2003, 2007; de Freitas, 2017). Barad (2003) uses the term "material-discursive" to acknowledge the mutual entailment of materiality and discursivity, the inseparability of matter and meaning, inherent to a relational ontology.

A look back at the two-slit experiment and the wave-particle paradox, of which diffraction plays a key role, problematizes neutrality, essentialized identities, and dualisms such as subject-object, nature-culture, and interior-exterior (Barad, 2007; Barad, 2014; de Freitas, 2017). Diffractively reading/thinking and carefully attuning to the mutual becomings as they emerge closes notions of interior/exterior and other related binaries that have been integral in mobilizing oppression through colonized modes of thinking about difference (Barad, 2014; Haraway, 1992; Juelskjær et al., 2021).

Intra-actions of critical social theories and quantum physics are evident in the way in which diffraction as a methodology is underscored by a sensitivity to the production of differences. Whereas differences are reduced or assimilated in the representational trap of static positionings or essentialized meanings mobilized by interpretative methodologies, a diffractive methodology frames differences as creative and affirmative (Barad, 2007; Bozalek & Zembylas, 2016; Haraway, 1994; Juelskjær et al., 2021). Diffraction, both as a physical phenomenon and methodology, is a process of producing differences and attending to the effects, affirming the constitutive role of difference in productions of consequential meanings. Referencing Haraway,

Barad (2007) states that "a diffractive methodology is a critical practice for making a difference in the world. It is a commitment to understanding which differences matter, how they matter, and for whom" (p. 90).

A refusal of the ontological dualism between matter and meaning upholds that all forms of knowledge production are at the same time formations of reality (Barad, 2003; de Freitas, 2017). Barad (2007) emphasizes that "practices of knowing are specific material engagements that participate in (re)configuring the world" and therefore the practices we enact matter (p. 90). Ontology, epistemology, and ethics are inseparable due to entanglement, and knowledge configurations are always value-laden (Juelskjaer & Schwennesen, 2012). For example, Barad's commitments to justice and responsibility are evident in diffraction as a methodology.

Research that reflect or mirror existing inequalities can contribute "to the reproduction of those very same inequalities" by reifying essentialized differences and their effects (Juelskjær et al., 2021, p. 11). A goal of a diffractive methodology is to enact social change. Diffraction as a methodology works against the representational trap of fixity and givenness by focusing on what phenomena do and what effects they have through intra-actions. Through this intention, diffractive methodologies produce novel ways of theorizing and performing research, thereby constituting new possibilities for ethical knowledge production and responsibility for the realities that are simultaneously enacted (Barad, 2003, 2012; Haraway, 1992). An example that speaks to this is Barad's (2003, 2007) conceptual framework agential realism. Agential realism reconfigures and mobilizes concepts (e.g., knowledge production) through a relational ontology grounded in diffractive readings, such as agency, intra-action, spacetimematter, diffraction, response-ability, apparatus, and phenomena[3] (Barad, 2007; Barad & Gandorfer, 2021). The reworking of concepts in

[3] These concepts will be contextualized in relation to agential realism within the chapter.

agential realism nullifies humanist assumptions and actuates the world through a posthumanist account of performativity as ever materializing and enfolding through entanglements of material-discursive matter (Barad, 2003, 2007).

Foregrounding ethical engagement, diffraction as a methodology requires generous, attentive care for reading texts (Dolphijn & van der Tuin, 2012). Texts in this sense extend beyond scholarship and conventional verbal texts to include the plethora of multimodal texts and literacies that contribute to knowledge production (see Kress & van Leeuwen, 2001). Respectful, detailed readings do justice to the viewpoints of others, and care resides in being attentive to the ways in which we, with each intra-action, are "re-doing the material configurations of spacetime-mattering[4]" (Dolphijn & van der Tuin, 2012, p. 68). As mentioned earlier, knowledge practices are part of the world's ongoing materialization. Therefore, there is responsibility for reading "constructively and deconstructively (not destructively) in making new patterns of understanding" (Barad, 2014, p. 187). A diffractive methodology does not do epistemological damage pitting one theory/position/stance against another; doing so produces violence and positions texts as knowable fixed frames of reference, reinforcing a metaphysics of individualism (Juelskjær & Schwennesen, 2012). Texts and readers do not pre-exist each other in a relational ontology, and the same goes for writing. Rather, both human and text are articulated with and through the other, affected by and affecting the other as constitutive forces (Murris & Bozalek, 2019).

Diffractive reading is characterized by reading through, rather than against, texts, while paying close attention to how insights emerge, what gets excluded, and how those exclusions

[4] Barad uses the term spacetimemattering as a reconfiguration of space, time, and matter that attends to inseparability. Barad (2013) explains "neither space nor time exists as determinate givens, as universals, outside of matter. Matter does not reside in space and move through time. Space and time are matter's agential performances" (p. 28). Diffraction as a methodology is nonlinear because the notions of past and future are iteratively reworked and enfolded through spacetimemattering.

matter and to whom (Barad, 2007; Juelskjær et al., 2021). Barad refers to this as "diffractively reading for patterns of difference that make a difference" (Dolphijn & van der Tuin, 2012, p.49). Diffraction as a methodology enables readings that produce ontological-political provocations and questions of difference and differencing, constituting knowledge practices that potentially can materialize in better worlds (Barad & Gandorfer, 2021; Juelskjaer & Schwennesen, 2012; Murris & Bozalek, 2019).

Diffractions of Diffraction as a Methodology: Applications by Other Scholars

Although diffraction was conceptualized and employed as a methodology by Barad, intra-actions with other scholars have contributed to creative iterations of diffractive methodologies. Up to this point, I have described diffraction as a methodology according to Barad or scholars directly referencing Barad. Applications by additional scholars are important to illustrate the methodology's various conceptualizations and flexible utility for research practices and knowledge production.

To investigate current applications of diffraction as a methodology, I conducted a database search for peer-reviewed journal articles published between 2010 and 2022 on Academic Search Complete (EBSCO). Academic Search Complete was chosen because of the multidisciplinary subject coverage and extensive database size (Gusenbauer & Haddaway, 2019). The keywords "diffraction as a methodology" OR "diffractive analysis" yielded 528 sources. Articles pertaining to the optical phenomenon of diffraction and/or its application in laboratory sciences were eliminated, leaving 45 articles for review (see Appendix).

Database search engines along with academic publication procedures function as a selective grid. Therefore, these search results are in no way a comprehensive body of published re-

search using diffractive methods between 2010-2022. I actually supplement with additional studies not included in the Academic Search Complete query for the literature review synthesis to follow. Although it is a partial representation of scholarship and study formats, I chose the database search for peer-reviewed articles because scholarly journals are a primary vehicle through which research knowledge circulates and extends. Additionally, 45 articles serve as an adequate sample size for the purposes of this investigation (Onwuegbuzie & Frels, 2016).

To begin, I read through each literature review article, annotating within the articles and writing notes in a separate document as I went along. Because I wanted to know how diffraction as a methodology was applied by researchers, I then used an inductive approach to content analysis, documenting characteristics of the articles into a digital spreadsheet, while also writing down other observations, ideas, and insights into my research journals (Krippendorf, 2019). Articles were read multiple times, framed by additional questions as similarities and departures emerged.

The retrieved articles demonstrate the broad applications of diffraction as a methodology across multiple academic fields and disciplines, including education (22 articles), performing arts (5 articles), gender studies (4 articles), healthcare (3 articles), and media studies (2 articles) as the five areas with the highest frequency. To further illustrate the diverse applications of diffraction as a methodology, I offer a selected list of keywords from the articles to showcase the range of topics explored: gender; intersexuality; factory design & construction; love; STE(A)M; opera production; creative pedagogies; project-based learning; Fitbit, Inc.; identity; language revival; physician-patient relations; virtual reality; anger; xenophobia; recipes; animal studies; dementia; dance; community psychology; dementia; Catholicity; labor supply; quiverfull; anorexia; Islamic clothing & dress; job security; and feminism.

When reviewing articles to compile the sample of keywords, I was struck by the number

of articles listing keywords that were seemingly disparate topics conjoined in the construction of the project. For example, Crath and Rangel's (2021) article proposing a framework of "cultural humility" for clinical assessment practices lists the following as keywords from the database search: physician-patient relations; social stigma; conceptual structures; responsibility; cultural competence; medical ethics; clinical assessment; cultural humility; diffractive analysis; new materialism; and technologized health care. The range of topics in many of the keyword lists speak to the relational complexity and constitutions of phenomena made intelligible through diffractive methodologies as it brings about "respectful engagements with different disciplinary practices" (Barad, 2007, p. 93).

Of the articles that attribute diffraction as a methodology to specific scholars, Barad is cited as the primary theorist in all, but one article: Marinkovic Chavez et al. (2022) reference Langhout (2016), who cites Barad and Haraway and was also included in the database search. As a methodology, diffraction is a concept for thinking about entangled, responsive, analytic processes. As suspected by the aim of this literature investigation, although Barad is attributed with the concept, like all concepts relationally embedded in situated contexts, diffraction is configured uniquely in each study. Diffraction gains new forms and meanings as it is put to use, but broad commonalities were located among applications. I synthesized three ways in which diffraction is put to work in the literature:

- As a way to think concepts differently by reading insights from texts through one another
- As a way to think differently about data
- As a way to explore new ways of becoming (through practices like writing and/or pedagogy)

In the following sections, I elaborate on these applications with selections from the literature. Although the presentation of these approaches is separated out for organization, keep in mind that diffractive research practices are entangled with concepts, materiality, and embodiment. Many of the articles touch upon all three of the uses mentioned above, signaling the inseparability and co-constitution of the research assemblage and the researcher as apparatus. Because each article is a unique configuration, related concepts are often signified with varied terminology. When referencing specific articles, I used the wording as expressed by the authors (e.g., new materialism, the new materialisms, feminist new materialism).

Thinking Differently About Concepts

Barad's approach of reading insights from different fields of thought through one another in their entanglements is the work of thinking concepts differently (see Barad, 2012, 2015, 2017, 2019). Importantly, thinking is itself a form of materialization and mattering. According to Barad, concepts are performative discursive articulations that become sedimented through iterative intra-activity (Barad & Gandorfer, 2021). Barad describes letting concepts breathe as a matter of justice: "It is what the diffractive methodology tries to do, namely working with concepts and at the same time opening them up, aerating them, so they can continue to breathe" (Barad & Gandorfer, 2021, p. 31).

Although the literature articles vary in their degrees of alignment with agential realism foundations and the specificity through which concepts were thought, diffractive readings produced conceptual reconfigurations of greater complexity. As examples, Chan (2020), Gibson et al. (2020), and Aslanian (2018) produced diffractive readings that attended to the specificity of micro-encounters that materialized concepts as dynamic and agentic, mutually responsive and influencing. Chan (2020) diffractively read light, theatre, and installation to invoke an agentic

understanding of light as distinctive and integrally interior to the theatre-world, "reimagining the aesthetics and the ethico-political of theatre" (p. 113). Gibson et al. (2020) traces the doings of person-centered care (PCC) through rehabilitation care events. With resistance to "finalizing any one way of understanding or doing PCC," the diffractive readings of PCC through the care events articulate PCC as "infinitely small, nimble, and cumulative through micro-acts of care" that cannot be known in advance of specific care encounters (p. 1536). Exploring the concept of love in early childhood education and care (ECEC) settings, Aslanian (2018) traced historical conceptions of love from Plato to Judeo-Christian traditions to Pestalozzi's *mystical* love of the Romantic era to modern concepts of love based on "scientific rationalism" (p. 178). Aslanian then diffractively read the historical scholarship, scholarly literature of love in ECEC contexts, and solicited stories from four kindergarten teachers through one another. Aslanian described how her embodied diffractive readings produced a liminal, contingent conceptualization of love that exceeded the "inherent limits each concept drew around itself" when understood from different philosophical and scientific perspectives alone. Aslanian explained that even as the varied perspectives articulated some of the feelings and motivations in love processes, they also simultaneously erased the embodied experiences of love. The diffractive reading practices contributed to understanding love as a dynamic space of becoming that neither Aslanian nor the children controlled.

Enabled by diffractive readings, scholars also wrote about relational emergences and what the concepts do in their entanglements. By turning over modesty and letting it breathe, Wagner (2017) developed an understanding of how moral bodies materialize with and through clothes in differentiated spaces, indicating ways bodies, clothing, and moralities are intra-ac-

tively entangled. Allen (2015) reconfigured the ontology of sexuality beyond its discursive constitutions and anthropocentric focus. In the article, Allen described examples of sexuality's relational emergences in a school setting as well as the different affects/effects produced, unhinging a representational account of what sexuality *is.* When diffractively read with feminist new materialisms, sexuality was co-constituted in an endless becoming of discourse and matter that at times surprised Allen out of habitual ways of reading matter and sexuality.

The nonhuman-human entanglements that produce and are produced by modesty and sexuality, for example, bring into being unique manifestations and ways of intra-acting in the world. Both Wagner (2017) and Allen (2015), as well as other scholars of the literature review, emphasized the performative aspects of concepts. Wagner (2017) illustrated a shame-modesty spectrum intra-acting with human bodies "that move with their clothing across spaces shaped by different gazes and discourses" (p. 3). Allen (2015) explained how the production of knowledge about sexuality at school in turn produced human subjects enfolded in sexuality's becoming, simultaneously implicating nonhuman things in sexuality's expression and meaning-making.

At times, diffractive readings led to mutated concepts with modified names that signal differences in the concepts' reconfigurations; similar to the way in which Barad (2007) termed agential realism, intra-action, response-ability, and many other concepts that emerged from the methodological use of diffraction. Dare (2020) read Brecht's *Alienation Effect* and Barad's agential realism through one another to think differently about virtual reality discourses and practices. Brecht's alienation effect "occurs when audiences are jolted out of their preconceptions and orthodox views" (Dare, 2020, p. 103). Dare's diffractive readings produced a new theoretical framing for an "A-effected virtual reality," one in which the "uncritical immersion" within deterministic virtual worlds that rely on a priori categorizations of human subjects is disrupted to provoke

and spur new forms of virtual reality (p. 105). A-effected virtual realities account for entanglements and performative understandings to alienate and jar participants, creating spaces for "questioning power relations and their systemic manifestation, including the powers brought to bear by technology" (Dare, 2020, p. 104).

Giorza (2022) diffracted posthuman theories and encounters in an early childhood classroom to reconfigure learning, the child as learner, and material products of learning to establish a posthumanist pedagogue. Giorza's posthumanist pedagogue relinquishes "the mantle of the all-knowing, all-seeing pedagogue, in control and command of the learning that happens for the children in one's care" to acknowledge learning as inward and outward flows of intra-active, collaborative becomings that exceed space and time (p. 282). In turn, learning becomes emancipated from conventional practices of teaching centered on language and instruction where the posthumanist pedagogue creates spaces that have "affordances for small-group collaborations and unmediated intra-actions with the chaos and surprise of direct experience" (Giorza, 2022, p. 282).

As the studies exhibited, diffraction as a methodology affords the opportunity to think concepts through more expansive, generative configurations. To varying degrees, diffractive readings mobilized concepts, increasing the capacity of researchers to experience the performative aspects of concepts toward novel understandings. Tracing relational emergences illustrated their material-discursive inseparability and liveliness; mapping concept to object demonstrated what the concept does or enables without separating it from the physical world.

Thinking Differently About Data

Barad's agential realist account of the world posits concepts and theories as living and breathing reconfigurings of the world (Barad, 2007; Barad & Gandorfer, 2021). Therefore, Barad (2012) explains "[s]pinning off in any old direction is neither theorizing nor viable; it loses the

thread, the touch of entangled beings (be)coming together-apart" (p. 208). Data, as traces of entangled beings (be)coming together apart, materialize concepts and theories (Barad, 2012). In addition to thinking differently about concepts, scholars are thinking diffractively with data to make intelligible particular material-discursive complexities that contribute to the world's materialization.

Scholars in the literature review ranged from thinking diffractively through conventionally collected data sets bounded together from previous studies (i.e., representational data) to conceptions of data aligning with post-qualitative inquiry perspectives: data are emergent phenomena inseparable from the research assemblage, and therefore, individuation of data, data collection, and data analysis are inconceivable (St. Pierre, 2019). Although the theoretical foundations undergirding how scholars approached data may be incongruent with agential realism or other immanent relational ontologies, empirical data, however manifested as such, are performative and have material-discursive existences of enfolded historicities that do work in the world (Barad, 2003).

Importantly, theories do not need to be commensurate for diffraction to be a productive methodology (Bozalek & Zemblas, 2017; Uprichard & Dawney, 2019). As a reminder, the aim of diffraction is not to synthesize or compare theories, but to attend to the interferences of different viewpoints and other matter to produce novel insights. Diffraction's attention to intra-actions also creates opportunities to investigate the differing apparatuses that materialize data or phenomena in particular ways. A compelling example comes from Uprichard and Dawney (2019).

Uprichard and Dawney (2019) proposed diffraction as a methodology that can address tensions within mixed methods research when quantitative and qualitative data resist integration;

data integration is presupposed as "the *optimal* outcome of mixed methods research" (p. 19). According to the authors, when mixed data do not cohere under the object of study, typically researchers reexamine the impact of epistemological differences and how the research was conducted. Rather, Uprichard and Dawney argue that because of the complexity of the social world, integration is not always possible and can be problematic because the object of research can be "complex, ontologically unstable, and may not be clearly bounded" (p. 20). Whereas mixed methods research is conventionally valued because mixed data make visible facets of complex social phenomena, a goal of data integration for valid and reliable research can oversimplify and misrepresent phenomena. Uprichard and Dawney explained that data diffraction, while not replacing data integration and other approaches, can open a dialogue that enables data to speak in different ways, revealing at times the partiality, messiness, and complexity of social phenomena and the political implications of particular research configurations.

In the following, I share selections from the literature search that highlight the diverse ways that diffraction enables researchers to approach and think differently with data. I use broad strokes at times to aid in a general understanding of diffraction with data through commonalities, but I want to emphasize that important, nuanced differences exist across all of the studies. I lift some examples in more detail, but to do justice to all of the empirical studies from the database search would exceed the constraints of this investigation. When stated, reasons varied as to why authors chose diffraction when working with data. I outline the broad reasons below with examples from the literature and then conclude this section with some of the many creative analytical methods authors used with data in their diffractive methodologies.

Alignment with theoretical perspectives

Similar to other methodological approaches, some researchers stated that they chose diffraction because it aligned with their theoretical perspectives[5]. Jusslin and Höglund (2021) thought through new materialism to explore the integration of creative dance in fifth-grade students' poetry reading and writing. Data included video recordings of group lessons and interviews. Diffracting the data through each other and together with the concepts of negotiation, entanglement, and intra-action enabled Jusslin and Höglund to identify "eight performative agents that made a difference in students' meaning-making processes" (p. 264). Described as a posthuman study of empathy and creativity in a theater workshop, Vagg's (2022) data included video recordings of the workshops, transcripts and video recordings of semi-structured focus group discussions and activities, field observations, photographs, artifacts, and artistic creations of empathy. Vagg used diffractive analysis to look beyond textual and linguistic data to explore embodiment as multisensorial data. For Tudor and Barraclough (2022)'s study of "behaviourial boys" in social work, diffraction offered ethical engagements imperative to posthumanism and feminist new materialism:

> This is an ethics of responsibility for the cuts we make, and stories we tell, in our research practices. Choosing to enact a diffractive analysis in research, thus, does not merely involve exposing hierarchical power relations, dominant truth claims and subjectifying practices but attending closely to moments of difference in the data to affirm new social and material relations that would otherwise be unimaginable. (p. 4)

[5] Listed in order of highest to lowest frequency, database articles' theoretical statements identified the terms posthumanism (12), feminist new materialisms (7), new materialisms (5), post-qualitative (2), agential realist perspective (1), feminist agential realist (1), feminist epistemology (1), post-foundationalism (1), feminist materialism (1), material feminist (1), affect theory (1), interpretivist paradigm (1), new empiricisms (1), postcolonialism (1), and post-critical (1). Some authors identified with more than one theoretical framework while some authors did not make specific statements.

Using interview data from a previous study, Tudor and Barraclough took up intra-action to re-analyze a moment that emerged from a school-based group program. Diffraction as a concept and method enabled Tudor and Barraclough to return to the material-discursive complexity of the data to affirm new social worker identities and subjectivities of boys often seen as behavior problems.

Thinking outside of normative frameworks

Researchers also chose diffraction because they stated the methodology enabled them to think through data outside of normative frameworks. Davies (2014) mapped encounters with anger among preschool children during observations at a Reggio Emilia-inspired school in Sweden. Davies described her article as a "diffractive experiment" that brought the reality of onto-epistemological entanglements to life. According to Davies, diffracting her observational notes through theory opened "the possibility of seeing how something different comes to matter, not only in the world that we observe but also in our research practice" (p. 734). Working with school children, in-service teachers, and a picturebook that "produces a narrative of exclusion and fear," García-González et al. (2020) sought to think differently about difference when examining the relations of books and readers through voice and video recording and field notes data (p. 543). Diffraction afforded García-González et al. analyses that resisted us/them binaries and opened up unforeseen patterns, identifying the different ways meaning spread, particularly when issues of racism and xenophobia emerged.

A final example used diffraction to animate interview data beyond static representations of interviewees' perspectives and experiences. Working with interview data from two teachers who create educational manipulatives for people with profound intellectual and multiple disabilities (PIMD) in Japan, Kusumi (2022) stated that a diffractive methodology "neither interprets

meanings in interview data nor reveals the pre-existing reality underlying them" (p. 5). Thinking data through theory, the diffractive approach acknowledged the interview data as utterances arising from collective assemblages. This examination was important to affirmatively illuminate vital materialities and work against stereotypical social constructivist beliefs that position "autonomous, rational, and well-intentioned individuals as superior," which devalue people with PIMD (p. 5).

Differentiate how matter becomes

Diffraction was also used with empirical data to differentiate how phenomena becomes and persists. I offer two examples here, but many articles from the search illustrated how diffraction can be used "to more carefully and complexly read data in the micro" to come to know phenomena beyond taken-for-granted understandings (Sherfinski & Chesanko, 2016, p. 18). Isaac (2022) referred to the interrogation of different voices that bring matter into being as a process of destabilizing phenomena. Isaac utilized diffraction to destabilize the spice mix ᑎᑕᑎᓭ [ber-be-re] and make visible the dominating capabilities of transcripts. Reading his localized experience of ᑎᑕᑎᓭ through six writer-editors' recipes, Isaac detailed the ways in which the recipe transcripts dislocated ᑎᑕᑎᓭ from its pre/colonized histories and relational existence; for example, ᑎᑕᑎᓭ became combinations of static ingredient lists, precise measurements, and time intervals. Reading through the limits of inscription, Isaac's diffractive analysis also situated the transcript as a simultaneous space of im/possible becomings: differentiating ᑎᑕᑎᓭ's entanglements mapped "ᑎᑕᑎᓭ's persistence of life, hope, and possibility even among the ex/inclusions of its transcripted recipes" (p. 1077).

Another example comes from Lenz Taguchi and Palmer's (2013) study of school girls' ill- and well-being in Sweden. According to the authors, when school girls in Sweden developed

psychological (ill)health, media discussions using research studies in medicine, psychology, and neuroscience situated the cause within the girls themselves or their families. The reasons for the girls' ill-being were related to overachievement, such as continuous stress and anxiety to perform. Responding to these enacted realities that placed responsibility on girls in the form of self-management, Lenz Taguchi and Palmer used diffractive analysis to show how the material-discursive school environment co-constituted and enacted girls' ill- and well-being. The authors diffractively engaged with research reports, media discussions, data produced by two girls (grade 7 and grade 10), and their own memories and critical incidents. During the research process, the phenomenon of girls' ill- and well-being emerged as collectively enacted, and therefore, a collective responsibility. The diffractive analysis showed that the entanglements of the school environment, including discourses on girls' health in the media and research, co-constituted and enacted the school girls' ill- and well-being.

(Re)turning

Whether returning or (re)turning, some authors returned to data previously analyzed to re-turn the data and produce anew with data diffraction. Mazzei (2014) and Levy et al. (2016) are examples of researchers who used diffraction to think differently about previously collected data. As an experiment in working the limits of research practices to produce unthought questions and knowledge, Mazzei (2014) read previously collected interview data through multiple theoretical insights. Mazzei used diffractive readings to spread "thought and meaning in unpredictable and productive emergences" as data and theory made themselves intelligible to one another (p. 742). She illustrated how the rhizomatic spreading of thoughts and knowledge through multiple readings produced much richer returns than the "easy sense produced by the reductive process of starting with coding and returning to experience" (p. 744). Rather than focusing on the obvious

themes evident in the data excerpt, Mazzei showed how thinking the data and theory through one another produced diffractive interferences and insights that would not be possible otherwise. The next article example, Levy et al. (2016), further exemplifies the productive potential of diffraction when other analytical approaches fall short of producing new knowledge and considerations.

When interview data from a predominantly feminist post-structuralist inquiry into preteens diagnosed with eating disorders and their ideas about healthy bodies yielded little of significance, Levy et al. (2016) wondered what might have been missed with their analytical methods:

> We had hoped that the relative dearth of existing literature on preteen girls and boys with eating disorders, coupled with the rigour we had maintained throughout the process of data analysis, might have exposed a gap that we could inhabit in some insightful ways. Yet the closer we looked at the data, and the more we resolved to find some hidden worthwhile meaning(s), the less we actually 'saw' of any 'real', or obvious significance. (p. 184)

The authors accepted that the transcript data had nothing further to yield given their established methods and epistemological lenses, yet the data continued to persist as a "mild irritation" (p. 184). They questioned whether or not the data was successfully resisting their analyses to ascribe something meaningful. Levy et al. returned to the resistant data with new theoretical supports that disrupted their habitual ways of analyzing and making sense of the interview transcripts. Notions of diffraction, entanglement, becoming, and mattering led to reading the interview data as a sense-event of bodymind. Engaging with the interview material through diffraction enabled the authors to work against their habitual modes of hearing and seeing research data, raising awareness for biases and blind spots. For example, dualist categories, such as mind/body

and physical/mental, were troubled in the diffractive process. Levy et al. noted that important "nuances and implications of this shadowy knowledge can be overlooked or dismissed, either when coding certain established nodes or themes, or when seeing to represent/interpret data within a given analytic framework," taking researchers away from the complexity and details of the data (p. 194).

Analytical techniques

Attending to how different ideas and matter affect and interfere with each other is an emergent analytical process of coming to know something differently (Davies, 2014). When using diffraction to think differently, researchers are developing creative analytical techniques to impose interference patterns through data. The examples below highlight the open-ended creative possibilities of using diffraction with data as well as starting points for researchers in need of wayfinding.

As previously mentioned, many studies in the database search theorized from relational ontologies (e.g., posthumanism, new materialism). From these perspectives, data is a co-configuration of the researcher, methods, contexts, and other bodies made visible through the forces of the study. When data is conceptualized as entangled assemblages of discursive, animate, and inanimate matter, determining what gets attended to within a study's analysis poses a theoretical disjuncture. Barad (2007, 2014) refers to the boundary-drawing practice of making some identities and attributes intelligible or determinant at the exclusion of others as a "cutting together-apart," an agential cut that temporarily stabilizes a phenomenon as a superficial separation of mattering. Researchers working with diffraction as a methodology have experimented with ways to cut data together-apart from the "research-assemblage" for further analysis (Fox & Alldred, 2015).

Although scholar Maggie MacLure was not identified in the database search, her concepts were applied in six of the articles, signaling fruitful approaches when selecting emergent data (see Allen, 2015; Chappell et al., 2021; Crickmay & Ruck Keene, 2022; Levy et al., 2016; Tudor & Barraclough, 2022; and Vagg, 2022). Her embodied concepts have useful affective, relational dimensions productive in keeping researchers open to emergent phenomena without predetermined destinations. MacLure (2010) wrote about encounters with research data that seemed to "glow" by intensifying engagement and provoking wonder. According to MacLure, when data glows it has intensity that holds the researcher's attention and generates "sensations resonating in the body as well as the brain" (p. 282).

Vagg (2022) diffracted MacLure's "glow" through layers of data analysis in her study exploring the relationship between creativity and empathy in theater devising workshops. Through her iterative engagements with data that included manually transcribing video recordings; reading through field notes, reflections, images, and artifacts; and generating visual maps using the software XMind, Vagg detailed how "glow moments" drove unexpected questions and brought forward data for deeper analysis (p. 548).

Related to the concept of "glow," "bone in the throat" and "hot-spots" are two MacLure (2006; 2013) figurations that articulate data that glow with "moments of productive disconcertion" (2013, p. 173). Specific to these concepts is that affective responses are uncomfortable and "undermine the analyst's imperial self-assurance," resisting the risk of knowledge closure and stasis (MacLure, 2013, p. 173). Levy et al. (2016) described their experience selecting resistant data for their study as a "bone in the throat" that caused "a mild irritation" (p. 184). They approached the resistant data using another MacLure (2006) concept, the "cabinet of curiosities," catalyzing their move toward diffracting the resistant data from different perspectives. Allen

(2015) selected four photographs from a previous study data set that included photographs taken by 22 participants using MacLure's (2013) description of data "hot-spots." Allen states that she was drawn to analyze the four photographs "copious times" because they provoked reactions that reached beyond the rational and articulable (p. 946). With repeated mining of the photographic data during Allen's previous study, the four images would resurface, persisting in capturing her attention. Allen described the four data hot-spots as annoying and haunting, yet making themselves intelligible to the researcher in the process.

Once data was selected, many researchers chose to "think with theory" and/or physically manipulate data to animate ideas through intra-actions (Jackson & Mazzei, 2012). For Jackson and Mazzei (2012), thinking with theory entails using theory to think with data and using data to think with theory, explicit moves to disrupt "the theory/practice binary by decentering each and instead showing how they *constitute or make one another*" and by attending to "how the questions that are used to think with *emerge in the middle*" (pp. 9-10, emphasis in original). In her 2014 article included in this literature review, Lisa Mazzei described the thinking with theory method articulated with Alecia Jackson as a diffractive reading of data, citing Barad's (2007) work. Although reading data and theory through each other could be subsumed under diffractive reading, I explain the different scholars cited in the literature review and the terms used for processes of thinking data and theory threaded through each other to aid in making the entanglements across approaches more transparent.

In her literature review article, Lisa Mazzei (2014) referenced her 2012 book co-authored with Alecia Jackson, *Thinking with Theory in Qualitative Research*. In the text, Jackson and Mazzei (2012) put the Deleuze and Guattari concept "plugging in" to use as a process "of reading-the-data-while-thinking-the-theory" (p. 743). Mazzei (2014) used the process of "plugging

in" to read interview data through Deleuze and Guattari's concept of "desire" and Barad's concept of "intra-action." Clark/Keefe et al. (2022) and Kuby and Christ (2018) are other researchers that cited Jackson and Mazzei (2012) and used "plugging in" to think their data through specific theoretical concepts.

Using an extensive data set collected over 4.5 months to explore young adults' identity work, Clark/Keefe et al. (2022) diffractively read data through developmentalism scholarship through Barad's agential realism. They also explained that they put Fullager and Taylor's "thinking-with" to use "to work along lines of more affective intensity," opening analytical insights of "knowing-in-being" alongside their eight young adult participants (Clark/Keefe et al., 2022, p. 5).

In addition to "plugging in," Kuby and Christ (2018) also credited St. Pierre's "concept as method" when explaining their approach to thinking data with theory in their study of the process and experiences of designing and facilitating an introductory qualitative research course. Similar to Clarke/Keefe et al. (2022), Kuby and Christ had an extensive multimodal data set of course artifacts, field notes, and audio-video recordings of class experiences and interviews. To better understand what was produced through the course, Kuby and Christ read data through Barad's concept spacetimematter, asking: "How and what does spacetimemattering produce in an introductory QR course aiming to open spaces for paradigms(ing)?" (p. 295).

Alison Warren (2021) is another author from the database search that cited Jackson and Mazzei and concept as method to think theory using diffractive analysis. Warren stated "[c]oncept-as-method methodologies respond to Deleuze and Guattari's (1991/1994) characterization of philosophy as creation of concepts, and explores what is produced in research assem-

blages, including problematising how data is understood" (p. 566). The study explored perceptions and experiences of love in early childhood teaching from a posthumanist perspective. Warren read the data (i.e. video recorded observations, field notes, and interview transcripts) through the "Deleuzo-Guattarian" concepts "rhizoanalysis" and "cartography of sense" to tease out "how love emerges in entangled affective flows in rhizomatic assemblages, as well as how language brings attention to sense, nonsense, and paradox" (p. 578).

Creative processes of physically manipulating data helped researchers engage with data in multisensory ways and make productive connections as different relations became visible through novel spatial arrangements. Conceptualizing their studies as material-discursive assemblages, Chappell et al. (2021) and Crath and Rangel (2021) assembled collages from wide ranges of study data and other tactile materials, including participant contributions, artifacts, theoretical texts, quotes, images, and artwork. The processes of creating the collages evoked curiosity through unpredictable affective intra-actions and coming to know the data differently. Similarly, Crickmay and Ruck Keene (2022) experienced unexpected questions and affects when experimenting with different textual manipulations: cutting data into fragments and layering texts in different ways, highlighting words that "glowed," sprinkling text with water as a form of tears and using the text chosen by the water to create a "found poem."

Aslanian (2018) also refigured textural data into poems to animate the provocative concept of love in early childhood education and care. Using solicited narratives from kindergarten teachers, Aslanian detailed how she experimented with cutting the texts into pieces, reordered them to produce new meanings, returned back to the original form of the texts, and "saw certain words which appeared more 'pregnant with meaning' than words with which it or they were con-

nected to" (p. 180). Aslanian then collected the words into poems, keeping the words in the original order to conserve the narrative trajectory. By crafting poems from the data, Aslanian "*reduced* the narratives in order to *expand* the spaces within them and open up meanings which otherwise lay concealed" (p. 180; emphasis in original).

Jenkins et al. (2021) and Arlander (2020) are other examples of studies that created new forms from physical data as analytical provocations. As a mixture that smears space, time, memory, and sensory data, Arlander created video "artistic cut-ups" from audiovisual recordings of herself in the same outdoor locations across different points in time. The iterative editing and viewing process was an immersion into the mixture of matter that Arlander explains is a "diffraction pattern that follows– or precede new moments of immersion and mixture" (p. 38).

As part of a project evaluation, Jenkins et al. (2021) were given access to artifacts generated through the Dementia Dog pilot project. Dementia Dog was established in 2011 in Scotland, UK as a collaboration between Alzheimer Scotland, Glasgow School of Art, and Dogs for Good, an animal assistance organization. The project placed specially trained dogs with couples living with dementia to assist in daily activities, such as bringing medication pouches to aid in adherence and wayfinding. Jenkins et al. composed three analytical vignettes using the "spoken and written words of the people with dementia, spousal carers and project staff who participated in the Dementia Dog pilot– words recorded by different people and collected at different time points over the 3-year period" (pp. 982-984). Creating the vignettes were not meant to construct a representation of the participants' lived experiences; rather, combining the artifactual data opened spaces that invited Jenkins et al. to recognize intra-actions that mutually constituted "people with dementia", "carers" and "dementia dogs".

A final example comes from Schadler (2019). Although Vagg (2022) used software to

visually arrange data in specific, yet complex ways as part of the study analysis process, I found Schadler's detailed explanation of diffractive data analysis using qualitative software intriguing. Using Barad's (2007) concept *exteriority within*, which establishes a superficial outside position within a phenomenon, Schadler showed how conventional analytical research tools can be reconfigured to work with materialist process ontologies.

Schadler's (2019) empirical projects entailed the materialization and boundaries that constitute figurations of family. The data collection process resulted in an extensive array of data: audio files of interviews, observation notes, photos, informative material, saved websites, artifacts, photos and videos. Schadler used the qualitative data analysis and research software Atlas.ti as a tool to store and manage the "raw" data, initial theories, and ongoing analysis. Acknowledging that data management techniques are part of the research apparatus and shape boundaries of research outcomes, she used the technological affordances of the software program to read through the wide range of multimodal data and "tag" data with words that identify "parts of data, topics and narrations that form dense boundaries" (p. 223). Schadler explained how a new materialist perspective transforms a coding-like research strategy into a tagging process:

> While traditional coding methods are used to categorize and reduce information, the process of tagging marks the information and relates it to specific processes and their boundary making practices...The researcher, the theory, the tools and the data are working together, and they are defining tags. (p. 223)

Schadler then used the tags to cluster data into sub-phenomena. Although the process is iterative, she explained referencing as a further step in analysis using the sub-phenomena. Referencing is a "process of rebuilding the complexity of the current world's differentiation" by referring to specific processes, intra-actions, and boundary-making practices enacted through the data

(p. 226). Schadler uses this process to stir up sedimented histories in the data, and then by re-building the sedimented histories, she is able to define the research object "from as many angles as possible" using descriptions of its materialization, "but always through the eyes/apparatus of a new materialist ethnography" (p. 226). Schadler's (2019) article is detailed with examples and theoretical supports that are beyond the scope of this writing. However, it is worth a closer look in that it exemplifies the creative, boundary-crossing capacities of diffractive methodologies.

Thinking Differently About Becoming

Relational ontological perspectives, such as Barad's (2007) agential realism and Deleuze and Guattari's (1980/1987) ontology of immanence, contest that research objects are at an ontological separation and researchers can be taught tools and techniques that are independent from a world they seek to learn about (Murris & Bozalek, 2019). Diffraction as a methodology attends to relational changes over time, the processes of differential becomings of material-discursive matter, while accounting for the entanglements of observation, measurement, and other boundary-drawing practices. Doing research is an experiential event where the act of knowledge production is a mutual performativity. Because researchers are entangled within the phenomenon of study, diffraction has offered opportunities for researchers to explore the intricate ways they are affected and co-constituted through research practices, at times pushing the boundaries of scholarly engagement and reconfiguring the researcher identity.

Crickmay and Ruck Keene (2022) conducted a study that compared the research processes and productions of a participatory music project when thematic analysis and then diffractive analysis were applied to the same questionnaire and interview data set. The article documents Crickmay and Ruck Keene's processes of "co-becoming" as researchers through their diffractive analysis that led to "a more open ended, emergent, felt engagement" with their research

work than their engagement with thematic analysis (p. 298). They contemplated the beneficial affordances of identifying patterns and themes using interpretive thematic analysis and the embodied experiences of researchers becoming differently through their diffractive analysis with data.

"Inspired by St. Pierre's claim that any empirical adventure with new materialisms must begin by living with theory," Clark and Thorpe (2020) began thinking and living with Barad while exploring their identities as researchers and mothers (p. 12)[6]. Clark and Thorpe described their study as a "diffractive thought experiment" that puts concepts to work through performative thinking practices (p. 12). Within the context of motherhood, they aimed to rethink the phenomena of women's relationships with their moving bodies and self-tracking technologies. With a direct focus on new ways of knowing embodiment and bodies as more-than-human and always becoming, Clark and Thorpe guided their "thought experiment" with the following research questions:

1. What might thinking diffractively entail in collaborative, feminist embodied research?
2. How does a diffractive methodology help us understand mother's moving bodies and self-tracking technologies differently? (p. 13)

Diffractively reading literature on moving bodies, motherhood, and technologies, and data produced over two weeks while wearing Fitbits (a commercially available self-tracking device) and reading scholarship from Barad, the authors identified new practices of knowing-in-being and becoming differently. First, they explained that the diffractive methodology helped them recognize the complexities of moving motherhood. In turn, this awareness heightened their

[6] See also Hook & Wolf (2018) from the database search as another article that explored the becomings of caregiver identities using researcher embodiment and diffraction.

skepticism and concern about the implications of research and policy that do not recognize the specificity of differences, fluidity, and dynamisms of motherhood. Second, Clark and Thorpe stated that within the entanglements of the diffractive methodology and their lives as academic mothers, different researcher selves were produced through their processes of becoming, and collaboration was enabled as a "highly valued form of feminist praxis" (p. 22). Through the experiment, Clarke and Thorpe were able to rethink processes of research in more broad ways. They explained that working through the uncertainty of theory-method-data together, their "diffractive thinking was continuously (re)shaped and (re)configured by the multiple forces at work," detailing how their diffractive methodology was also in a continuous process of becoming (p. 23).

While many of the authors in this literature review touched upon various ways they were affected and in processes of becoming through their diffractive thinking, other authors wrote at length about the specific becomings of other humans and entities realized through diffraction. Drawing on material feminism, Clarke/Keefe et al.'s (2022) diffractive inquiry aimed to enable insights that would open possibilities for new understandings of becoming beyond developmentalism discourses. The authors used a participatory arts-engaged research design to "creatively speculate" alongside a small group of young adults over processes of identity development (p. 2). In addition to describing their own becomings as researchers entangled in the inquiry, Clarke/Keefe et al. used the diffractive techniques mentioned earlier (i.e., "plugging in" and "thinking-with") to deconstruct and reassemble developmental discourses through participants' verbal and arts-based expressions of their subjective experiences with identity. According to Clark/Keefe et al., the insights that emerged from the tracings of material-discursive processes and entanglements of "identity works work" serves as a provocation for others "working in,

through, and on the well-worn notches of developmental discourse" to become increasingly responsible and responsive to the ways that young adult bodies sustain in their becomings through notions of coherence, stability, and progression (p. 8).

Other notable examples come from Kuby and Christ (2018) and Marinkovic Chavez et al. (2022). Kuby and Christ (2018) described in detail the processual becomings of an introductory qualitative research course designed to "disrupt the status quo of QR and to question taken-for-granted assumptions," pedagogy in higher education, themselves as the designers and instructors of the course, and the students as "(becoming) qualitative inquirers" (p. 291)[7]. As one of the few articles from the database search that did not cite Barad or frame their study through a relational ontology (or any theoretical perspective, for that matter), Marinkovic Chavez et al. (2022) described in great detail their use of diffraction to explore the processes and outcomes of Think Big, a multinational collaboration for participatory research with children. Adult and child co-researchers from Australia, Chile, Columbia, and the United Kingdom carried out locally led participatory studies. The authors employed diffraction as a methodology to discuss the "links and tensions between the different ways of knowing and putting participatory principles into practice" without making comparisons between projects. Marinkovic Chavez et al. explained:

> We did not want to compete over who's project was "more participatory" than the rest. Instead, our aim was to create a dialogue about what we understood as working with child coresearchers in a participatory way that was meaningful and feasible in the different contexts where we worked. (p. 315)

[7] See Chappell et al. (2021) for another article that detailed processes of becoming in higher education teaching and learning.

The diffraction as a methodology approach enabled Think Big to achieve a shared language and essential ethical principles on what it means for meaningful participation without imposing a dominant ideology or worldview. In this way, Think Big became a collaboration of "large organic networks [that] are grounded on the local level but expand globally, giving them the power to think globally and act locally" (Marinkovic Chavez et al., 2022, p. 315).

Another entity or assemblage through which becoming differently is attributed to diffraction as a methodology is scholarly writing. Barad has published through various writing genres[8] and explained that genres are different material practices of thinking, "thinking-in-its-materiality," that create "conditions of possibility of what kinds of questions become intelligible, what entanglements might come to the fore or not" (Juelskjær et al., 2021, pp. 132-133). Authors are taking up scholarly writing as a diffractive apparatus and different material practices of intra-acting within the world's ongoing performativity. Davies (2014) and Lenz Taguchi and Palmer (2013) acknowledged their awareness of diffractions intra-acting through the processes of presenting their research. Lenz Taguchi and Palmer (2013) explained

> it was in the writing of the analysis/paper and in the hands-on production of the power point to be presented that the diffractive analysis, more than any place else, took place. This is where new additional cuts were made and where different data were literally written into each other. (p. 676)

Davies (2014) stated that the act of documenting the analytical work for her article continued to interfere with the research problem and the questions that emerged, thus entangling back into her analytical work in unpredictable encounters. Mohandes (2022) wrote an auto/eth-

[8] See Barad 2010, 2012a, 2012b for selected examples.

nography drawing from his experiences as an early childhood educator and then enacted a diffractive analysis to the writing piece "to unsettle essentialist conceptualizations of gender/sex in the early years workforce" (p. 17). Like Aslanian (2018) and Crickmay and Ruck Keene (2022), Mohandes (2022) used poetry writing as an analytical process and artifact of the inquiry in this article publication.

In relation to writing genres, like poetry, that push the boundaries of what is recognizable as respectable scholarship, authors are publishing "thinking-in-its-materiality," that invite readers to spectate or directly engage in the diffractions of their projects. Wilson et al. (2021) and Gough and Gough (2017) engaged in collaborative writing practices as a form of diffraction and included excerpts in their articles. Wilson et al. (2021) wrote autobiographies as early career researchers in 2017. In an attempt to embrace the uncertainty brought on amidst the pandemic, Wilson et al. engaged in a "re-membering through diffractive analysis" of reading each other's texts, writing, and re-writing of their autobiographical accounts (p. 254). The autobiographical collaborative writing enabled the authors to "speculate and re-member as relational co-becoming as a means of knowledge-making" (Wilson et al., 2021, p. 254). Gough and Gough (2017) used collaborative biographical writing as a method of inquiry and included an excerpt as "a playfully scripted conversation (a conversation scripted in the manner of a play)" between the two researchers and other theorists (p. 1113). Gough and Gough explained they made this excerpt writing decision because conversations of thinking and talking together while cohabitating have proven generative in provoking novel questions and outward thinking while the expression of their conversation in the form of a play "would best capture the embodied and performative dimensions" of their inquiry (p. 1113).

For expansive research projects that collect multimodal data over months, like Chappell

et al. (2021) and Kuby and Christ (2018), moving readers through understanding diffractive readings or analyses can pose a challenge within the constraints of scholarly writing publication standards. Drawing from posthumanism, Kuby and Christ (2018) and Chappell et al. (2021) immersed their inquiries within novel approaches to higher education courses. With extensive data sets diffractively worked through, the articles made use of print affordances (beyond the more commonly used subheadings in many of the database articles) to aid readers in understanding the experiential productions of diffraction.

From their "module redesign and delivery around 'posthumanist project-based learning'," Chappell et al. (2021) capitalized on digital technologies and included numerous images of module artifacts, a SoundCloud weblink with a prompt for readers to re-enact a student's embodied experience, and a Vimeo weblink to a professionally produced experiential film intended to honor the course entanglements within the students' works (p. 1). During the design and facilitating of an introductory qualitative research course, Kuby and Christ (2018) encountered aporias, "a puzzle, an internal contradiction, a passable impassibility," while creating a space for students to think differently about paradigms (p. 296). The authors described aporias as "productive, energizing, baffling, uncertain, and perhaps necessary," and with their article, they tried "to embody a small aporia in [their] writing, given the limits of two-dimensional, alphabetic writing" (p. 296). The aporia materialized as "diffractive puzzlements" of interview transcripts with theoretical concepts and Kuby and Christ's analyses, with different fonts and text features signaling different parts of the puzzle. Explained by Kuby and Christ, the puzzlement of different fonts demonstrated the aporias that were experienced with their intentions in planning the course as well as what they and the students experienced. They also acknowledged that, with the choice of

writing style, they "are attempting to work simultaneously against *and* within the limits, linearity, and structures of language and journal publication parameters" (Kuby & Christ, 2018, p. 296, emphasis in original).

Affordances of Diffraction as a Methodology

Diffraction as a methodology entails tracing and analyzing the constituent parts of the research phenomena and then synthesizing for novel thinking. The methodology is not entirely different from other approaches to knowledge production but stands apart in how it makes entanglements and intra-actions visible from which knowledge and phenomena co-materialize. Barad reminds us that diffraction as a methodology "entails a different ethics than one that presumes we get to reset time, erase the past, cancel our debts, and start anew with the new" and stated that "close respectful and response-able (enabling response) attention to the details…is important to try *to do justice*" to a text or a phenomenon (Juelskjær & Schwennesen, 2012, p. 13, emphasis in original).

This attention to a phenomenon's embedded, entangled historicity (i.e., the sedimenting of iterative intra-actions that materialize the phenomenon) requires researchers to be self-accountable, critical, and responsible in their engagement with the world (Geerts & van der Tuin, 2016). To not question the intra-actions of entanglements would mean to uncritically accept the world in some materialized form as already given, foreclosing on differential becomings and rendering phenomena less capable of speaking (Barad & Gandorfer, 2021). While not all researchers using diffraction as a methodology foregrounded ethical attentiveness in their published scholarship and perhaps in their research practices, the conscious and unconscious decisions researchers make determine what is made to matter and what gets excluded from mattering. It is this ethical attention to the specificity of the phenomenon's materialization that reconfigures

"what becomes the unquestioned ground of theorizing" and a driving affordance of diffraction as a methodology (Barad & Gandorfer, 2021, p. 31).

As explained earlier, Barad's agential realism and development of diffraction as a methodology disrupt linear, humanist understandings of knowledge production and enable engagement in thinking processes that invite the unpredictable to emerge. By following the flow of events or encounters as they unfold, the methodology addresses the situated partiality of knowledge production as well as the impossibility to represent or reproduce research events as Truths about the world. Researchers are *of* the world and inseparable from the studied "object" (Barad, 2007). Recognizing the specificity of research practices and dwelling on how those differences matter constitute spaces of opportunity for learning and, importantly, spaces for researchers and phenomena to become differently in the encounters through which they emerge (Bozalek & Zemblas, 2017; Davies, 2014; Juelskjær et al., 2021). Diffraction as a methodology affords the opportunity to study both the nature of the research apparatus and the object of study (Dolphijn & van der Tuin, 2012).

As many articles in the review of literature illustrated, diffraction as a methodology produced new ways of understanding and becoming. By traversing binaries and embracing uncertainty, the methodology aided researchers in disrupting determinisms toward more fluid and complex understandings, opening up what may be seen as "inherent limits" of concepts (Barad & Gandorfer, 2021). Calling for a methodology of diffraction in community psychology, Langhout (2016) drew insights from Gloria Anzaldúa, an American scholar of Chicana cultural theory, feminism, and queer theory whom was highly influential to Barad's scholarship[9]:

[9] see Barad, 2014; Juelskjær et al., 2021

> [W]hen differing social identities come together, we are able to make connections that might otherwise remain invisible, meaning we can make visible our entanglements, overlaps, contradictions, complications, oppositions, and web of relations, and act upon them…In other words, multiplicity and movement are made visible, due to the focus on in-between spaces (p. 326)

The in-between spaces map the effects of differences for both diffraction as a physical phenomenon and methodology (Haraway, 1992). Differences are an effect of entanglements within and between entities. From this position, differences are from within, opposed to essentialized notions of difference and notions of interior/exterior and related binaries that have been integral to colonized modes of thinking (Barad, 2014; Juelskjær et al., 2021). Traversing binaries invites alternative, more just modes of living to come into view (Hook & Wolfe, 2018). Therefore, another affordance of diffraction as a methodology is the acknowledgement of affirmative differences that resist reductions and assimilations.

Recognizing the world as relational, inseparable, and interdependent (or intra-dependent), diffraction as a methodology pays attention to differences that matter while also attending to matters of care for the other of which we are all a part (Barad, 2012). Diffraction as a methodology resists the onto-epistemological damage comparison and critique entail. Comparison, like reflection, rests on an ontological essentialism and obscures patterns of difference by pitting one against the other (Bozalek & Zembylas, 2017). Critique necessitates power producing binaries through acts of distancing or othering that include/exclude what matter matters and for whom (Barad, 2014). Barad acknowledged that while "[c]ritique may provide some important insights at first glance," it closes down rather than opens up judicious understandings, and "often times it

isn't at all helpful politically. The presumed exterior and oftentimes superior positionality of critique doesn't have the kind of political traction that is so needed" (Juelskjær et al., 2021, p. 14). Several authors from the review of literature acknowledged diffraction as an affirmative methodology. Marinkovic Chavez et al. (2022) and F. Warren (2021) explicitly stated that they chose diffractive approaches to affirm differences as generative instead of raising differences that could potentially be destructive.

Another affordance related to how diffraction as a methodology produces new ways of understanding and becoming is through sustained attentiveness to micropolitical encounters. By opening up space to see constitutive forces, what phenomena do, and what effects they have through intra-action, diffractive approaches attend to fine details that can go unnoticed or assimilated under other methodological approaches. Remaining rigorously attentive to important details "investigates the material-discursive boundary-making practices that produce 'objects' and 'subjects' and other differences," inherent to respectful, responsible research engagement (Barad, 2007, p. 93). Diffraction's focus on constitutive forces and consequential meanings analyzes how phenomena or assemblages produce "*micropolitical* movements of power and resistance, social divisions and hierarchies, and opportunities and constraints" (Fox & Alldred, 2017, p. 183, emphasis in original). As an example from the review of literature, Gibson et al. (2020) acknowledged healthcare practices as laden with moral meaning and value and chose diffractive analysis to examine the micro-politics of person-centered care in everyday rehabilitation work through the "multiple forces (care logics, professional expectations, internalized responsibilities, institutional imperatives, conventions, policies, etc.) that co-produce particular practices" (p. 1530). The analyses made visible how power circulated through "micro-doings" within the "multiple

interacting forces, conditions, assumptions, and actions" that intra-acted and shaped each rehabilitation encounter (p. 1531). Gibson et al. concluded that what constitutes good person-centered care cannot be determined in advance but emerges in the doing-together. From their insights, the article offers recommendations for healthcare practitioners.

Diffraction as a methodology also critically engages with what Gitelman et al. (2013) coined as the "commodity fiction" of data: "the belief that data in a 'raw' form is out there available to be collected independently of its origins, context, and temporal history" (cited in Sanches et al., 2022, p. 1). As previously explained, data is performative, becoming through material-discursive intra-actions of the research-assemblage (Fox & Alldred, 2015). Approaching research with uncertainty and attending to power imbalances in ways that invite mutual response and responsiveness enable data to speak in different ways. The diffractive approaches used by authors, such as Merewether (2019) and Crath and Rangel (2021), to think data differently illustrate "the pragmatic, disjointed and unfinished qualities of data, and its capacities to exceed our expectations and prompt new thought" (Reinertsen, 2014, p. 314).

Perhaps one of the greatest affordances of diffraction as a methodology is its transdisciplinary approach to knowledge production and flexibility for broad applications. In a review of literature, Choi and Pak (2006) summarized the teamwork approaches of multidisciplinary, interdisciplinary, and transdisciplinary practices using common words: multidisciplinary as additive, interdisciplinary as interactive, and transdisciplinary as holistic. Diffraction as a methodology transcends, and at times troubles, disciplinary boundaries and mobilizes "transdisciplinary work that enables them to contribute to various domains of thinking" in ways that attend to important details within their specialized arguments while accounting for the enfolded diverse histories

(Juelskjær et al., 2021, p. 12). Diffraction as a methodology takes up Hennessy's call for a transdisciplinary approach that "does not merely draw from an array of disciplines but rather inquires into the histories of the organization of knowledges and their function in the formation of subjectivities … mak[ing] visible and put[ting] into crisis the structural links between the disciplining of knowledge and larger social arrangements" (Hennessy, 1993, as cited in Barad, 2007, p. 93). In addition to Barad's work, the sample review of literature has many examples of transdisciplinary scholarship; for example, Aslanian's (2018) inquiry of love in early childhood contexts included insights from early childhood care and pedagogy, philosophy, psychology, theology, and neuroscience. Diffraction as a methodology enables a critical rethinking of science and the social as separate entities and reaffirms their relational entanglements through boundary-crossing practices of knowledge production.

Limitations

For diffraction as a methodology, like all phenomena, with affordances often come entangled limitations. While studying the practices of knowing as they are enacted lends certain affordances to diffraction as a methodology, the context-specificity of findings can pose challenges for applications within areas of applied research, such as healthcare, education, and labor (Fox & Alldred, 2021). As Fox and Alldred (2021) noted, "the potential for [diffraction as a methodology] to generate a near-infinite multiplicity of contingent – and different – conclusions from research data poses a challenge for its users to produce the kind of 'evidence' conventionally sought by policy-makers and practitioners" (p. 3). Applied research projects, such as research that informs policy on child welfare or research to develop healthcare practices to improve patients' compliance with medical regiments, are often funded by government agencies, commercial companies, or nonprofits (Bickman & Rog, 2009). To inform what is commonly referred to

as evidence-based policy and practice, these bodies typically seek generalizable research outputs that will guide their decision-making and lead to immediate improvements in societal problems (Fisher, 2016).

Additionally, paying attention to the fine details and constituting histories of phenomena required in diffractive analysis is time-consuming work that requires sustained commitment without a procedural formula to follow. The open-endedness and accepted uncertainty on the part of the researcher allows the unknown to emerge but raises concerns about research quality criteria and recognizability as rigorous scholarship. As previously mentioned, the contextually bound nature of diffraction as a methodology resists generalizability, which does not meet the conventional research quality benchmark of reliability (Bryman at al., 2008). Reliability is the extent to which research procedures yield the same results or measurements when replicated by other researchers so that conclusionary findings can be agreed upon to formulate theories or make claims about broader groups of subjects or situations (i.e., generalizations). Relatedly, Bryman et al. (2008) reported that explicitness and transparency of research procedures are important quality benchmarks. Studies that utilize diffraction as a methodology may not clearly explain in what ways and to what extent diffractions influenced findings, and to do a complete accounting is an impossibility due to the nature of entanglements. The methodology also does not provide a means to evaluate the effects of the researcher, as an integral part of the observational apparatus, on research outcomes. For applied research fields, some effects might be minimal, and can therefore be accommodated or ignored, while other effects might be extensive and fatal for social research applications (Fox & Alldred, 2021).

Quality & Rigor

At this time, diffraction as a methodology might veer too far from familiar qualitative and

quantitative interpretivist approaches to be readily, and respectfully, embraced into many academic circles and institutions. Kerasovitis (2020) recognizes "the centrality of the researcher and the openness [diffraction as a methodology] professes via the removal of a prescribed method, demand not less but exceedingly more rigour" (p. 67). Unlike scholarship aimed at a priori knowledge and research that targets descriptive accounts of what a phenomenon is or means, diffraction's focus on relational processes and what phenomena do demand rigorous attention to subtle differencing and contingent effects, including interrogating the effects of the research apparatus. Therefore, diffractive approaches require different characterizations constituting quality research than research using other methodologies.

Like all social knowledge, conceptions of quality are contingent within local contexts, and scholars have offered different perspectives on what constitutes quality when diffraction as a methodology is employed (Tracy, 2010). Through their readings of Barad's agential realism, Juelskjær et al. (2021) identified response-ability and objectivity[10] as criteria for research methodology quality. They state:

> [E]very study must always be designed for the occasion (so to speak) in order to live up to the quality criteria of response-ability and objectivity. There is no larger methodology that determines how to go about a given study. And both the form and strength with which the phenomenon responds will obviously be affected depending upon whether it is in the form of a disturbance, a re-assessment, trouble, nuances, complications, re-confirmation, re-configuration or a combination thereof. As a matter of fact, the phenomenon may even respond in incommensurable ways. Responses and sensory apparatus(es) must

[10] Objectivity in the sense of Haraway's (1988) situated knowledges and Harding's (1992) strong objectivity of conscious acknowledgement that the production of knowledge always exists in relation to power structures and are unique embodiments of the world.

> therefore somehow be brought into sync, and the researcher must undertake a process of tuning in…the study must be designed in such a way that the explored phenomenon is given the opportunity to act back and provide some kind of response to the research question in the form of re-configuring it, or even re-configuring the phenomenon as such. (pp. 144-145)

Dissemination of the research utilizing diffractive methodologies brings about different quality criteria as well. Fox & Alldred (2021) state that the degree of specificity about the constituent parts, including the research apparatus, is imperative to lift the veil of study findings. Others state that quality is in the utility of outcomes. Chappell et al. (2021) proposed that research quality be judged based on ethicality and how the research "intensifies engagement and agitates to action" (p. 10). The authors state that they "aim to be judged on the creative, ethical and provocative quality" of their diffractive analysis and imaginings for higher education knowledge production (p. 10). Along a similar vein, Rosiek (2013) considers the merit of speculative research approaches, like diffraction, by the quality of change scholarly practices contribute to "reconstruct our experiences and the experiences of others" (p. 699).

Possibilities

Despite paradigm differences and challenges of procedural ambiguity, more and more scholars are taking up diffractive approaches, inevitably leading to differing iterations and their contingent productions (Crickmay & Ruck Keene, 2022; Dunk, 2020; Udén, 2018). As a reminder, diffractive approaches aim to trouble dualities of one or the other, and the emphasis on affirmative differencing encourages respectful engagement across paradigms and practices[11].

[11] Selected examples from the review of literature: Crickmay & Ruck Keene (2022); Jenkins et al. (2021); Marinkovic Chavez et al. (2022); Mayer (2021); F. Warren (2021)

Although diffraction as a methodology troubles various foundational belief systems and was partly developed as an alternative to representational practices, diffraction as a methodology does not situate itself in a binary with representationalism. Scholarship in its current form is reliant upon representation and reflexivity, and diffraction as a methodology is entangled with both reflexivity and representation in knowledge making practices (see Rosiek, 2021 and Langhout, 2016; Serra Undurraga, 2021, respectively). As explained previously, the methodology does not have scripted procedures because the application requires responsiveness to situated contexts. This flexibility affords unique adaptations to how the methodology is taken up, and as Fox and Alldred (2021) and Uprichard and Dawney (2019) argued, diffractive analysis can prove beneficial when used in conjunction with other approaches. However, this is not to say that anything goes. As Barad (2012) states: "Spinning off in any old direction is neither theorizing nor viable; it loses the thread, the touch of entangled beings (be)coming together-apart" (p. 208). Diffraction as a methodology explores how entangled material-discursive matter materialize the world. This includes how theorizing is engaging as part *of* the world rather than viewing theorizing as capturing, describing, or discovering aspects of the world from an exterior position. Thinking is an embodied practice, and diffraction as a methodology is a part *of* the world's materialization, requiring that researchers are "in touch", or sensitive, to the ways in which their intra-actions with materiality contribute to sense-making (Barad, 2012, p. 208).

Many scholars, recognizing the need for pragmatic research applications, are addressing the limitations of diffractive methodologies in their work. Although diffraction as a methodology "is one of the most researcher-centric and context-dependent analytic approaches yet devised," human involvement that embraces the messy complexity of matter grounds research findings as

applicable and relevant to the social world (Fox & Alldred, 2021, p. 7). Acknowledging that current policymaking is often inefficient and less impactful than expected, Ulmer (2016) explained the shortcomings of widely accepted "objective" policy research to inform effective policymaking:

> Because conventional policy models attempt to overlay simplicity upon complex systems, complexity often impedes the realization of intended policy targets. Though well-designed policy models convey a certain logical esthetic, once policy leaves the page and enters the 'real world', the messiness begins. (p. 1392)

Ulmer (2016) proposed diffractive readings as a means through which diverse theoretical perspectives could produce broader perspectives regarding the complex ways various entities collectively shape policy, illustrating with teacher leadership data how diffractive reading approaches could inform critical policy analysis. Ulmer diffractively read interview data from nine "high-profile" teacher leaders in the US through political theorist, Jane Bennett's (2010) *Vibrant Matter: A Political Ecology of Things* and cultural theorist, Gloria Anzaldúa's (1987, 2002) writings about B/borderlands and multiple, intersecting identities. Ulmer was able to identify how policy-based teacher leadership becomes inseparable and continuously evolves through the intra-actions of politics, organizational structures, and digital technologies. The diffractive readings also produced insights into the teacher leaders' professional movements, examining how they routinely crossed borders and boundaries from leading within schools to policy arenas. Diffractively reading the data set through the critical theories enabled Ulmer to examine the participants' roles from different perspectives, as individuals and as members of larger, discursive systems. Ulmer states that "understanding educational policy differently may result in better educational policy-making" (p. 1381).

Although challenges exist with applying findings for practice and policy, Fox and Alldred (2015a) see benefits located within diffractive approaches that unpack the micropolitics of research assemblages. According to the authors, micropolitics are the flows of power between relations in assemblages that affect "the capacities or constraints upon capacities in some—and not other—bodies, collectivities and non-human formations" (p. 403). Research theories and methodologies function as knowledge-generating machines designed to do specific tasks. By focusing on the micropolitics of research practices through a diffractive lens, researchers can study how different research configurations function to construct recommendations for policy and practice guidelines. The analysis of power through constituent parts of the research assemblage makes possible understandings of the differing effects of data collection, analysis, and writing "machines", and the consequences for findings, events, and researchers; this includes identifying who gains and loses through the process. For example, how a change in methodology, such as survey to ethnography, alters the possible intra-actions and flows of power, and thus alters what kinds of "knowledge" are produced and what applications will be possible. By emphasizing differences, diffraction serves as a tool for researchers to theorize through different perspectives and analyze "differences in how policies are produced, implemented, experienced and imagined." (Ulmer, 2016, p. 1382). This attention to differences has the potential to create methodological openings that stimulate different ways of making and understanding policy.

Recognizing that findings from diffractive approaches resist the generalizability often required to inform public and social policy, the invitation to think outside of normative structures has activated unconventional research paths that demonstrate the utility of diffractive approaches to improve social practices and challenge injustices. Strom et al. (2019) described multiple ex-

amples of research-activism projects that directly influenced practice and policy. Strom et al. explained that the projects were "specific actualizations of spacetimemattering" diffractively produced "from the singular mixture of each of our lives—from our politics of location (Rich, 1984), situated knowledges (Haraway, 1997) and the ordinary affects (Stewart, 2008) that contribute to the world-making practices that we engage with daily" (p. 7). As an illustration, Renold (2019) co-created AGENDA with and for young people in Wales using a participatory form of youth research (see https://agendaonline.co.uk/welcome/). AGENDA is a government sponsored toolkit aimed at addressing "gendered and sexual violence while re-mattering conceptualizations of healthy relationships" (Strom et al., 2019, p. 26). In addition to engaging youth across Wales and internationally, AGENDA and its connected activities have "influenced legislation like Wales' Violence against Women, Domestic Abuse and Sexual Violence Act (2015) and the formation of the new Welsh Government Relationships and Sexuality Education (RSE) curriculum and guidance for Schools" (Strom et al., 2019, pp. 26-27). Although Renold does not explicitly identify the methodology as diffractive, the "cartography" of AGENDA's lively emergence traces and describes the intra-actions of teenage participants; transcribed interview data on gendered and sexual violence; researchers; skirts; rulers; assemblies; the global Violence Against Girls and Women campaign, "Read My Lips"; art-ful encounters; post-qualitative scholars; and numerous other named contributors that dynamically materialized AGENDA. According to Renold, the approach was "a making process that was secreting its own co-ordinates as it unfolded and became more-than what any of us could have predicted in advance" (p. 215).

The transdisciplinary approach, ethical foundation, and creative momentum of diffraction as a methodology offer promising possibilities for improving material conditions and experi-

ences for humans and other-than-humans. As a final illustration, Sanches et al. (2022) is an exciting example of the wide-ranging possibilities of diffraction as a methodology looking ahead. Using five case studies, the authors build on and extend the notion of "lived data" in design research. They explained their use of "diffraction-in-action" with "biodata," data about "people's bodies, behaviors, and more controversially, their thoughts and feelings" collected from sensors worn throughout the design process (p. 2). Attending to the process of collecting and working with biodata for design projects, Sanches et al. wanted a methodology that attended to the inherited histories of design decisions that constituted the sensing technologies, such as different user settings than the ones being designed for, and was responsive to the ways in which designers have particular insights about "social and embodied experiences of trying out sensors, accumulating data, and scaffolding interpretations and insights that might be distilled from emergent data" (p. 2). The diversity of the case studies led to multiple findings that Sanches et al. (2022) synthesized into key design principles and illustrated

> how diffractively engaging with biodata, or designing (with) data as it is lived, helps designers attend to the many factors and subjective decisions inherent to data, moving away from a representationalist frame of working with data, surfacing instead how data production both affects and depends on the world that is entangled with, and therefore fostering more rigorous, careful engagements with data more broadly. (p. 2)

The case studies show how "diffraction-in-action" can help designers attend to the ways that people's bodies and the related biodata are entangled in lived experiences, rather than working with data as a straightforward representation of reality. By interrogating agential cuts to gain deeper understandings (i.e., the historical tracings of design decisions) and diffracting diverse

data (e.g., participant journal entries, researcher logs of quantitative and descriptive data, differently engineered prototypes and the related effects, skin conductance transformed into digital numerical values) through design processes, Sanches et al. demonstrate the flexible and broad utility of diffraction as a methodology to cross boundaries and produce generative alternatives for applied research fields. Importantly, the case studies were responsive to intra-actions with data as material and discursive, performative, and materializing from unique histories, which included the researchers as a part. As demonstrated by several studies in this review, the attention to relational entanglements in knowledge production cultivate research practices and outcomes that are in touch and relevant to social enterprise, embracing the complexity and unknown of the world's ongoing materialization.

In closing

While some more than others, all knowledge is partial, including the descriptions and analyses of this writing. However, I hope the lines I drew through scholarly encounters with diffraction as a methodology offer a clearer picture into the enfolded and layered development of this novel approach to research. There are likely limitations and important critical arguments that I do not have the purview to currently see, but my assumption is that the affordances and flexibility of diffraction as a methodology enable it to continuously evolve in practices of knowledge production in ways that are affirmative, ethical, and relevant.

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2 LEARNING TARGETS IN AN EARLY ELEMENTARY CLASSROOM: AN AGENTIAL REALIST EXAMINATION

Introduction

Learning targets, a form of stated learning objectives, are an integral part of curriculum and instruction commonly found in elementary classrooms across the United States. The use of stated learning goals stems from outcome-based education models mobilized by the longstanding standards, assessment, and accountability movement (Black et al., 2003; Hamre et al., 2014, Hattie, 2012; Marzano, 1998; Marzano & Brown, 2007; Seidle, Rimmele, & Prenzel, 2005; Stiggins, Arter, Chappuis, & Chappuis, 2009). Despite the scarcity of supporting research in terms of long-term achievement and social equity, outcome-based educational policies and practices persist (Evans & King, 1994; Polikoff, Petrilli, & Loveless, 2020). These policies often contribute to constructs of educational quality, including teaching and learning, that are universal and measurable (Dahlberg & Moss, 2008). This universal formula assumes that quality factors and practices can be applied anywhere, at any time, to achieve standardized results (Dahlberg, Moss, & Pence, 2007). The cultural embeddedness and universal assumption of what constitutes quality are rarely addressed, and standardized quality measures impose a one-size-fits-all model of educational success that both imposes and excludes cultural beliefs, values, and practices.

As an in-service lower elementary grades teacher and researcher, I witness the many ways in which outcome-based educational policies and practices bear down on teachers and students. The mandatory use of learning targets and their corresponding instructional procedures are at the center of this manuscript's investigation. In my teaching role, I can trace discourses espousing the use of learning target practices to attain higher student achievement scores. However, I can also trace the ways in which learning targets, when used as intended, are culpable in

normalizing frameworks that deny diverse ways of being. As a teacher that is required to write and use learning targets, I often grapple with the learning and subjectivities produced and those that go unnoticed or unrealized. On one hand, teachers are employed to instruct students to achieve academic standards, such as the Common Core State Standards. Reframing standards through learning targets and their corresponding practices are touted as an effective strategy that raises student achievement towards such standards (Berger, Rugen, & Woodfin, 2014; Moss & Brookhart, 2012). On the other hand, and importantly so, this manuscript presents an inquiry into what else learning targets aid in producing beside higher achievement scores and other explicit academic outcomes.

Learning targets are standards-based objectives that are written in student-friendly language by teachers; the intention is to clearly describe to students what they are expected to learn and be able to do by the end of a class, unit, or project (Berger, Rugen, & Woodfin, 2014; Moss & Brookhart, 2012). The use of the term 'target' is to convey to students that they are aiming for something specific during their engagement in the corresponding activity (Berger, Rugen, & Woodfin, 2014). Learning targets and their related instructional protocols are not inherently good or bad but contribute to situated practices of teaching and learning with multiple, simultaneously occurring effects. During a review of current research investigating the use and implications of stated learning goals with elementary students, I found the inquiries were limited to positivist paradigms that sought to evaluate effects on student achievement (see Halverson et al., 2007; Locke & Latham, 2002; Moss et al., 2011; Ross et al., 2010; Seidel et al., 2005). This manuscript contributes to scholarship on learning targets as a commonly used pedagogical device, but through a more expansive and generative theoretical lens.

Recognizing the need for elementary educational research that resists reductive, static representations and instead engages the complexity of classroom environments, this manuscript presents a new materialist study that investigated how learning targets functioned in a 2nd grade classroom assemblage within a school I taught during the 2021-2022 school year. New materialism perspectives afford the opportunity to explore the agentic capacities of learning targets as lively and affecting through a multiplicity of networks, including educational marketization; linear, developmentalism discourses; assessments and evaluations; instructional planning and pedagogy; and human and nonhuman classroom matter (Bennett, 2010; Coole & Frost, 2010; Fenwick et al., 2011). The investigation used diffraction as a methodology to examine the relational entanglements of human and nonhuman entities that co-constituted the classroom events and corresponding research practices (Barad, 2007). Rather than searching for meaning, diffraction as a methodology focuses on what phenomena do in co-constituting the world's ongoing materialization. By working against reductive research approaches ubiquitous in educational policymaking and evaluation that often put the onus of academic achievement on children's and teachers' individual abilities and behaviors, this study identified some of the countless constituting agents that materialized the classroom environment and experiences in complex, situated ways.

Drawing from feminist new materialism scholarship, particularly the work of Karen Barad (1996, 2007), learning targets are recognized as relationally constituted and constituting through the early elementary classroom setting. Diffractively reading insights from quantum physics, science studies, and critical social theories through one another, Barad (1996, 2007) developed the theory of agential realism as an ethico-onto-epistemological framework. Agential realism affirms that matter is both performative in what it does as well as onto-epistemological

through acts of theorizing that materialize phenomena in particular ways. It is through the material-discursive force of matter that particular articulations of the world become meaningful. Therefore, our constructed knowledges have real material consequences in the world that entail ethical responsibility (Barad, 1996).

For agential realism, the modifier "agential" specifies a departure from "traditional forms of realism that deny any active participation on the part of the knower" (Barad, 1996, p. 183). From an agential realist standpoint, phenomena or the observed objects are inseparable from the agencies of observation, what Barad (2003) refers to as the apparatus. Researchers are not neutral observers external to phenomena, but both phenomena and researchers are co-constituted through their direct material engagements (Barad, 2007). Important to this investigation was my situated position as an educator familiar with and entangled within the research phenomena. The intersection of veteran teacher and educational researcher enabled a heightened sensitivity toward what learning targets co-produced beyond contributions to measurable achievement outcomes. As part of the research apparatus, I want to acknowledge that facts and values are entangled (Juelskjaer & Schwennesen, 2012). Therefore, the data and subjects produced through the inquiry and this manuscript are inherently imbued with apparatus values and meanings (Murris & Bozalek, 2019). My experiences with the tensions and negotiations of teaching young children undergird this inquiry.

Using observational field notes and video-recorded data from a 2nd grade science lesson, the study explored how learning targets, as an example of classroom practices influenced by outcome-based educational policies, are powerful contributors in shaping the early elementary classroom. Entangled with bodies not as visible in the elementary classroom, such as educational re-

search-policy-evaluation systems, instructional mandates are driven by universalized quality discourses. Universalized, one-size-fits-all approaches lack consideration for the ethical complexity of being in relation with children in ways that do not foreclose on their differential desires and becomings. Rather than confirming or challenging research that touts learning targets as an effective, and therefore necessary, instructional practice to raise student achievement, this manuscript puts feminist new materialism thinking to work to explore what else learning targets produce aside from student achievement. The following questions served as a frame to explore the situated context of learning targets in the 2nd grade classroom: How do learning targets work? What kinds of work do learning targets do? What do the learning targets function with in this context and in relation to the variable bodies they encountered? What role do humans play in operating and producing learning target practices? What role do learning targets play in producing early elementary practices and subjectivities? In the remainder of this manuscript, I attend to these questions as I attempt to trace the kinds of bodies, relationships, subjectivities, and practices that are co-constituted by learning targets.

In the section that follows, I operationalize learning targets by describing their characteristics and the actions they intend to order. I then offer a more detailed explanation of the theoretical approaches that ground this inquiry. To investigate learning targets, this study put Barad's concept *apparatus* to diffractive, analytical work. Because the intention was to expand understandings of how learning targets work and explore what they produced during the 2nd grade science lesson, analyses of the study's research apparatuses were necessary to identify the multifaceted ways relational forces and the learning target phenomenon were made intelligible. Through this investigation, learning targets materialized as an event, as *something happening*, signaling that learning targets do not exist a priori, but happen again and again in different ways (Manning

and Massumi, 2014). I describe some of these events and relational emergences from the classroom observation and discuss implications of learning target practices for elementary education settings. I close with a pedagogical provocation to reconfigure learning target practices in ways that leave space for alternative ways of being and sense-making, through embodied practices of relational accountability.

Learning Targets, an Outcome-Based Education Device

While the term, *learning target*, is present in other forums and scholarship with similar conceptualizations, *learning target* as introduced and put to work by EL Education, a K-12 educational reform organization, will be the operationalized construct for this investigation (see www.eleducation.org). The research-site elementary school is a "credentialed school" for EL Education, requiring that specific practices be in place to maintain credentialed status. According to the EL Education website, "[c]redentialed schools have effectively integrated our Core Practices at all levels of teaching, leading, and learning so that schools are engines for excellent equitable outcomes" (EL Education, n. d.). As one of the EL Education's Core Practices, learning targets have considerable influence across EL Education credentialed schools. They function through various networks, including professional development for administrators and teachers, instructional planning documents, teaching protocols, assessments of learning outcomes, evaluation systems, and ubiquitous displays of learning target statements from weekly family newsletters to lesson worksheets to hallway exhibits of student work.

Produced and marketed through EL Education, Berger, Rugen, and Woodfin's (2014) text, *Leaders of their Own Learning*, explain learning targets as the "foundation and the connective tissue of a student-engaged assessment system" (p. 14). According to Berger, Rugen, and Woodfin (2014):

> Student-engaged assessment changes the primary role of assessment from evaluating and ranking students to motivating them to learn. It builds the independence, critical thinking skills, perseverance, and self-reflective understanding students need for college and careers and that is required by the Common Core State Standards. (p.5)

This description and related details conveyed throughout the text reiterate learning and schooling as something adults do *to* children. Ironically, student-engaged assessment and learning targets are intended to empower students by enabling them to understand and invest in their own growth; however, the targets of this growth are predetermined by adults. With ties to funding, educational accountability requires assessments that are based upon indicators of educational outcomes (Bagnall, 1994). Outcome-based indicators of achievement and success, like quality, are predetermined and standardized, leaving little room for diversity and complexity.

Berger, Rugen, and Woodfin (2014) explain that a strong learning target meets the following criteria. I pair each criterion with an example to better illustrate what is meant by a "strong" learning target; note, as a reminder, the absence of student-learner agency:

- Derived from national or state standards used in school curriculum maps and program materials (e.g., 2nd grade Common Core State Standard RL2.3 states: "Describe how characters in a story respond to major events and challenges.")
- Written in language accessible to students and begins with the stem "I can…" (e.g., *I can describe how characters in a story solve problems and overcome challenges*.)
- Measurable and uses concrete verbs, such as identify, compare, analyze, etc.; the verb points to the way in which the target will be assessed. (E.g., *I can describe how characters in a story solve problems and overcome challenges*. In this example, students would be assessed based on their description of how the characters in stories solved problems.)

- Specific by referring to the particular context of the lesson, project, or unit (e.g., This learning target would take place in a reading context of narrative texts in which understanding text structures, like problem and solution or cause and effect, is the intended long-term goal.)
- Focused on the intended learning by stating the skills or knowledge students will develop, not the intended doing such as what the students will complete (e.g., *I can describe how characters in a story solve problems and overcome challenges* focuses on the development of narrative comprehension and the ability to describe related events, versus *I can create a story map to describe how characters in a story solve problems and overcome challenges*, which focuses primarily on the completion of a story map.)
- Matches the cognitive process required of the students, such as knowledge, skill, or reasoning (e.g., *I can describe how characters in a story solve problems and overcome challenges* versus *I can apply how characters in a story solve problems and overcome challenges*.)

In addition to meeting the required criteria, a series of "key actions for teachers and students" are expected when implementing learning targets (Berger, Rugen, & Woodfin, 2014, p. 46). These include:

- Discussing and *unpacking* important verbiage in the learning target so that students firmly understand what is expected of them and how they will demonstrate they *met the target* (e.g., For the learning target, *I can describe how characters in a story solve problems and overcome challenges*, the teacher guides the students to understand unfamiliar vocabulary in the learning target, annotating the learning target with synonyms and examples for students to reference, and explains the activity or product in which students

will show they can describe at least one problem and solution in a narrative, such as completing a T-chart.)

- The teacher refers to the learning target throughout the lesson and aligns activities to support students in meeting the target. Students are expected to articulate how each activity is helping them move closer to achieving the targeted learning.
- The teacher checks for whole-class understanding while the students self-assess where they are in relation to the learning target using signals, such as thumbs-up-down-middle or fist-to-five.
- The teacher checks for individual understandings and uses data to make decisions about the next instructional steps. Data include student work, like exit tickets and journal reflections, that demonstrate students' understandings in relation to the learning target.
- The teacher engages the students to understand how daily lessons will help them meet long-term learning targets connected to state and Common Core standards they are working toward. (e.g., The teacher makes explicit connections to how understanding text structures helps students become more proficient readers.)

If followed consistently and with fidelity, the rationale is that students will understand the purpose of the work they are asked to do, build coherent understandings of the content domain, and develop high levels of the skills necessary to achieve in that area (Dean, Hubbell, Pitler, & Stone, 2012).

As the above language implies, learning targets are the vehicle through which standards and measurable expectations are delivered to students so that they can succeed on achievement assessments. The use of learning targets focuses teachers' efforts in interpreting standards and

aligning lesson instruction and activities to directly address the standards, while refocusing students' attention back toward the intended goal of each lesson. Therefore, the procedural expectations of reiterating the learning target throughout lessons and attempting to control students' efforts and attention foreclose divergent possibilities for sense-making, students' alternative amalgams, and ultimately the subjectivities and becomings students undertake (Bagnall, 1994).

Theoretical Foundation

As previously mentioned, this study is grounded in new materialism perspectives and draws specifically from Karen Barad's (2007) agential realism as a relational process ontology. New materialism signifies a diverse body of theory-praxis that rethinks the way materiality is implicated in the creation of worlds (see Dolphijn & van der Tuin, 2012; Coole & Frost, 2010). Matter, both physical and discursive, materialize worlds through a relational and performative ontology (Barad, 2007). This means that there is no separate, outside position from other matter, and no position, idea, or object pre-exists another. Rather, all matter is co-constituted through relational processes of becoming with other matter (Barad, 2007; Braidotti, 2002). Material things are performative and not inert, exterior objects to be acted upon by humans; they act together, in relational entanglements, with other types of things and forces to invite, exclude, and regulate thoughts and actions (Alaimo, 2010; Barad, 2003). The non-anthropocentric approach of new materialist discourses shares an agenda with posthumanism in that the human is no longer privileged as the sovereign agent that grants meaning to passive objects and other bodies. A humanist framework functions from the Cartesian position that humans construct the world, and therefore entities of the world do not exist until given form by humans. Posthuman theories, including new materialisms, differ by acknowledging the agency that arises through the relations of innumerable matter in organizing experiences and events.

New materialist thought pushes against notions of humans characterized as separate, fully interiorized individuals operating in neutral spaces, and directs our attention toward material-discursive forces that are generally ignored or made invisible. The materiality of education is often taken as the background context in which educational practices take place or seen as tools to advance educational performance (Fenwick, Edwards, & Sawchuk, 2011). However, educational practice, or the *doing*, is not ontologically separate from learning, but the very substance of it. From a new materialist perspective, all beings are constituted through our relational entanglements, and it is through these relations that we come to know and co-constitute epistemological phenomena (Barad, 2007). Everyday educational activities, knowing, and being are critically shaped through material-discursive forces (Sørensen, 2009). Relational ontologies, such as those in new materialism and posthuman theories and Indigenous epistemologies, acknowledge the co-creation of beings and worlds as evolving from countless relational entanglements of heterogenous matter (see Thayer-Bacon, 2017). New materialism affords ways of investigating learning targets as active agents that co-constitute classroom assemblages and phenomena, rather than as inert constructs mobilized by human intentions. Investigating within the specificity of relations to explore what emerges or gets excluded acknowledges the multitude of power imbalances arising from complex fields of forces in elementary education and educational research. New materialist thinking foregrounds this emphasis on the micropolitical as an ethical priority and a re-configuration of how we knowingly participate as researchers within the world (Dolphijn & van der Tuin, 2012).

Agential Realism

In the seminal text, *Meeting the Universe Halfway*, theoretical physicist Karen Barad (2007) explicated agential realism as an epistemological-ontological-ethical framework. As a

philosophical framework, agential realism speaks to the inseparable nature of ethics, ontology, and epistemology. Unlike social constructivism and relativism, agential realism is grounded in realist, materialist accounts of how the material world is brought into being as entanglements of material-discursive matter. All matter, including practices, are both material and discursive: "Neither is articulated/articulable in the absence of the other; matter and meaning are mutually articulated" (Barad, 2003, p. 822). Agential realism

> is *of* the Western canon while at the same time continuously and rigorously undoing what is said to ground its very foundations— not by means of deconstructing the origins of *meanings*, but by asking both how meaning comes to matter, and how matter comes to mean *differently*. (Barad & Gandorfer, 2021, p. 14)

Quantum physics underpins the entire construction of agential realism, challenging the Newtonian classical physics position of the world as made up of separate entities with inherent characteristics that dominates much of Western ontology. Barad (2003) states that it "is vitally important to understand how matter matters" and uses novel terminology grounded in quantum physics to more accurately represent the qualities of agential realism (p. 803). *Entanglement* is the fundamental state of inseparability and connectivity through which all matter and mattering emerge (Barad, 2007). The material-discursive matter of the world are performative and brought into being through *intra-actions* with other matter. The term *intra-action* replaces the commonly used term *interaction* to more accurately reference the ontological indistinction of entities and their mutual constitutions (Barad, 2003; Barad, 2007). Whereas the prefix of *inter*action assumes separate, independently existing entities, *intra*-action speaks to the materialization of entities within the world's inseparable wholeness.

Matter becomes intelligible in specific ways through what Barad (2007) refers to as *agential cuts*. Whereas phenomena are the primary ontological unit, agential cuts "produce determinate boundaries and properties of 'entities' within phenomena…In the absence of specific agential intra-actions, these ontic-sematic boundaries are indeterminate" (Barad, 2007, p. 148). It is through these specific agential intra-actions that the constituent parts of phenomena become determinate and that particular articulations become meaningful as concepts (Barad, 2007).

Barad's (2007) agential cut concept draws from the work of physicist Niels Bohr, who proposed that the properties of objects are indeterminate until configured through a measuring apparatus. Bohr argued that when we measure something, we are not discovering a reality that was there all along, but rather that the measurement determines a previously indeterminate reality. The observations and acts of measurement create reality as the phenomena, or research objects, interfere with the measuring apparatus; when we ask a question, the manner of the question we ask forces phenomena to respond to us in a particular way, which reveals some things but shields other things from our view. For example, when measuring a particle's position in space, the particle interferes with the apparatus in such a way that the particle's momentum is indeterminate. This conclusion of Bohr's is famously referred to as the Copenhagen interpretation. Posed in 1920, the Copenhagen interpretation states that a quantum particle does not exist in one state or another, but in all of its possible states, referred to as the particle's *coherent superposition* (Gribbin, 1984). It is only when observed that the quantum particle is essentially forced to choose one probable state that becomes the one observed. The Copenhagen interpretation drew from collaborative experiments measuring the wave or particle form of photons as well as measurements to determine the momentum and position of particles (Barad, 2007; Gribbin, 1984).

The Research Apparatus

This profound shift in recognizing how the world materializes entails significant implications for knowledge-making practices. For example, agential realism radically disrupts conventional notions of realism, objectivity, agency, and causality. Conventional understandings of scientific objectivity assume that subjects and objects have fixed, inherent properties that can be determined through acts of measurement. From this position, the research object is viewed as separately existing outside of the researcher and other knowledge-making apparatuses (e.g., scales, video/audio recorders, microscopes, X-ray images), and the effects of observing-measuring[12] are assumed to be negligible or are dismissed through concepts such as objectivity, positionality, and reflexivity (Cannon, 2022).

Agential realism does not have the same concerns with objectivism, bias, and validity because research phenomena are recognized as articulations of the world formed from momentary congregations of people, things, and ideas in specific times and places (Nordstrom, 2015). Rather, agential realism is concerned with the onto-epistemological entanglements of humans, nonhumans, culture, and discourse, and how those entanglements generate contingent meanings and knowledge. According to Barad (2007), objectivity "requires an accounting of the constitutive practices in the fullness of their materialities, including the enactment of boundaries and exclusions" (p. 391). As Barad uses the term, *apparatuses* are boundary-making practices that enact agential cuts. Phenomena are ontologically and epistemologically inseparable from their knowledge-making apparatuses. For example, when exploring the experiences of first year teachers, the following apparatuses: researcher, theories, interview protocol, interviewee, audio-re-

[12] I hyphenated observing and measuring to signify that the act of observing is synonymous with measuring. Measuring and observing are descriptive knowledge-making practices.

cording device, anecdotal notes, transcripts, analytical coding, academic writing, and so on (inclusive of their unique histories and contextual states), are processual in determining the boundaries that make teacher experiences articulable as a phenomenon. As in the example, researchers are apparatuses, participating with the world in creating articulations of phenomena. Therefore, bias is inherent because researchers "are themselves specific parts of the world's ongoing configuration" (Barad, 2007, p. 341).

The drawing of boundaries to materialize phenomena simultaneously excludes other matter from mattering. Derived from the quantum physics concept of complementarity, when one apparatus instantiates a particular materialization of the world another is necessarily excluded (Barad, 2007; Hollin, Forsyth, Giraud, & Potts, 2017). Using the same research apparatus example from above, bodily gestures or tones of voice could be made not to matter when the interview event is reduced to transcription in an agential cut. A change in the research apparatus creates a corresponding change in the agential cuts and the delineation of the phenomenon's intelligibility; different agential cuts produce different phenomena (Barad, 2007). The inclusions and exclusions of apparatuses (re)configure[13] the world. Agential realism acknowledges that all acts of research are political and brings to bear this ethical awareness and accountability for the realities humans help to enact.

[13] The inclusion of parentheses within words is another technique Barad uses to modify language to better express entanglement and the performative nature of reality. The quarantined word parts of (re)configure and other terms, like re(con)figuration, (re)constitute, and (re)materialization, signal attention to the continuous processes of entangled materializations through which there are no beginning and end points.

For this study, agential realism and related concepts from Barad (2007) were particularly generative in exploring the performative nature of learning targets in the 2nd grade science lesson. I[14] am accountable to the ways in which this inquiry materialized the learning target phenomenon. Meaning is always contestable; different meanings are always possible because of the ongoing intra-actions that produce them. Thus, Barad (2007) emphasizes, "[t]he failure to take proper account of the role of apparatuses in the production of phenomena seriously compromises the objectivity of the investigation" (p. 232). Apparatuses are open-ended practices that make full accountings impossible. However, in what is to come, I embark on an imperfect, partial accounting of the study's knowledge-making apparatuses in shaping the phenomenon of learning targets.

I do this accounting by diffractively reading myself as researcher and the recordings produced through the 2nd grade science lesson through agential realist concepts. Diffractive reading is an analytical practice of diffraction as a methodology, and methodologies are also knowledge-making apparatuses. In the next section, I introduce readers to diffraction as a methodology and explain how the methodology contributed to the materialization of the learning target phenomenon. I then shift the focus to the study's other apparatuses to trace what the apparatuses collaboratively made visible, intelligible, and material. This includes what was made possible as consequences of the apparatuses, and how apparatuses simultaneously produced me differently.

[14] Working within the confines of language, I want to make clear that when I use terms that signify subjects, including myself, the terms are used with entanglement in mind and the inclusion of their constituting relations. Subjects are phenomena and do not pre-exist their relations as independently existing entities. It is also important to note that just as phenomena are processual material-discursive matter, words intra-act to reconfigure matter to materialize in contingent ways. For example, when using terms like "explained" or "stated", there is a conventional sense of a past. Agential realism disrupts notions of time as linear and separate from all other matter. Time, like the concept of space, are not predetermined, but come into being intra-actively through the emergence of phenomena. Statements, like "explained" and "stated" are not static representations of what once was. Through an agential realist sensibility, statements intra-actively produce reconfigurations.

Diffraction as a Methodology

An agential realist inquiry requires a methodology that examines how relational networks or assemblages of discursive, animate, and inanimate matter intra-act to produce the world (Barad, 2007; Taylor & Ivinson, 2013). Colebrook (2002), drawing from Deleuzian-Spinozan philosophy, states "that a thing is nothing other than its affective power," the intensities that power bodies to move and be moved (p. 173). Barad (2007) refers to these affective forces as agency. Bodies are understood as "assemblages of forces" (Bolaños, 2007, p. 119) and can be anything: "an animal, a body of sounds, a mind or an idea; it can be a linguistic corpus, a social body, a collectivity" (Deleuze, 1988, p. 127). Through their affective power or agency and our capacities to be affected, we recognize these entities in contingent, particular ways. Barad uses *enactment* to refer to the intra-actions of nonhuman and human bodies, concepts, affects, emotions, and other phenomena that become bounded as emergent data (Barad, 2007; Davies, 2014). Through this position, the unit of analysis shifts from human agents, actions, experiences, and what things or social institutions *are* to what matter *does* through its relations and capacities for intra-action. While conventional conceptualizations of matter are understood as knowable with the fixed essence or property of independently existing objects, diffraction as a methodology takes into account this reconfiguring of matter as existing through intra-active material processes of emergence, including how research as well is "an enactment of knowing-in-being that emerges in the event of doing research itself" (Taylor, 2016, p. 18).

Diffraction as a methodology was introduced by Donna Haraway (1997) as a tool for feminist research and an alternative to the metaphor of reflection. Although diffraction and reflection are both optical phenomena, reflection produces representations of sameness through il-

lusions of mirroring, what Haraway refers to as displacing "the same elsewhere" (p. 16). Diffraction, on the other hand, produces patterns of difference through interference (Barad, 2007; Haraway, 1997). Haraway (1992) argues that diffraction as a material-semiotic enactment is more useful than reflection and reflexivity in that it entails a more "subtle vision" that produces and attends to small, but consequential differences in the constitution of worlds (p. 300). Whereas reflection and refraction assume knowing subjects apart from their objects of knowing and invite "the illusion of essential, fixed positions" (Haraway, 1992, p. 300), diffraction accounts for the situated knowledge-making apparatuses that "record the history of interactions, interference, reinforcement, difference" (Haraway, 1997, p. 273).

Karen Barad (2003, 2007, 2014) further developed Haraway's diffraction through the lens of quantum physics. For Barad, diffraction is not a metaphor, which would imply representationalism, but a physical phenomenon and a materializing enactment that produces differences of epistemological, ontological, and ethical magnitude. Barad (2007) illustrates examples of physical diffraction using quantum particles and ocean waves passing through openings and interfering with obstructions, both particle and wave examples spreading differently than they would otherwise. Although perhaps not as visible to the human eye, diffraction as a methodology attends to the entanglements of ideas and other materials in ways that acknowledge that knowing is never done in isolation, but is always affected by different forces coming together, producing differently than they would otherwise. A diffractive research approach attunes to how these differences are being created in the world and the effects they produce. For Barad (2007), diffraction as a methodology

> does not fix what is the object and what is the subject in advance, and so unlike methods of reading one text or set of ideas against another where one set serves as a fixed frame of

> reference, diffraction involves reading insights through one another in ways that illuminate differences as they emerge: how different differences get made, what gets excluded, and how those exclusions matter. (p. 30)

There is not a prescribed framework for a diffractive methodology because researchers are *of* the world in which they seek to study and ontologically inseparable (Barad, 2007; Murris & Bozalek, 2019; St. Pierre, 2016). As previously discussed, each research assemblage functions as a uniquely situated apparatus of which the researcher is a part, and all forms of knowledge production are at the same time formations of reality (Barad, 2007). Prescribed frameworks assume an a priori reality to which scientific practices reveal what is already there from a position of exteriority.

Different methodological frameworks produce different agential cuts with profound implications; "bodies differentially materialize as particular patterns *of* the world as a result of the specific cuts and reconfigurings that are enacted" (Barad, 2007, p. 176, emphasis in original). Research methodologies are specific arrangements of apparatuses engineered to guide how agency flows. The methodological strategies and techniques influence how events, instruments, and researchers intra-act, and theoretical perspectives establish specific capacities for how data are interpreted (Fox & Alldred, 2015). For example, an interview protocol mediates agential forces flowing between interviewee and interviewer and a phenomenological perspective could transform interview transcripts into thematic concepts through inductive coding.

As knowledge-making apparatuses, methodologies mobilize theories and practices that make some aspects of phenomena visible while suppressing or erasing other possibilities. By attuning to the differences intra-actions produce, diffraction as a methodology recognizes that assemblages of matter are rhizomatic and in continuous states of "becoming" (Deleuze & Guattari,

1987, p. 256). Assemblages have an economy of agential forces flowing through their constituent relations. Because an intra-action may have multiple unanticipated effects on other bodies, ideas, and resources, entities become variable in their capacities of and for agential force. There are dynamic tensions within the agential flows as objects of study and research apparatuses intra-act (Fox & Alldred, 2015).

Fox and Alldred (2015) explain that "a research-assemblage (and its constituent data collection machine, validity machine, analysis machine and so forth) may be engineered to reduce an affect (for instance, an aggregation of data by pre-coding), and to foster others (e.g., a line of flight that offers a new perspective on an event)" (p. 411). Withholding preconceived determinations as much as possible, diffraction as a methodology invites the unknown to emerge by attending to power imbalances to increase the possibilities for mutual response. The agential cuts of the diffractive apparatus happen in response to relational differences that emerge in research enactments. Attending to "the specificities of intra-actions" heightens researcher's sensitivities and "speaks to the particularities of the power imbalances of the complexity of a field of forces" (Dolphijn & van Tuin, 2012, p. 55). Although diffraction as a methodology resists research practices that enable standardized generalizations, it makes visible the array of complex material practices that contribute to the inquiry and characterize research phenomena. Diffraction allows researchers to study both the nature of the research apparatus and the research object (Barad, 2007).

The theoretical entanglements of diffraction as a methodology made this exploration of learning targets conceivable. Agential realism re(con)figures learning targets as an entangled and lively phenomenon with the capacity to intra-act, effect, and be affected. The theoretical notion of relational agency and mutual constitution are built into the overall research apparatus of this

study. Because the study was designed to think differently about learning targets and explore the complex entanglements of the corresponding classroom events, it was necessary to depart from habitual, normative readings of data and the reductive practices of coding. Agential realism's theoretical framework offers a much wider set of enacting forces to consider in analyses. Rather than experiencing classroom environments from a deterministic perspective that subsumed differences, approaching the study as an experiment in diffractive thinking invited the unknown: novel connections and insights emerged as well as new questions, all of which noticeably affected my teacher-researcher subjectivity. Diffractive analysis allowed for different conceptualizations of meaning, knowledge, and ethics as well as a subtle vision for relational effects. Throughout the study, intra-actions of reading entities through each other created diffractive patterns that produced learning targets differently, becoming bounded and stabilized in ways contingent to the agential cuts of the study apparatuses. I will discuss the becoming of the learning target phenomenon in greater detail later in the manuscript and will now extend the focus from the overall research apparatus of diffraction as a methodology toward what the other apparatuses made visible, intelligible, and material in the study practices.

As a reminder, apparatuses are entangled and intra-acting. Their processual character undermines any conception of a determining social structure that shapes phenomena. The process of writing this manuscript reminds me that apparatuses are rhizomatic and "perpetually open to rearrangements, rearticulations, and other reworkings" that continue to shape the research assemblage and configurations of learning targets (Barad, 2007, p. 170). The included apparatuses of *Self, Recording*, and *Re-membering* are entangled and non-hierarchical; neither component can stand apart from another despite their presentations as individuated terms and entities. That being said, I organized the following section by apparatus in an attempt to convey how each explored

apparatus contributed to the material-discursive conceptualization of learning targets and their related practices. The decision to section off the apparatuses was an agential cut that imposed superficial boundaries intended for focused clarity. However, aims for clarity within the limitations of this textual format excludes many of the complexities of entanglement and the continuous flux of mutual constitutions threaded through the research assemblage. I attempted to hold the apparatuses still long enough to theorize and write, but their excess and entanglements continue to be in constant tension with the stabilizing form and alpha-numeric textual limitations of writing.

I understand the self as a phenomenon that includes material-discursive practices of embodiment and identity. The apparatus of self is specific to my role as the researching subject, which is continuously constituted by the materiality of human and nonhuman resources, my subjective experiences, and societies in which I have been socialized. The recording apparatus produced data from the 2nd grade science lesson event. This is inclusive of audio-video recorded data and the recording of written field notes. The apparatuses of knowing are a nested entanglement within the apparatus of re-membering. Re-membering takes the form of presentation. It comprises the material-discursive practices that effect and produce learning targets as a research project and the presentation of its findings.

Self

Research is a shared enactment that includes research subjects, tools, discourses, values, norms, and research objects (Barad, 2007). Intra-actions with methods, instruments, and subjects allow the self to become the research subject, the component of the apparatus that observes the properties of the research object, and present specific research outcomes as knowledge (Schadler, 2019). As an important reminder, knowing cannot be claimed as a solely human practice because "knowing is a matter of part of the world making itself intelligible to another part" (Barad,

2003, p. 829). As Barad (2007) describes below, researchers are *of* the world they seek to understand and inseparable from knowledge-making apparatuses:

> According to agential realism, knowing, thinking, measuring, theorizing, and observing are material practices of intra-acting within and as part of the world. What do we learn by engaging in such practices? We do not uncover pre-existing facts about independently existing things as they exist frozen in time like little statues positioned in the world. Rather, we learn about phenomena – about specific material configurations of the world's becoming. The point is not simply to put the observer or knower back in the world (as if the world were a container and we needed merely to acknowledge our situatedness in it) but to understand and take account of the fact that we too are part of the world's differential becoming. (pp. 90-91)

As previously discussed, phenomena are the primary ontological unit of relations, inseparable from their intra-acting components. Agential cuts, specific agential intra-actions, enact boundaries and properties of the components through which parts or "objects" of the phenomenon become determinate and concepts become meaningful. This localized separation happens *within* the inherent ontological indeterminacy of the phenomenon. The properties attributed to a phenomenon are inseparable from the "observed object" and the "agencies of observation", in other words, the apparatus (Barad, 2003, p. 814). Barad's (2003; 2007) concept of *exteriority within* establishes an outside position within a phenomenon. The relation of the social and the scientific is a relation of *exteriority within* that provides the conditions for objectivity in the absence of a conventional ontological position of absolute exteriority or separation between observer and observed (Barad, 2003).

Matter, in its dynamism and creativity, constantly produce differentiations that can be analyzed or measured through the agencies of observation. *Exteriority within* acknowledges the "embodied cut between the object and the agencies of observation" (Barad, 2007, p. 115). Recognizing that there is not this knowing from a distance, the learning target phenomenon is an entanglement of subject and object. Throughout the study and this presentation, learning targets emerge(d) through the entanglements of the research apparatus and observed events. As methods, outcomes, events, and I intra-act(ed) through different situations, the properties and boundaries continuously change(d). As the research subject, I am inseparable from the methods, instruments, and research objects (Schadler, 2019). It is through the production of agential cuts that this specific rendering of my embodied self comes to matter. I do not willfully make agential cuts alone, but rather as part of the larger material arrangements of the research assemblage, I help enact cuts in the ongoing configurations of the inquiry and learning target phenomenon (Barad, 2007). However, such shared enactments do not shirk the responsibilities for the agential cuts I help(ed) make. Diffractively analyzing learning targets through the apparatuses of knowing takes account of the entangled materializations, but throughout the study, ethics and responsibility were an embodied presence that influenced agential cuts.

Ethics and responsibility to study participants were present in the formal processes of identifying and obtaining consent for the research site and human participants. Ethics and responsibility were also engrained in the design of the study through the entanglement with agential realism as an ethico-onto-epistemological theory; what is made to matter and what is excluded from mattering has real material consequences for the world's ongoing materialization that entails ethical responsibility (Barad, 2007). This required thoughtful consideration for the

methodological intra-actions that shaped the study as well as constant attentiveness to the moment-to-moment enactments that emerged. My awareness through these enactments were often diffracted with Barad's concept *response-ability*, a reconfiguration of *responsibility* (Dolphijn & van der Tuin, 2012; Juelskjær, Plauborg, Adrian, 2021; Kleinmann, 2012).

Barad explains: "According to agential realism, 'responsibility' is not about right response, but rather a matter of inviting, welcoming, and enabling the response of the Other[15]. That is, what is at issue is response-ability—the ability to respond" (Kleinmann, 2012, p. 81). This entails "listening for the response of the other and an obligation to be responsive to the other, who is not entirely separate from what we call the self" (Dolphijn & van der Tuin, 2012, p. 69). Response-ability invites the possibility of mutual response in moments of intra-action by attending to power imbalances in ways that render the other capable of responding (Dolphijn & van der Tuin, 2012). Holding something "fixed excludes an entire range of possibilities in advance, eliding important dimensions of the workings of power" (Barad, 2003, p. 826). In my ego of knowing as a teacher, judgments and predicted anticipations are habitual. Response-ability was an important concept to think through so that new conceptualizations-configurations-becomings could emerge.

The experiences of working and teaching within elementary education are enfolded into my being, influencing the agential cuts I helped to make. Learning targets and I have shared countless enactments through our close proximities. The exploration of learning targets arose from a desire to make visible alternative modes of teaching and learning in elementary education. This desiring is threaded with the tensions and negotiations I experienced while teaching

[15] "Otherness," according to Barad (2010), "is an entangled relation of difference" (p. 265). As previously discussed, entanglements are the irreducible specific material relations of the world's ongoing differentiation. The "self" and the "other" are entangled; there is no fixed division. Rather, the "other" and "self" emerge through agential cuts, a cutting together-apart.

and being in relation with colleagues and students. Colleagues and I would discuss the professional expectations of following learning target protocols, feeling that little room was left for considering the different needs, learning styles, and interests of the students under our care. These conversations included shared frustrations of seeing many of the same students positioned as unsuccessful in terms of meeting lesson learning targets and the implications for students' well-being, such as their self-efficacy, levels of anxiety, and attitudes towards school and learning. Because of these experiences and embodied beliefs, practicing response-ability was necessary to restrain my assumptions from making predeterminations during the study observations and analyses. When aware, I attempted to position my attention within a situated curiosity and attune to observed and felt subtleties. The decision to include the recording apparatus into the methodological design was an act of response-ability in that the intention was to create a space for patient, cyclical engagement. Response-ability continues to breathe through my awareness as I aim to do justice to the texts (using the term in the broadest sense), trying to be attuned and sensitive, through diffractive analysis and this presentation.

The embodied research subject that I am referring to as the self or I is entangled with the "data collection" methods used in the study, observation and audio-video recording. Although I move on from the explicit section for the apparatus of self, the self is inseparable from any other apparatus and the phenomena produced through their shared enactments. The self materialized throughout the inquiry and continues intra-acting through this diffractive thinking and writing engagement.

Recording

As previously mentioned, the recording apparatus of the study comprises the material-discursive practices associated with the 2nd grade science lesson observation event. This includes

the processes to include the research site and study participants, the observation schedules, the classroom environment, two iPads as video-recording devices, field notes, and the analytical method. I was consciously aware of these agential cuts and acknowledge the innumerable possibilities that were excluded. Some decisions were made as probable attempts to center the phenomena for deeper analysis. For example, I chose the 2nd grade classroom setting because the teacher, Ms. Schorn (all names are pseudonyms), was consistently identified as *proficient* on indicators of instructional practices using the Georgia Teacher Keys Effectiveness System evaluation (Georgia Department of Education, n.d.) and the EL Education *Stages of Implementation: Assessment in Daily Instruction* rubric[16] used in EL Education schools to assess the implementation of learning target protocols. Other factors, such as the time of day and science lesson content, were not consciously strategic choices.

Two iPads, fitted with short tripods, were positioned on shelves along the wall parallel to what is considered the front of the classroom. There is a large touchscreen display hanging on the wall that served as an instructional focal point and interactive tool and a carpet large enough for all of the children to sit neatly in a square on the floor. Behind and to the sides of the carpet were rectangular tables with designated space and assigned plastic chairs for each student. iPad 1 was on the top shelf, close to a corner of the room, and angled slightly down. The positioning of the iPad and the technological capabilities of its hardware-software assemblage made it possible to frame majority of the classroom space within its video recording boundaries. iPad 2 was located near the opposite corner of the same wall. Its position on the middle shelf did not frame as much of the classroom space as iPad 1, but the lower position enabled differently detailed video

[16] Although the EL Education rubric is only available to EL Education network schools, a similar rubric is publicly available at https://eleducation.org/resources/chapter-2-checking-for-understanding-during-daily-lessons.

and audio recording. As anticipated, the recordings produced by iPad 1 drew my attention to enactments that catalyzed the formation and movement of bodies around the spaces of the room. iPad 2 produced recordings of many of the same enactments, but entities, characteristics, and intra-actions became visible and audible through their closer distances and more parallel locations to iPad 2's camera lens.

iPad 2 and iPad 1 started recording within seconds of each other and continued recording through the length of the science lesson event, approximately 48 minutes. After the iPads began recording, I stood along the middle of the back wall to avoid blocking the camera lenses. I limited my movements, attempting to minimize awareness of my presence and interferences with the lesson Ms. Schorn planned for that time. With my study notebook and pen, I wrote down the starting time as 10:32 and then recorded physical descriptions of the classroom environment that were likely not in the purview of the other recording apparatuses. Periodically, I wrote down the time, in the event that matching the field notes with the times in the video recordings were generative. I described anchor charts, displays of student work, and direct statements located on the walls that referenced learning targets. The notes describe the ambience of the event: the lighting of the room, the sunny weather outside the classroom window, the temperature, and sounds. Interspersed through the description of the classroom space, I recorded descriptions of Ms. Schorn and the students' expressions, gestures, and actions with other human and nonhuman material. I resisted making assumptions and drawing conclusions during the observation event; for example, recognizing when I assumed that a student was bored when their eyes and hands were "drawing" on the table top with the pencil eraser during class discussions or that another student was displaying "attention-seeking behavior" by speaking out without raising their hand. However, I did

write down numerous wonderings[17] related to learning targets to consider more deeply later, awareness of how I was feeling at different times, and theoretical provocations.

Bodies, iPad devices, recording software, self, space, sounds, videos, and more are all ontologically inseparable, entangled phenomena. Their boundaries, and thus distinctions from one another, emerged from within the recording apparatus. The recording apparatus agentially produced the teacher and students as research subjects. The iPads and I enacted agential cuts, making a provisional boundary around the observation. However, as previously discussed, boundaries "do not sit still" (Barad, 2007, p. 171). Although the boundary around the observation event offered some onto-epistemological stability to explore what is contained within the video frames and written observations, meanings are always contestable and continuously entangle with matter that exceed the provisional boundaries of the observation event (Nordstrom, 2015). "Ambiguities always exist" (Barad, 2007, p. 430). Acts of recording can never capture meaning. The observation event does not involve iPads, writing tools, and me interacting with a priori bodies (human and nonhuman) within a specific timeframe. Rather, the boundaries of the bodies and formations are agentially cut and demarcated within the material-discursive entanglement of bodies, movements, and place. Intelligible and unintelligible meanings were generated by the intra-actions between the iPads, participants, me, culture, space, discourse, classroom materials, and so on. Different meanings are always possible on account of the intra-actions that produce them. The observation event attempted "to grasp always already contested meanings that are part of and produced by dynamic intra-actions" (Nordstrom, 2015, p. 395).

Diffractive thinking through the observation event would happen at unpredictable times, prompting me to record thoughts down on whatever was conveniently on hand, often the voice

[17] Wonderings, as a form of curious questioning, can be traced to a common practice at my school. When analyzing data, school staff reviews data through an "I notice/I wonder" protocol intended to withhold premature judgments.

recording device on my phone. However, a formal schedule was also followed for analysis. The method of analysis was circular and started with writing down observations and connections with what was seen, heard, and felt when watching the videos. Writing with loose leaf paper and pens of various colors afforded the capabilities of drawing and mapping connections and ideas. The next iteration included typing sequences of enactments observable within the rectangular frames of the videos, paired with the corresponding time markers. Time markers were included so that I could reference the field notes recorded within the same timeframes to temporally layer meanings. The different transformations of the recordings reignited the intra-actions of the observation event, sparking my sensorial memories and making the relational complexity of the classroom assemblage and numerous enactments visible. The inseparability of matter and meaning was ever present as the recordings and agential realist concepts diffracted through each other. The intra-actions of the diffractive analyses frequently reminded me that the world "is doing theory (is theorizing) and it is also *doing concepts*" (Barad & Gandorfer, 2021, p. 26, emphasis in original). For example: the *agential cuts* made and what was made to matter by the learning target assemblage; the *indeterminacy* and fluctuation of boundaries of the learning target, classroom, and research *assemblages*; rather than thinking of the classroom *space* as a container and *time* as an independent parameter to organize events around, I think of the *enfolding* of *spacetimematter* and how boundaries get diffractively materialized and sedimented through one another; and relatedly, visible, simultaneous effects of intra-actions that troubled linear notions of *causality*.[18]

[18] Linear causality assumes separately determinate entities that preexist their intra-actions. Barad (2007) explains that causality "is not about momentum transfer among individual events or beings. The future is not the end point of a set of branching chain reactions" (p. 394). Cause and effect emerge through intra-actions in the differential making of spacetimematter. This ongoing reconfiguring of matter means there are no inherent beginnings or ends, but rather an enfolding of matter in its historicity, "the sedimenting of iterative intra-actions in their specificity" (Barad & Gandorfer, 2021, p. 19). I thought about the children's embodied subjectivities emerging from their unique enfolded historicities as they relate to schooling and how intra-actions further sediment, or stabilize their relational identities with school, or destabilize their relationships with schooling, turning up sedimented configurations toward new ways of becoming.

I recorded traces of the diffractive thinking in the field notes journal. Numerous concepts, "discursive articulations in their materiality" (Barad & Gandorfer, 2021, pp. 25-26), emerged, but cuts would be necessary to do justice to the selected texts through attentive and response-able engagement.

I framed several engagements, or intra-actions, with the recordings through the research questions. I searched for the presence of learning targets in the stabilized form of "I can" statements on display and in the language taken up by the teacher and students. I located differentiations related to learning targets, such as when question and response discussions evolved into directive statements and the differences in the responses that various knowledges and actions produced. I then analyzed these traces with questions of connectivity and boundaries in mind, considering the nonlinear cause-and-effect relations that crossed multiple temporalities. Working diffractively through the research questions and recordings, I often arrived at entangled knots of multiple forces. The relational space of the classroom environment emerged in these shared moments. The space materialized "as a product of cultural, social, political, and economic interactions, imaginings, desires, and relations" of which learning targets were apart (Singh et al., 2007, p. 197). Through the next apparatus of knowing, I re-member learning targets to illustrate how they contributed to the material-discursive practices that shaped the classroom environment into a space of normativity, often suppressing the plurality of differences through hierarchical and binary forces.

Re-membering

The recording apparatus of the observation event generated agential cuts and is thus productive of a particular "mattering" (Barad, 2003, p. 822) of the learning target phenomenon. Learning targets, like all phenomena, are neither determinate nor pre-existing but materialize in

the practices that make them meaningful. Re-membering is an embodied act of sense-making that does not take cuts as given (Barad, 2017). It is "a reconfiguring/re-articulating (of) the world" (Barad & Gandorfer, 2021, p. 17). Re-membering entails tracing the entanglements within and through the research apparatus so the boundaries, properties, and meanings of the learning target phenomenon are differentially enacted.

As a reminder, learning targets are not a thing, but an iterative doing with other material-discursive matter. Consequently, learning targets are simultaneously enacted and enacting. This means for instance that a learning target statement should not merely be seen as an enacting material-technological force that orders the sequence of instructional moves to a benchmark that signifies learning. It should also be seen as enacted—as a learning target statement in a particular context—by other entities; for example, the classroom wall display, the science lesson plan, the students and Ms. Schorn, this research inquiry, etc. The agential cuts and the formation of learning targets depends on the location, the discursive interpretations, and the bodies intra-acting with and through them. The research apparatus does not have the capacity to account for all of the entities comprising this exploration of learning targets nor access to their internal states. What becomes intelligible through the research apparatus are productions of intra-active desiring and response-ability. Desire is not conceptualized here as an affective possession of human subject experiences. As Barad explained, desire is "some felt sense of being pulled towards" a field of differencing within "the entanglement with/in the other" (Barad & Gandorfer, 2021, p. 43). Sensed within the field is agential potential, the build-up of energy that has yet to be activated by desire's intra-active responsiveness with/in the other. Response-ability entails an acute sensitivity to differential desiring, where desiring is *a doing* of matter's "ongoing yearning for expression" (Barad & Gandorfer, 2021, p. 49). The ontological performances of desiring and response-

ability to the learning target phenomenon determined what became, and continues to become, intelligible through this research process and acts of re-membering.

From within and through the recording apparatus of the classroom observation event, the intelligibility of learning targets changed forms as they materialized as part of the science lesson procedures. The first sign of learning targets appeared in the field notes and videos as static "I can" statements. A collection of copy paper, each imprinted with a learning target for math, reading, or writing created a display on the front wall of the classroom. Another statement, "I can reflect on our field experience to the Nature Center," was written with marker on sentence strips attached to another classroom wall. Next to the sentence stripped statement on the wall were worksheet papers marked with the traces of their related learning target, showcasing students' penciled writings of their favorite parts of the field trip and corresponding illustrations. Two more "I can" statements were visible on the interactive display board at the front of the classroom. Both learning targets were related to the science lesson about to begin. The learning target on the top stated *I can classify objects using physical properties*. The learning target below stated *I can record scientific observations*. Soon after the start of the observation event, the first learning target statement on the display board became mobilized through an enactment that included Ms. Schorn. Assembled from the video recordings, the first nine minutes of the lesson goes as follows.

After the students were seated at their tables with their pencils in hand, Ms. Schorn began the science lesson by telling the students to "put your eyes on this learning target," pointing to the learning target displayed on top. She asked Trey to read the statement aloud, which he does. The video recordings then show Ms. Schorn leaving the side of the display board to walk around the front of the classroom, closer to the seated students, while saying, "I want you to pick one

word that you think is important in this learning target and at the count of three, you're going to whisper it. Wait, give me a thumbs up if you've got your word." She then models with her thumb up, followed by asking Sean looking down at a pencil resting on the table if he has his word. Ms. Schorn's tells the students to be ready to whisper their word and begins counting down. At the end of the countdown, she reminds them to whisper the word they think is important. The videos show many, but not all, students speaking. Ms. Schorn's recorded voice then says, "Oh, I heard classify!" She opens the annotation app on the display and uses her finger to draw a rectangle around "classify" in the learning target statement. Ms Schorn then asks, "What does classify mean?" About one-third of the students raise their hands in the air for the chance to respond. Ms. Schorn calls on Ben to answer her question. Ben states, "Classify means like, in Fundations [a phonics curriculum and instructional segment of the students' school day], we classify some stuff, like we classify some stuff… like we could classify a column that we do like blends and diagraphs… like categories. Putting stuff in categories." Ms. Schorn's voice is heard on the video recording saying, "Ooh, categories," before writing "categories" above the boxed word, "classify". She then says, "There's a word for that, putting stuff in categories. Can you think of another word other than classify?" Zoe is called on by Ms. Schorn and says, "organize." Ms. Schorn annotates "organize" next to "categories" and says, "I'm thinking of another word, too. What's another word for organizing, putting things in categories?" A recorded voice says, "categorize", to which Ms. Schorn points to "categories" and asks, "What else?" The video shows her looking around the room. There are no student hands in the air, waiting to be called on. Ms. Schorn then says, "I'm looking for a word that starts with S." Ben shouts out, "Sort!" Ms. Schorn tells Ben to raise his hand. After Ben raises his hand, Ms. Schorn says his name. Ben says the word again, and Ms. Schorn writes "sort" above "classify".

Now that "classify" has been *broken down*, it is time to *breakdown* the *how* of the lesson goal, per learning target procedures. Ms. Schorn says, "We are going to sort, organize, classify into categories, objects— how are we going to do it? Raise your hand." She models raising her hand and looks around the room. Ben again calls out, "Sort!" In the recordings, Ms. Schorn looks in the direction of Sean and Casey, seated at the center table, whispering to each other over the possession of the pencil in Sean's hand. Ms. Schorn says, "How are we going to sort, Casey, how are we going to sort, how are we going to look at these objects to sort them." Upon hearing her name, Casey's body stops moving. Ms. Schorn continues, 'How are we going to sort? Casey, how are we going to sort? How are we going to look at these objects to sort them?' Casey tilts her head down toward the table top and does not acknowledge Ms. Schorn's questions. Ms. Schorn tries again, "Casey, how are we [Casey turns her head toward Ms. Schorn] going to classify these objects, what are we going to look at?' Casey responds, 'uhm…' in the recording, and Ms. Schorn reads and points to the corresponding words on the display, "Our learning target says, I can classify objects by using physical properties." I sense a hesitant tone in the recording of Casey's voice as she says, "Uhm, physical properties?" Ms. Schorn repeats the words, "physical properties", and underlines those words in the learning target statement with her finger. Ms. Schorn asks Niko if she knows what physical properties are. Niko responds, "Well, I think I know what a property is." Ms. Schorn moves the discussion along, "OK, well what's a property?" Niko replies, "It's like something that you own." Ms. Schorn responds with interest or intrigue sensed in her recorded voice, "Ooh, that can be property, like you own it." Ms. Schorn picks up a dry erase marker and tells the students that she can describe a physical property of the marker using its color. Ben shouts out, "Solid!" He then raises his hand, waiting to be called on. Another student explains the shape of the marker, mimicking the shape with her hands, and Ben

shouts, “Cylinder!” The student repeats “cylinder”, and Ms. Schorn adds the word “shape” next to “color”, both words above the underlined words “physical properties” in the learning target statement. The discussion of physical properties continues, and “matter”, “solid”, and “smooth” are added to the display board.

After discussing some of the physical properties of the marker, Ms. Schorn continues the lesson by explaining how the students will describe an object in as much detail as possible on a recording sheet, although she does not directly attach the action to the second learning target. The multiple enactments assembled from the video recordings comprised the expected instructional practice of beginning a lesson by “breaking down” the vocabulary of the learning target statement. “Breaking down” learning target statements are established as a necessity for students to understand what they are expected to do during the lesson timeframe. The annotated learning target statement is on display, intended for students to reference if they are unclear of the lesson’s expectations as well as for teachers to revisit as needed during the lesson activities and concluding lesson debrief.

Although beginnings are referenced here, there is no beginning, or end for that matter, in a real sense. The recording apparatus arbitrarily imposed a boundary that constituted the observation event into a start to end timeline. The re-membering of the specific learning targets on the display board does not start with their recorded visibility. Phenomena take form as enfoldings of spacetimematter[19]: boundaries get diffractively materialized and sedimented through one another. What emerged as a learning target in the 2nd grade classroom was an enfolding of heterogenous histories that included particular discursive practices related to teaching and learning,

[19] Spacetimematter is Barad’s (2007) combining of terms to more accurately account for the entanglement and simultaneous emergence of space, time, and matter through intra-activity. Just as matter is not a predetermined given, neither are space and time.

such as *best practices*; educational organizations and institutions; educational scholarship; curriculum publications; professional learning engagements and teacher preparation programs; evaluations and accreditations; standardized assessments and grading systems; mandated lesson plan formats and protocols; grade-level collaborative planning meetings; classroom arrangements and materials; and various humans.

Because of my proximal distance and entangled histories with learning targets at the research site school, I can trace the lesson's learning targets to intra-actions with elementary teaching professional learning texts that emphasized the effective utility of learning target practices; with 2nd grade science standards that materialized the learning targets into specific wording for intended audiences and actions intended for teachers and students to perform; with unit and lesson documentation that situate the learning target statements and the actions they order within temporal frames for teaching and assessing; with instructional materials and technologies and students and teachers that combine with other matter to materialize learning target practices within the observed classroom space.

Continuing back through the recording apparatus, the learning targets intra-actively performed a distinct path from the introductory discussion of the learning target vocabulary to the lesson finale--- the "debriefing" of what was learned and students reflecting on where they believed themselves to be in terms of the learning targets. The timespacemattering of the classroom was shaped by the structuring practices of learning targets in ways that exerted pressure for path-conformity from the beginning to the end of the recording event.

The pathway became visible through iPad 1's video showing bodies moving as collectivities throughout the recording; for example, the wave of student bodies walking to their assigned table spots, pencils removed from pouches hanging on the backs of chairs, student bodies sitting

down, heads turning to follow Ms. Schorn's movements, and hands raising and lowering in response to words vocalized by Ms. Schorn. Some collective actions can be traced to intra-actions, like with Ms. Schorn's directive words or the textual and graphical prompts on the students' recording sheets, but other collective actions appeared to share tacit body knowledge, likely from the reinforcement of desirable behaviors and repeated patterns of acceptable social interactions within the classroom context. For example, when one of the objects to be observed (a commercially packaged bottle of water, a bottle of Coca-Cola, a bottle of Sprite, a plastic cup with some Pop Rocks candy inside along with the opened packaging) were placed in the center of the six tables surrounded by seated students, students' facial expressions and utterances could be read as excitement. However, almost every student visible in the video recordings did not touch the objects as if there was a shared understanding that directions would first have to be given by Ms. Schorn.

The iterative enactments that comprised the classroom practices helped constitute knowing bodies of taken-for-granted expectations. Student bodies that moved apart or differently from the collective gatherings were sometimes scolded or told what they were supposed to do by the teacher or other students. The video from iPad 2 showed Ms. Schorn placing objects in the center of the student tables. Audible in the recording is a student voice telling Ben, "Don't touch it," referring to the cup of Pop Rocks Ms. Schorn put at their table. Ms. Schorn places a bottle of water in the center of another table. The only student visible in the recordings that touches the objects placed by Ms. Schorn rotates the plastic bottle of water while looking at it. A student seated across from her repeatedly tells her to stop. Ms. Schorn approaches the table and tells the students that it is okay to touch the bottle. She steps back from the table, and the recording of her voice gets louder, saying that all of the students will need to touch and observe their material so

they can “write down its physical properties” on the back of their papers. Here, Ms. Shorn used words to draw boundaries around acceptable actions and then reinforced what the students were expected to do. However, although it was not explicitly stated, the students seemed to know that the objects were not to be opened or tasted since no students attempted to do so.

Ms. Schorn enacted and is enacted by the learning target assemblage, which is inclusive of their shared histories of professional justifications and expectations and the pre-determined pathway articulated in the science lesson plan. The explicit actions of learning target practices shaped the planning and enactment of the science lesson, creating a narrow pathway of expected, and therefore acceptable, behaviors moving through the lesson. The actions of students reinforced the hierarchy that inscribed Ms. Schorn within the primary position of power and the guide through the lesson’s path. At one point in the recordings, Alex raises her hand to get Ms. Schorn’s attention. As she walks over, Alex states with a sensed frustration that Jade is not “sharing” the Sprite bottle. Ms. Schorn tells Jade to place the bottle back at the center of the table. When Ms. Schorn walks away, Jade “makes a face” at Alex while Alex pulls the bottle toward her end of the table. Throughout the lesson activity of observing and writing down physical properties, Ms. Schorn can be seen circulating the room; mediating the sharing of objects; speaking to students, at times pointing to object features; and reminding students to write down their observations on their paper before “time is up”.

Micropractices of power intra-acted as the learning target assemblage attempted to produce the classroom events and entities in determinate ways. Unlike vastly networked institutions, such as political or economic structures, micropractices intra-actively impose force that serves to control individuals in more subtle ways, often suppressing the opportunity for recognition. Grounded on a logic that following specific actions will result in higher student achievement,

Ms. Schorn followed the sequence of actions ordered by the learning target assemblage: (1) The learning target statements written during a 2nd grade collaborative planning meeting for the standard, *Science Georgia Standards of Excellence S2P1. Obtain, evaluate, and communicate information about the properties of matter and changes that occur in objects,* are displayed and discussed with students; (2) The planned activities and majority of Ms. Schorn's actions that are framed in the video recordings align to the learning target focus; (3) Ms. Schorn circulated the room, checking on students' verbalizations and papers as insights to their understandings, while also using physical and verbal cues in an attempt to keep their efforts on the expected behaviors and activities; (4) Ms. Schorn debriefed the lesson by connecting the activities back to the learning targets with discussion questions about what was observed and how students classified materials as solids, liquids, and gasses, and then telling the students to self-assess how well they performed. The expectations of designing and leading students through the explicit, narrow pathway to achieve the lesson objectives are governed by the learning target assemblage. The ubiquitous presence and reinforcement of learning target practices and expectations in and beyond the school environment renders other educational theories invisible or marginal. For example, student-centered learning theories that materialized in inquiry-based pedagogical practices were once a popular approach at the research site school. The open-ended, less restrictive pathway of inquiry-based approaches were made marginal to learning target's "efficient" and "effective" approach to standard-based learning outcomes. Recognition of Ms. Schorn's adherence to the practices imposed by learning target rationales in the form of positive administrative feedback and evaluations affirm learning targets as an effective professional practice, creating a resistance to think otherwise. In turn, students were also subjugated by intra-actions with classroom behavioral norms to act accordingly, intra-actions that took place both during the lesson as well as

from the enfolding historicity (see footnote 18) of intra-actions that shape(d) their becomings (Deleuze & Guattari, 1980/1987) within classroom assemblages.

The students performed particular roles in relation and responsiveness to the regulated pathway framed by learning target practices. At times, students responded in anticipated or acceptable ways, such as answering Ms. Schorn's question with an expected answer or writing down an observed physical property on the paper per her instructions. Other enactments from the video recordings show students making subtle movements, such as looking for Ms. Schorn's location before snatching a pencil from another student to turn the pencil into a sword ready for playful battle or participating in whispered conversations in between Ms. Schorn's direct line of sight. Other times, student movements were not so subtle, such as leaving a chair to sharpen a pencil, the loud sounds of the mechanical sharpener instituting a mid-sentence break in Ms. Schorn's discussion question, or the transformation of a table into a bomb shelter. The students were expected to observe what would happen when Ms. Schorn placed the opening of a balloon with Pop Rocks inside over the top of a Sprite bottle, holding the balloon up so that the candies fell inside the soda. The intra-action of matter caused gas to inflate the balloon with hissing and liquid dripping out of the bottle-balloon opening. The intra-action of matter also intra-acted with Ben, causing him to shoutout, "Get under the table! Get into your bomb shelters!" as he crouched below the nearest table along with two other students. Other students duck behind their chairs, still watching the Sprite bottle-balloon-Pop Rocks in Ms. Schorn's hand. Indiscernible shouting and giggling can be heard in the recordings. Ms. Schorn returned the students and materials back to the lesson path by asking students, "Did it blow up?" Learning targets functioned through the predetermined planning and enactment of the lesson path. The visible collectivities (i.e., student bodies performing in similar ways with other classroom matter) helped to maintain the pathway

through the lesson while some materials and students intra-acted in ways that surprised or disrupted the learning target structure, potentializing openings toward different pathways. Although openings toward different pathways were generated, such as Ben's enactment of table-bomb shelter that created a disturbance/diffraction of the student collective and learning path, openings were quickly foreclosed by Ms. Schorn's adherence to the predetermined lesson path and ensuing compliance of the student collective.

Learning targets and their pathway of classroom practices are entangled with the chronological construction of time as external linear intervals which people organize around. Not only does time regulate the rhythm of the school day through explicit schedules of activities that are supposed to happen at certain times and places, but within the schedule are lessons planned out to specific marks of time that shape the pathway of learning target practices and productions in the classroom. The actions ordered by the learning targets take place in a specific order and at specific times. Ms. Schorn is produced as the "authoritative organizer" that attempts to synchronize the students' attention and actions with the lesson events to stay "on schedule" (Hohti, 2015, p. 189). At the beginning of the observation event, the song, *Lovely Day,* queued how much time was left for students to ready themselves before the day's next lesson begins. The daily routine of the song as a transition marker was visible in how the student bodies moved in various ways around the room and then slowly formed a collectivity as the end of the song neared, moving to their assigned chairs and cleared off tables. Ms. Schorn would tell the students how much time they had to complete a particular task; for example, 30-seconds to get pencils out and be ready for the science lesson, before slowly counting aloud from thirty to zero, or prompting the students to whisper aloud their learning target words at the count of three. The passing of time measured by Ms. Schorn's counting intra-acted in the materiality of the classroom as human and

nonhuman matter were rearranged in attempts to align efforts toward the next coordinated lesson event. The digital timer on the interactive display served to moderate the "independent work" portion of the lesson, the writing of their observations of physical properties on their papers, to aid students in self-regulating in conjunction with the remaining time.

The entanglement of time and learning targets are fundamental to how the 2nd grade classroom was organized and enacted, contributing to how teaching and learning were configured. The learning target practices performed through time-regulated series of expectations and visibly evoked embodied responses and actions from students. I read student bodies expressing emotions of eagerness for the next planned event while others appeared anxious or confused with keeping pace with the path's momentum. The temporal expectations were intended to keep students' attentions and actions on the learning target path so that the lesson finished as planned, further constraining the visibility or imaginings of alternative paths.

Discussion

The learning target practices attempted to exert control over what happened, and therefore what was possible, during the science lesson. The performed pathway carved out a binary between acceptable and unacceptable ways of being, visible in the differential responses from others during the classroom observation event. The narrowness to which acceptable ways of being were iteratively enacted contributed to defining and constraining normative meanings to practices. In many ways, learning targets performed as an apparatus. The utility of the practices shaped onto-epistemological phenomena and determined the boundaries for successful teaching and learning performances.

Through a number of transformations, scientific processes and understandings were reduced to the learning target statements and planned lesson activities. The construct of learning

emerged as an outcome of following the instructions and participating in the activities mobilized by Ms. Schorn. Learning was largely constituted as something that emerged through and was represented by language: the learning target statements on display and then thoroughly discussed with the intentions that the words signify unified understandings; the questions verbalized by Ms. Schorn at different points during the lesson with the expectation that students' responses are evidence of their learning; the marks made on the worksheets through which students demonstrate their abilities to reach the learning targets. Science was configured as a stable process of making observations of discrete properties to confirm what is already known, bounded as practices that elide questioning cuts, contestable understandings, and novel explorations. Learning was configured as a linear, sequential process to gain universalized, measurable knowledge. When a student response was misaligned with the expected understanding, their response was either ignored or corrected. For example, when Ms. Schorn asked Casey to share an observation of the bottle of water, Casey responded that it was blue, referring to the label. Ms. Schorn then picked up the bottle, running her finger down the side of the bottle, and asked Casey, "but what color is this?" Casey said that the water was "see through", a smile from Ms. Schorn appears in the recording as confirmation of Casey's correct response. Casey perhaps did not know that the liquid inside the bottle was of greater mattering than the solid container or the water bottle viewed as a whole entity. The clearness of the solid plastic container was not made to matter nor were other containing parts of the objects; during the lesson debrief portion, the objects emerged as either a liquid (water, Sprite, Coca Cola), solid (Pop Rocks candy), or gas (the specific gas was not mentioned in the lesson but was referred to as "the gas in the balloon"), bounded separately from their containers.

The emphasis on language as a means to learning and representation of knowing privileges mind over body and matter. Of the 45-minute lesson, approximately 20 minutes of the lesson were explicitly discussion-based (the breakdown of the learning target vocabulary at the beginning of the lesson and the debrief of the lesson at the end). The expected observation of objects was coupled with writing down what was observed. Ms. Schorn guided students during the observation task with questions about what students observed, followed by reminders to write. The children's bodies as a resource and intra-active component for learning seemed not to matter much during the observation event. Aside from the visual, other sensorial observations were either ignored or reconfigured by Ms. Schorn into visual observations, perhaps leading students to understand that physical characteristics need only be seen to sort matter into categories of solids, liquids, and gasses. During the vocabulary breakdown of "physical characteristics" at the beginning of the lesson, one student asked to smell the marker Ms. Schorn told them to describe. Ms. Schorn acknowledged that smell could be a characteristic but did not add "smell" to the learning target statement annotations. When asked what they observed from the bottle of Sprite, a student answered that "Sprite tingles in your mouth." In response, Ms. Schorn directs their attention to the bubbles inside the bottle, saying that she sees bubbles. Positive acknowledgement of students physically handling objects to observe beyond the visual, such as one student rolling the side of a water bottle against her face, were not identified in the recordings. Students were also seated at their tables throughout the lesson, constraining their movements and possible implications for learning, such as stretching or standing to increase alertness. The student bodies expressed varying emotions, but those went largely unnoticed or unacknowledged by Ms. Schorn. During the last portion of the lesson, Casey goes to the area of the classroom intended for people who need to take a break from the classroom events or entities. I wrote down that Casey was crying in my

observation notes. Another student walked toward her and began asking if Casey was okay when Ms. Schorn tells the student that Casey "needs space." The attention on the students' written and verbal words and behavior in relation to classroom norms reduces the children to their cognitive abilities and social interactions.

The learning targets prioritize what forms of learning and doing are valued and worthy of attention, configuring the physical materials of the lesson as tools to achieve "higher" goals. However, the tangible matter (e.g., chairs, paper, interactive display, Pop Rocks) comprising the classroom are active participants in the enactments. Their dynamic network of relations emerged differently through intra-actions that behaved with the learning target governance as extensions or companions for play (Prout, 2005; Ruckerstein, 2013). For example, the digital timer, worksheets, and objects intended for observation emerged as extensions of the learning target practices, aimed at directing the attention and movements of the classroom. Other nonhuman physical matter emerged as play companions, such as a pencil turned into a sword or a worksheet peephole through which one student viewed the classroom. The ways in which nonhuman physical matter intra-act and co-materialize entities in the classroom is inexhaustible, such as snacks the students ate prior to the science lesson or furniture that shapes movements of bodies, but I share one more example of how physical matter can also be a resource for expression or for regulating emotions during the observation event. Prior to Casey leaving her seat to take a break, she can be seen in the recordings showing careful attentiveness to observing and writing on her paper. She works slower than the other visible students, checking her spelling against the labels on the bottles and her writing with that of a peer. While Casey is seated in the break area and quietly crying, the worksheet that participated in her careful efforts to meet the learning targets transformed in her fingers to torn bits on the floor, traces of Casey's enfolded frustrations

through the lesson event. Learning target practices continued to perpetuate configurations of learning as internal cognitive processes that are linear and measurable, overshadowing or rendering other alternative forms of learning, literacies, and ways of being invisible.

Through its history of iterative enactments with/in educational institutions, curriculum, research, professional networks, policy, publishing, and accountability efforts, the durability and far-reaching strength of learning target assemblages govern what is deemed as the appropriate or correct way to teach a standard, and in turn, regulates classroom intra-actions. Tracing enactments through the learning target pathway, different subjectivities intra-actively materialized as others were excluded. Ms. Schorn emerged as the professionally competent teacher, aware of the "appropriate" way to teach a given standard. The children emerged as students with problematic behavior that interfered in the learning process or cooperative students that followed directions when asked, for example. Intra-actions with learning target practices afforded children as attentive, inattentive, bored, or engaged; the children are not just bodies that exist, but bodies that listen, wait, fidget, answer, whisper, comply, disrupt, and, and, and. "Human bodies are phenomena that appropriate and are appropriated by specific boundaries and properties through open intra-action dynamics" (Barad, 2007, p. 172). Just as students' responses are constrained but not determined by the teacher's questions, students' actions are constrained by learning targets, but not determined. Not solely compelled by humans, moments of unknown potential and sites of possibility challenged the preplanned learning target path, creating spaces for "lines of flight" (Deleuze & Guattari, 1980/1987). A line of flight happens when intra-actions bring about an increased capacity for bodies to evolve into creative material-discursive transformations, producing new ways of thinking-being or becoming.[20]

[20] Although the term "lines of flight" was conceptualized by Deleuze and Guattari in their book, *A Thousand Plateaus*, I interpret the concept through an agential realist lens.

Toward a Response-able Pedagogy

Matter is performative and intra-acts together with other types of matter to "exclude, invite and regulate particular forms of participation in enactments, some of which we term education. What then is produced can appear to be policy, gender identity, or expertise, or a social structure such as racism" (Fenwick et al., 2011, p. 4). Intra-actions that reconfigure the 2nd grade classroom matter, not only for the becomings of human matter, but in unforeseen ways that intra-act and co-constitute beyond the spacetime of the classroom. The learning target assemblage yielded force that stabilized instructional procedures as effective, and therefore expected, teaching practices. Through the assemblage, the concept of student learning faced a procedural configuration of following directions to complete explicit tasks over making meaning in open-ended, less determinate ways. Entangled with the constraints of daily schedules of allotted time and keeping pace with grade-level scope-and-sequences, moments of enacting learning target procedures leave teachers, like Ms. Schorn, little space to consider thinking-doing-being otherwise. Referencing Bourdieu, Jones (2013) described this as the "automaton" within us taking over. Taken-for-granted practices construct walls to thinking and barriers to response-ability, for both educational pedagogy and research practices. Importantly, a radical opening to de/stabilize what comes to be is present within each intra-action, and we can consider the ways in which this ethical awareness can resist the automaton and bring about more relational awareness for teaching and research apparatuses.

"Not every intra-action is possible, but the number of possibilities is infinite" (Barad, 2012b, p. 14). Ontological indeterminacy potentializes reconfigurations within intra-actions as "phenomena-in-their-becoming emerge" (Bozalek, 2022, p. 1). It is this opening through which relations threaded between teachers and students can be reconfigured to materialize a pedagogy

sensitive and responsively welcoming to differences. This would require reworking the boundaries of learning targets that impose normative understandings and ways of being, while continuing to question practices before other cuts become habitually taken-for-granted, foreclosing on response-ability.

A pedagogy grounded in response-ability disrupts habitual modes of intra-acting with children by attuning teachers' senses to differences that surface and responding in ways that welcome and cultivate a student's various modes of expression. In this sense, response-ability is an intentional process of diffraction to come to know and be differently through "differential responsiveness" (Barad, 2007, p. 380). This requires that the teacher approach student intra-actions, including those that extend beyond the physical presence of their human bodies, with respect, curiosity, and attentiveness. To do so, it is necessary to reject pre-formed judgments to create space to be affected, "activating the sensibility of all our embodied faculties" (Lenz Taguchi, 2012, p. 272).

The materiality of environments acutely conditions young children's relationships with the world (Frigerio et al., 2017). The average student in the United States spends approximately one-sixth of their waking hours in school, so much of the school environment shapes students' personal, academic, and social relationships (Ansari et al., 2020). In considering the observation event recordings through my experiences as a teacher practitioner, I argue that the environment of many public elementary schools often takes the form of restriction and constraint. The stabilized, regulating structure of common teaching practices shape timespacematter, including the ways students are positioned and intra-actively materialized. Predetermined teaching practices

that proceed with little regard for the complexity of agential forces constituting the classroom obscures diversity, and it is within the familiar, quotidian teaching practices that "systemic injustices are made *invisible*" (Calabrese Barton & Tan, 2020, p. 433, emphasis in original).

Calabrese Barton and Tan (2020) argue that the current approach to equity as access to "high quality" learning opportunities "for *all* students, with special attention paid to ensuring that minoritized students gain access", does little to address the social injustices manifested through local classroom practices (p. 434, emphasis in original). Proponents for the same access to high quality pedagogies, tools, and curriculum materials argue it renders instruction more equitable and efficient (Martin, 2019). However, when equity is perceived as sameness, it "dismisses structural barriers of poverty, disability and race" entangled with other important differences that affect how children intra-act and become as members in a learning community (Timberlake et al., 2017, p. 46).

Single frameworks, such as learning target practices, deny opportunities for students to thrive academically with confidence (Tan et al., 2022). To center the dignity of students, schools need to be affirming spaces where "normalcy" is not assumed and differences are embraced (Kumashiro, 2000). Response-ability has the potential to participate in the micropolitics of elementary classrooms as an ethico-political practice that can contribute to anti-oppression efforts (Barad, 2007). As Kumashiro (2000) explained,

> [T]he situated nature of oppression (whereby oppression plays out differently for different people in different contexts) and the multiple and intersecting identities of students make difficult any anti-oppressive effort that revolves around only one identity and only one form of oppression. Perhaps what is needed, then, are efforts that explicitly attempt to address multiplicity and keep goals and boundaries fluid and situated. In other words,

> what is produced or practiced as a safe space, a supportive program, a feminist pedagogy, or a culturally relevant pedagogy cannot be a strategy that claims to be the solution for all people at all times, but rather, is a product or practice that is constantly being contested and redefined. Rather than search for a *strategy that works*, I urge the participation in efforts that address the articulated and known needs and individuality of the students, but that constantly look *to the margins* to find students who are being missed and needs that have yet to be articulated. Educators should create safe spaces based on what they see is needed right now, but they should also constantly re-create the spaces by asking, whom does this space harm or exclude? (pp. 30-31, emphases in original)

In regard to response-able intra-actions, the question that emerges is who and what comes to matter in each moment. This is surely a lofty request and challenging shift for elementary school teachers to consider, but worthy of potentializing. How might the becomings of uniquely situated children differ with attention to response-ability? Justice and dignity are a matter of mattering, and too often children's affects and desires risk exclusion. To explicitly speak to the now and future relations entangled with children's becomings exceeds the boundaries of this manuscript, but these entanglements are of collective and critical importance when considering the world and realities that materialize. Resisting prescriptive rules, attending to power imbalances, and continuously (re)awakening ourselves to the other through response-able engagement increases our relational capacity for mutual flourishing.

Concluding Remarks

The emphasis on learning targets throughout instructional planning and lesson activities articulates what knowledge is valued and will therefore be measured to determine academic success for students. The procedural expectations of implementing learning targets constrains the

actions of teachers and continuously aims to direct the attention and desires of the students. These academic performances stifle alternative possibilities while also co-constructing perceptions of instructional quality for elementary educational institutions.

As mentioned earlier, learning targets and the related practices are not inherently harmful. After all, educational institutions must prioritize particular knowledge and practices over others. What is harmful is when the cultural embeddedness and universal assumptions of educational institutions go unaddressed and/or result in narrow frameworks that exclude alternative ways of understanding and speaking about the world. Learning targets have the capacity to contribute to ethical teaching and learning experiences when configured with flexibility that leaves space for response-ability. This paper does not aim to provide answers and posit binaries of good or bad teaching practices. Rather the aim is to raise awareness for the complexity of intra-actions, tensions, and negotiations teachers face in relation to educational "goals" that materialize children's subjectivities and realities as well as configurations of the world. For example, respecting students' divergent needs and desires with responsive actions are often at odds with professional expectations of staying on schedule with teaching specific standards through predetermined lessons. Processes are equally important and should not be made marginal to outcomes (Hlebowitsh, 2012). Recognition for the complexity and encompassing multiple potentialities co-existing and co-creating elementary classrooms invite opportunities to consider what might or might not materialize. This includes the ways in which students' subjectivities and possibilities are formed through assertions of power. The awareness of our intra-actions entail accountability for what is made to matter and what gets excluded from mattering as an effect (Barad, 2007). For Barad (2003), response-ability is a matter of doing justice: "Particular possibilities for acting exist at every moment, and these changing possibilities entail a responsibility to intervene in the

world's becoming, to contest and rework what matters and what is excluded from mattering" (p. 827).

If we take Barad's apparatus concept seriously as how research practices materialize matter and what matters, consideration must be given for choices we make in research design. Barad (2007) states: "'marks are left on bodies': bodies differentially materialize as particular patterns *of* the world as a result of the specific cuts and reconfigurings that are enacted" (p. 176, emphasis in original). This is also true for educational intra-actions. By examining the phenomenon of learning targets through an accounting of the study's apparatuses, agential realism enabled me to diffractively work through intra-actions that shaped the research assemblage. This exploration articulates meaning and knowing as dynamic--- always in motion as contestable and performative. This attention to apparatuses of knowing created space for learning targets to be (re)articulated as a complex, generative phenomenon. Like the apparatuses explored in this inquiry, learning targets shaped knowledge-making practices of the classroom through intra-actions with non-human and human matter. Learning targets are not mute entities that can be taken for granted as static tools or techniques for human learning. Learning targets are material-discursive practices that are part of and result from outcome-based educational frameworks. Different frameworks are possible, and as a result of their relationality, different material-discursive practices of learning targets are both possible and, I argue, desirable. Learning targets work through iterative collaboration. Opportunities to rework taken-for-granted relationships and assumptions are present, threaded across larger learning target structures to micropolitical classroom enactments. Questioning cuts and stirring up sedimented boundaries across/through educational networks creates the necessary space for more response-able engagement and ethical educational practices.

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