

Xiaodi Zhou
University of Texas
Rio Grande Valley

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THRESHOLD FOR LEARNING: THE CASE FOR PRIORITIZING THE IN-BETWEEN SPACES IN EDUCATION

Abstract: In this paper, the author analyses learning as a function of the threshold between parties and ideas. Using Bakhtinian dialogic theory, literacy learning in particular is envisioned as a dialogue of the threshold. This instructional threshold is viewed both in pedagogical and biological terms. The physiological process of learning is described, making a biological case for instructional scaffolding and the gradual release of responsibility in the classroom. The dialogue of different disciplines serves as integration of several thresholds and further strengthening of learning. Curriculum integration is then promoted as a means to lasting learning.

Keywords: dialogue of the threshold, scaffolding, learning and memory, integrated curriculum.

Introduction

Learning in the classroom through understanding, a reconciliation of the tensions between the instructor's world and the students' (Zuniga, 2003), as well as those of the students with each other, with the texts they read, and with their extant prior know-how, is incited through dialogue (Bakhtin, 1984; Freire, 1970). Specifically, I contend that this dynamic is characterized as a dialogue of the threshold, as meaning "is born *between people* collectively searching for truth, in the process of their dialogic interaction" (Bakhtin, 1984: 110). In this interpersonal, as well as intrapersonal (Hermans, 2001), transaction of minds, undoubtedly tension and contradictions abound, as we may never fully interpret another message, missing subtle nuances tempered by the idiosyncratic experiences and contemplations of the speaker at the time. Yet, it is precisely this cacophonous space that I wish to contemplate, amid these caverns where my mind chooses to wade.

I believe that true learning exists in this threshold space, this dynamic mutually negotiated and inchoate chasm in-between, where students with teachers, and amongst each other, and within themselves, create and come to terms with these tensions from contrasts and distinctions, however subtle. Amidst the spaces between parties in the classroom, critical engagements can manifest as "participants in the act stand on *the threshold* (on the threshold between life and death, falsehood and truth, sanity and insanity)" (Bakhtin, 1984: 147, parenthetical in original). Students and teachers can at times engage in this back-and-forth give-and-take between seemingly contradictory notions to arrive at a negotiated double-voiced understanding (Zhou, 2019).

Merriam and Webster define "threshold" as a "boundary [and] a place or point of entering or beginning," which to Bakhtin (1984) usually meant the point at which an individual or entity is on the cusp of death or being renewed. In analysis of the serio-comical genre in literature, for instance, often these two conditions are simultaneous, giving contradictory counterpositions, one laid upon the other in one literary work. In fact, medieval Carnival, a time of creativity and artistic freedom, was a state of being analogous to the serio-comical genre with the double-sidedness of laughter and crying, of adulation simultaneous with derision. Carnival was a celebration of both death and rejuvenation. Tears can result from elation or despair, and laughter can be spawned in desperation or euphoria. The most profound

works of art can occur in these deliberate moments of strain amidst ambiguity, ambivalence, and equivocation within the threshold of our emotions and ideations.

Materials and Methods

For this study, I conducted a literature review of literary theory and practice, as well as the neuroscience of learning and memory, and meshed these elements with my own experiences teaching and researching of literacy. In this eclectic theoretical review (Campbell et al., 2014), I synthesised literary theory with dialogic theory, as well as neuroscientific thought, along with pedagogical theories and musical elements. Grounding these findings from the literature is a basis of an autoethnography of my own pedagogical and theoretical journey (Chang, 2016). I categorised my readings as theoretical, pedagogical, historical, and finally scientific. I made notes on my contemplations and epiphanies from the perusal of texts and my own introspection, totaling 52 pages. I then coded these notes, and looked for themes, which served as heading for my Results section, and wound up with larger categories after analysis of these initial categories, resulting in the headings for the Discussion section.

Results

Biology of Learning

When teachers learn to harness this tense threshold space for learning, to optimize its life-giving qualities, their instruction will be more impactful and relevant. When ideas in the classroom are reciprocative, learning becomes more rigorous, with the influx of differences dancing with one's own thoughts. There is neurobiological basis for the mutuality of ideas incurring lasting learning. For instance, neural pathways representing a thought or memory are strengthened due to repeated access of the pathway because protein channels form to abet the flow of sodium and potassium along the cell in propagating an action potential (Squire, 2009). Calcium ions rush into the presynaptic neuron which triggers the release of these neurotransmitters. At the synaptic cleft between neurons, various neurotransmitters, like serotonin, dopamine, norepinephrine, epinephrine, acetylcholine, glutamates, and GABA are expelled from the terminal bouton and travel across to the postsynaptic neuron, instigating excitatory, inhibitory, or modulatory effect.

But, even as most neurotransmitters flow to the postsynaptic neuron causing a wave of depolarization known as an action potential, others are reuptaken by the presynaptic neuron at the axon terminal. Also, the presynaptic cell may also be innervated by other axons from other neurons. Thus, there is a give-and-take of influence, as well as an exchange of chemical elements, like sodium and calcium, as two cells communicate and dialogue with each other. A pathway that is strengthened through the phosphorylation of proteins of neuronal receptors in the hippocampus facilitating long-term potentiation is apt to form new protein channels that abet that particular thought, instigating long-term lasting learning (Lynch, 2004).

Such also is the dynamic of dialogue in education; as the instructor speaks words incited by thoughts, students may ask questions based on their understanding. There is then a synaptic cleft in a sense in the classroom where ideas are like waves of action potentials, and neurotransmitters are like the communicated words. I contend that this dialogue of neurons in learning and memory mirrors the dialogic process facilitating learning in the classroom. It is in this give-and-take democratic climate open to multiple voices and words told in multiple languages that "truth" can be negotiated and substantiated and learning and growth occur.

Seminal psychologists have also postulated about the mental process of learning (e.g., Vygotsky, 1978), advocating appetitive sequencing of information most conducive to acquisition and retention. There may also be neurobiological basis for Vygotsky's Zone of Proximal Development (Perez, 2020), for neurons can only form pathways to other nearby neurons, resulting in the scaffolding of neural pathways, and thusly also of cognition. Cells cannot skip over intermediary cells and form axonal and

dendritic connections with distal others, but rather must form links with intermediary neurons on their way to the target neurons. So, pedagogical scaffolding of learning may describe the neural mapping of learning and memory across different cells and regions in the brain.

A thought, a network of cells that encompass such a postulation, is induced by the activation of particular neurons in a region of the brain (Squire, 2009). Vygotsky's ideas about learning and development, prior to our more detailed and granular understanding of the neuronal processes involved in learning and memory, actually make a lot of sense when the pedagogical theory is viewed from a neuroscientific framework. He believed children must learn by scaffolding new learning atop what they already know, forming the basis for creating neural pathways for strengthening particular sequences of neurons.

In instruction, this means we cannot as teachers skip over chunks of material needed as intermediary learning to bridge understanding to merit a completed pathway. We need to ferry our students' thoughts along a corridor toward some epiphany, or at least to gain some realization, about the topic at hand, so their brains can form these completed paths themselves. Yet, no two students will form the exact path, which is why people each understand ideas in our own individual ways. As we structure our lesson with connective minilessons or PowerPoint slides that presages some destination, we are constructing a foundation of and for students' individualized learning.

That is not to say all students learn in this methodical manner, as there are some individuals with minds that make those intermediary connections by themselves, without the prompting of an instructor. In education, preservice teachers are often taught the axiom of gradually releasing responsibility for learning from teachers onto students (Fisher & Frey, 2021). When lesson planning, they may follow the "I Do, We Do, You Do" model. This instructional sequence begins with the teacher demonstrating what is being learned first, followed by group practice, and finally transitioning to individual practice. Yet, some students may not need such sequential guiding and can arrive at some more advanced connection themselves.

Say for example, a class was learning about limericks. The teacher may begin with writing a limerick on the board, either one composed already by another, or make one up on the spot. She or he would follow the AABBA rhyme scheme, with the third and fourth lines shorter than the rest of the lines, those that are anapestic. Next, the students practice making their own in groups, and sharing these when they are done. Finally, either as a closing exercise or for homework, students compose limericks individually on their own. Some students may be able to construct their own after being exposed to an example of a limerick, while others require the more detailed scaffolded instructional steps.

Pedagogically, the teacher exposed students to models of the idea being taught while discussing the traits of limericks. By doing so, neurologically both visual and auditory centers are engaged, generating particular sets of neural connections. When constructing limericks with the teacher, students are using information recently stored in the working memory and employing them to mimic the task being taught. Because they are working in groups or as a class with the help of the teacher, they do not need to remember every step, but can fill in gaps in their understanding with the input from others, strengthening a particular pathway through long-term potentiation. By repeating a task, that particular pathway is repeatedly accessed, and those specific connections strengthened.

Finally, when students are performing the task independently, either a classwork or as homework, they are utilizing their learning in creating their own work. At night, subconsciously during rapid eye movement (REM) sleep, the brain processes the new information, and such semantic and episodic memory transitions to long-term memory through the creation of proteins at synapses between the sequences of neurons. By doing the learning tasks, students' understanding of the phenomenon is not restricted to semantic memory, but also involves episodic memory, or memory of occurrences throughout the day, such as that of the act of learning about limericks in class.

Threshold for Learning

In the intermediary space between brain cells, between instructors and students, as well as between students with each other and students with texts, there is also a threshold of tension. Disparate ideas interact in this amorphous, inchoate space. More and more this threshold for learning has become the space between a computer monitor and a student, especially since the pandemic. The medium of learning is becoming ever more important, functioning as the threshold in between individuals and betwixt disparate ideas. Learning is about meshing these differences in simultaneity, to incur personal meaning from outside stimuli.

Learning is filled with aha moments, moments of realization and epiphanies. My greatest joy is seeing a student in my class suddenly sit up or eyes widening for that brief yet resplendent moment, her countenance changing ever so subtly while reading a book or listening to others' words. I can almost see the neural networks forming an impulse to cranial nerve number seven, the facial nerve, inciting a smile. During these moments of student observation of the effects of my instruction, there prompts my own self-awareness, a feedback loop, a course evaluation in real-time.

All this occurs in the imaginary threshold between teacher and student, between the individual's prior experiences and any novel acquisition. As new information is processed atop and with existing knowledge, new neural connections are spawning from the established paths of prior ones. The new thought, new learning, has an established foundational path that has already been strengthened through repeated access and the long-term potentiation of certain neuronal connections meriting synaptic plasticity (Lynch, 2004), and so the new leaning may be just slight variation of the already learned material, or a minor detour path.

So, the threshold is about a marriage between the known or familiar with the unfamiliar. In this collision of two affects, a semantic bond is enkindled. Yet, this type of scaffolding does not merely induce self-fulfilling biases and only stiffen already learned facts. For, in the creative idiosyncratic ways individual students process, retain, and synthesize information, certain stimuli can have a myriad of effects on their minds. Such are the seeds for creativity and ingenuity, how the same information can lead different people to vastly different inspirations.

Thus, I contend, that it is in these in-between-spaces, whether the neuronal synapses, the physical space between classmates conversing, the space between the instructor and the students, or that distance between a text and students, where learning transpires. In these spaces, students may take what they know, add what they learn, and author a new thought. Their neurons branch toward new vertices, to new destinations in their brain, where other sensory, semantic, or episodic memories are stored. Each unique cascade of action potentials merits a novel possibility.

This is why each student learns the same material differently, because of their unique cascade of idiosyncratic neurons. This is where creativity and self-initiative is enkindled, as thoughts dance their own particular jig, arriving at unexpected destinations. When our neurons follow their impulsive whims, when they are not cordoned and ushered down hackneyed paths, but are able to wander to new untreaded trails, they presage new insightful possibilities, like an artist who has created a fresh deafening painting, a musician who composed a novel hypnotic melody, or a writer authoring a piece of him or herself in pristine, unspoiled ink. Those deliberate acts of creation are spawned in that wellspring of in-between tension when multiple voices chorus a feeling.

The issue for instructors and educational theorists then is to maximize the productivity in this space to yield greater synaptic activity and optimize the retention of learning and synthesis of information. As you, the reader, just read these words, they germinated and set off a parade of neuronal firings, activating certain ideas and memories, perhaps during a moment of instruction when you were teaching, or during a day sitting in class as a student, or perhaps you were remembering your favorite tune when you read about the hypnotic melody in the last paragraph. These words then have a direct effect

depending on your personal history and inclinations to direct innervations with a particular set of neurons, instigating a particular thought or memory from certain regions in the brain. With those thoughts or memories, perhaps waves of emotions flood over you with signals from the amygdala or hypothalamus or the hippocampus, the regions of the brain responsible for emotions.

In these states of transience, the in-between realm rife with chemicals and action potentials, lies true learning or the internalization of knowledge. Words exchanged between parties activate this give-and-take of neuronal actions, of neurotransmitters ferrying across countless synaptic clefts, inciting variegated effects across the brain. Words or a combination of words represent ideas that has taken a language years and repeated usages to refine and shape their meanings. Their phonology then corresponds to a morphology in a particular language, when they are then given a langue, or dictionary definition, as well as earn a parole, or the colloquial meaning (Saussure, 1966).

Thresholds in Literature

There is also a threshold between the langue of a word with its parole, so both exist almost simultaneously or alternatively. This is true of many slang words, like *cool*, *lit*, or *fire*. These three words meaning, respectively, *mildly cold*, the *past tense of light*, and *flames*, but their paroles may be *very good* or *pleasing*, *amazing* or *exciting*, and *trendy* or *on point*. Now depending on the context, either one of these definitions can color the word, but there is always tension between the two definitions, so the words are double-faced and double-voiced, even when only one version of the word is being used.

This is example of a word's significance dialoguing with its hidden alterity, and in the negotiation of meaning is the threshold between the two meanings. Thus, a threshold occurs between two meanings, and the individual must pick the appropriate connotation amidst this tension. In some cases, this tension on the border is sustained, such as the case with puns. For instance, in *Macbeth*, when Shakespeare writes as Macbeth speaking to Banquo in Act 3, Scene 1, "We should have else desired your good advice which still hath been both grave and prosperous in this day's council, but we'll take tomorrow," he is referring both to the seriousness of the advice given by Banquo and alludes to Banquo's eventual death, foreshadowing his murder at Macbeth's behest. Of course, the ending of his thoughts on "tomorrow" also presages MacBeth's climactic "Tomorrow, tomorrow, tomorrow" speech in Act 5.

Thus, these twin meanings of the word *grave*, both as *a heightened sense of import* and as *resting place for the dead*, clash and meet in synchrony. Someone reading Shakespeare would need to be able to juggle both definitions in tandem to experience the complexities of his characters and their minds. The tension between the two meanings, between the superficial meaning here of *solemn* and the double entendre of *macabre death*. Or in *Hamlet* in Act 1, Scene 2, when Hamlet responds to Claudius' feigned fatherly care when he asks Hamlet why the clouds still hang over him, "Not so my lord. I'm too much in the sun." Here, *sun* is pun for *son*, meaning he is at the same time not in clouds because he is too often in the *sun*, sarcastically expressing how he is overly happy, while also implying Claudius in overstepping his bounds in casting Hamlet as his son. In this tension, this threshold of meaning, we have double-voiced speech carrying twin meanings. When a reader transacts with such literary devices, she or he needs to navigate the threshold space, being keen to both voices and hold in them in tandem to experience the full effect of language.

Learning and understanding result from negotiating these tensions, not by defusing them, nor by placating oneself, but by joining in on the vacillating tendencies so both meanings are validated in succession. Being double-voiced in understanding means being privy to both sides of any conjecture, and develop a metaperspective, suspended above the fray (Zhou, 2019). Via this perspective, one may see the phenomenon under examination as a dynamic orchestral arrangement of multiple sounds. Although one can tease out the distinct instruments, the intricate harmonization of notes, or the different keys being played, the beauty is in the combination and dialogue of these disparate elements. Meaning and musical enjoyment occurs at the threshold of these differences.

Literacy Instructional Thresholds

What do these threshold spaces actually look like in the classroom, and how do we as instructors harness them? As instructors, we always aim to optimize the tension in students' minds by challenging them to consider some novel idea that trespasses prior boundaries of possibilities. When I taught Western literature in China, my students were usually accustomed to memorizing things I told them, and then compose those same thoughts, often in the same words I spoke when they took tests. Most had years of banking education with unreflective and unidirectional input of information (Sung & Pederson, 2012).

However, in addition to the mandatory textbook assigned for my course, with commercially produced passages to instruct English reading, such as excerpts from classic Western prose like *Wuthering Heights* and *The Adventures of Huckleberry Finn*, I also assigned other full-length novels, like *The Perks of Being a Wallflower* and *The Catcher in the Rye*. After each week's reading, my students reflected on what they read in their journals. I wanted my students to transact with elements of the US culture, and even though some students did not like these texts, a few of them developed a love of Chbosky and Salinger's prose. One student even wrote one week that *The Catcher in the Rye* really spoke to her because she identified with Holden Caulfield. As a Chinese girl growing up in the 2000s in China, the fact that she felt a connection to a text about a White teenage boy from New York City in the 1950s showed me that elements of Holden's experiences intersected with her own. With introduction to this distinct experience and reality, new understanding was enkindled.

As she read Salinger's words, some passages or pages touched her. The ideas from these sections incited waves of neuronal firings, perhaps eliciting memories of her own adolescence, of her own search for belonging and connection while on her own. Where many of my student saw Holden as a whiny, shallow, and naïve teenager, she, like me, felt a connection to him and his search for belonging on a visceral level. Literature with characters brought to life in transaction with text can engender such a relationship. Words bridge experiences wrought from the author's soul endowed onto the reader's own.

When I taught about genres in the US, I made a point to teach about the basics: fiction, non-fiction, drama, and poetry varieties. Additionally, I also taught about categories like comedies, tragedies, horror, fantasies, and biographies. While these genre classifications each had distinctive features, I also liked to teach about their intersections, those hybrid products of their unions, such as the serio-comical and the non-fiction novel. Students needed to understand each disparate genre, but also their hybrid unions, such as with meshing the solemn with the humorous in serio-comical, reminiscent of the upside-down, inside-out dynamic laden in Carnival.

What occurs with these novel intersections (pardon the pun), is a marriage of different literary inclinations. As with any marriage, there may be disagreements and discord, but also moments of synchrony and bliss. The union of differences conjures a dynamic hybridity, such as the inclusion of Polonius' bumbling balderdash or Rosencrantz and Guildenstern's comic incompetence in a solemn tragedy about a grieving prince who must decide whether to avenge his father's fratricide murder or to protect his own mortal soul. The clash of contrasts portrays a more authentic reality, with its imperfect incongruities, tempering the affects of the audience.

Another text that exemplifies this duality is Cervantes' *Don Quixote* (Bakhtin, 1984). Sancho Panza's short corpulence and stark descriptions of his bodily functions personify the spirit of Carnival, a connection further emphasized by his contrast with the exacerbated nobility of Don Quixote, who has the polar opposite appearance, being tall and lanky. Their escapades reflect the complexities of realism, where the façade of fantasy is tempered with the whims of the mundane. This ulterior world of the reader who can judge and deconstruct the world of the book, which is beset by many dimensions, both narratively and character-wise, is thanks to such Carnavalesque craft.

When students are made aware of these literary effects, or better yet, if they discovered these elements of craft on their own, their recognition incites genuine learning, spawning a web of neuronal connections

and protein syntheses across their brain, innervating language regions (e.g., Wernicke's region, Broca's region, the angular gyrus, insular cortex) and the hippocampus, which is responsible for learning and memory. Thus, there are physical changes spurred by mental processes, as neurotransmitters and sodium and potassium channels activate across the brain spurred by thinking and learning. When learning is scaffolded effectively, branches of neurons form completed thought pathways, and new learning is fitted into existing schemas to author novel insights.

Discussion

Internal Thresholds

These moments of threshold, full of tension, even relates to historical seasonal times of the year. Just as Carnival welcomed the beginning of Lent in the Christian calendar, the time between the two events was also a dialogue of the threshold, as people from all walks of life met in the town square still dressed in costumes and donning masks while others cleared away the debris from the celebrations preparing for their somber pious ritual (Insert Figure 1). At this tension between the austerity of Lent and the hedonism of Carnival is a threshold of states of mind, where two diametrically opposed conditions face each other. At these threshold spaces, there is dialogic innervation of the old with the new, yesterday with tomorrow, in an incongruous unstable present.

A person who just experienced the corporeal and cathartic ritual of Carnival, must now enter the restrictive and austere moment of Lent, a polar opposite condition. During these days, in the debris of the upheaval, there are still signs of the ruckus as harbinger to the temperance of Lent. The mood swing from elation to solemnity is almost analogous to an antithetical change from a manic state to a depressive state. In these in-between spaces, like waking up from a wild drunken party, the residual alcohol clinging to your palette, the body aches all felt in unison, your mind shifts to the sober week of work or school ahead. This tension, when one foot is still in one place, and the other is somewhere completely new, is hybridity.

In psychology, this shift in mood is reminiscent to bipolar disorder, where manic episodes may be followed by a depressive bout (Nutt, 2008). High levels of norepinephrine may instigate the manic state, while lower levels of serotonin may compel the depressive state. So, the chemical imbalances in the prefrontal cortex, grey matter, and the hippocampus regions of the brain induce shifts in mood. Chemical molecules, or physical matter, create wildly different internal states, or immaterial states of being. Thus, this paper then also considers the threshold between mind and body, between the internal world and the external manifestation. Such is the same Cartesian enigma that has perplexed humanity for ages.

When Rene Descartes wrote *Les Passions de l'âme* or *The Passions of the Soul* in 1649, he penned a treatise on how the mind, or in his words, the soul, and the body coordinated and conjoined through the pineal gland (Lokhorst, 2005). Modern science has indicated that this physical organ in the midbrain between the two hemispheres in the epithalamus affects the body through the secretion of chemical compounds. The physiological functions of this gland is the secretion of melatonin and the production of sex hormones, influencing our sleep-wake cycles and sexual urges. So, perhaps the pineal gland is a gateway between the mind and the body, as with the other components of our endocrine system.

With respects to education, when the physical material world is described with words as ink on a page, and the mind transacts with those words, the reader conjures similar notions in his or her brain. This conjoining of the internal with the external, the gateway to our internal ruminations induces meaning and personal understanding. Our inner world consists of thoughts and emotions, which can in turn manifest physically as actions, such as behavior, language, or manifesting affect. But, at the threshold of the internal and external worlds, at the event horizon between the two sides of reality, exists a combustible space, saturated with potential energy.

Just as the threshold between Carnival and Lent, like the emergence of dawn's yolk breaking the nadir darkness of night, the dawning of a new age still carries vestiges of the old. In the hybridized, multivoiced middle, new ideas and insights can be gleaned to afford important advancements. Possibilities straddle differences, so that the potential for creativity is magnified. It is in this in-between state, not fully one way or the other, that the tense reverberation of novelty is incited. In this tense discomfort, one can reflect on the past and anticipate the future, as old thoughts and ideas combine with new ones, which are folded into existing schemas for compartmentalizing knowledge, changing them while being changed through accommodation and assimilation (Piaget, 1976).

At the level of the brain, this push and pull of ideas may mirror a similar mutual change at the neuronal level, as some pathways veer to new directions with the new connection forged between brain cells, or the new connection may be assimilated to the existing pathway extending its axonal fibers along the established pathway. Either condition may then influence the individual's thoughts, those ignited in the cerebral cortex, as well as spur emotions from the amygdala and limbic centers, as well as the hippocampus and hypothalamus. Here, there is an additional threshold between our thoughts and emotions, forces emanating from discrete places in our brain.

I believe the mind and body, thoughts and actions, exist in a duality, which may be why I am partial to cognitive behavioral therapy, like REBT (rational emotive behavioral therapy), which targets both the irrational thinking *and* those deleterious actions of patients (Ellis, 1995). I believe such therapy targets precisely the often-dichotomous criteria of thinking with action, our mind with what that mind commands in the physical world, even if subconsciously. This internal turmoil in the crevice of the tangible and the intangible is rife for awareness and growth. This sort of reciprocity is also evident in the therapeutic relationship with the dynamics of transference, or when the client projects expectations onto the counselor, and countertransference, or when the counselor is impacted by feelings about or towards the client (Racker, 2018).

When we learn new knowledge, especially ones that incite a paradigm shift in our minds, the distance between ourselves and our world restricts, as we are closer to understanding the essence of existence. Meaning and understanding is in this choreographed synchrony, of neurons bridging disparate pathways, scaffolding new learning atop existing ones already in one's long-term memory. In this tethered connection, insight, novelty, and ingenuity are bred, because disparate facets of one's mind are enkindled forming a new hybrid thought.

Thus, just as language evolves and progresses through hybridity and confluence of differences, just as genes do the same for the diversity of species, our ideas also embellish with hybrid influences. When thoughts are co-constructed with a slew of synaptic pathways, diverse strands of knowledge mesh and synthesize together. For example, in this paper, my understanding of literacy and literature intersect with my knowledge of history, psychology, and neuroscience. I have deconstructed my own path to understanding by breaking apart the distinct components of my understanding and described how they come together to graft together a synthesis of knowledge. Amid these internal, mental boundaries, there is enlightenment from their symbiosis.

It is precisely these realizations about how we think and remember, these metacognitive ruminations forging new conjectures adding to human knowledge, that makes us understand and tinker with the actual process of learning and memory. This internal epiphany then will set off a series of other neuronal chains that compel our actions to better our understanding of our world. Pedagogically, this line of reasoning implies teachers should be open to diverse responses to their instruction, to allow students' contentions of their instruction to be multiple and encourage a diversity not only of modes and media of expression, but also varying personal understandings of taught components. Just as every book may mean different things depending on the reader (Rosenblatt, 1994), every instruction will be interpreted and understood differently depending on the student.

Implications for Education

Given the benefits of multiple neuronal innervations for learning and memory (Raman & O’Leary, 2021), effective instruction needs to approach from multiple distinct directions of knowing. When we teach ideas using multiple disciplines, we enhance how we teach and how students learn. In my own instruction, particularly for an Integrated Curriculums course I taught at a university in Georgia, I have had to demonstrate how instruction can be effectively delivered via multiple disciplines.

For instance, I once taught my students about the instruction of fractions and ratios, which superficially appears solely a mathematical discipline. Yet, I also demonstrated how I can also teach science, as in balancing chemical equations and finding out ratios of compounds to be combined to produce a solution, as well as musical instruction with half notes, quarter notes, and eighth notes, etc. My students also noted how the time signature was also expressed as a fraction, with the numerator representing the number of beats per measure and the denominator being the type of note per beat (e.g., 4 for quarter note, 8 for eighth note).

Thus, the instruction of this one mathematical notion of fractions, for which we also integrated ELA through word problems, used so many other disciplines. In such a way, mathematical learning was infused with language arts learning, science learning, and musical learning. Neuronally, disparate regions of the brain, ones that participated in the learning and memory, as well as storage, of musical learning, ones for scientific learning, and those for language arts learning, all were accessed for the learning of fractions.

Learning fractions was not an isolated event, but one that conjoined disparate know-hows. Additionally, if the teacher used manipulatives or had students perform demonstrations of fractions either with mixing compounds or participating in movement, there would be muscle memory along with episodic memory of doing things. This is also the benefit of fieldtrips for children, when they can conjoin semantic learning with episodic experiences, and integrate separate mental dimensions in the service of understanding. When all these disparate disciplines, stored in separate places in different collections of neurons in the brain, come together to integrate and synthesize new understanding, that new learning is colored by a multiplicity in conceiving of the phenomenon.

Additionally, even beyond the multimodality for learning, individual differences in students are celebrated and contribute to education. I have had preservice teachers in my courses compose paintings as tribute to their learning that semester, build models of houses, compose original songs and play them on a guitar they brought with them to class, as well as sing their own songs, or dance their self-choreographed interpretive dance. Learning was tied to their own interests, their own strengths, so what we were learning as a class intersected with what they were familiar with or were especially talented at performing.

In such a way, new neural connections could be connected with established ones, those pathway and connections formed from years of practice and repeated ruminations. Perhaps, in this way, the new learning could even be more meaningful as they are paired with what students already enjoyed, almost like pairing a conditioned stimulus with an unconditioned one in behavioral psychology. Also, by connecting new learning with a previously mastered concept or skill, those appetitive feeling associated with the extant knowledge can transfer to the new learning as well, as areas responsible for emotions are activated with the new learning.

Diversity, difference, and multiplicity need not be avoided, but celebrated and creatively bonded in heteroglossic union. When we acquire new knowledge from diverse modalities and media, we provide differentiated and more accurate accommodations for students to receive education as well as showcase their learning (New London Group, 1996). Neuroscientifically, different regions of the brain are activated to conceive and learn about a new phenomenon, thereby intersecting the different

pathways to converge on one new area of learning. Meaning is abetted by the cross-referencing and the dual confirmation of an insight from distinct disciplines or arenas.

When we learn about fractions by not only activating our math region of the brain, but also the scientific, the musical, and the linguistic regions, multiple regions of the brain coordinate learning together. Our understanding of other notions, like *harmony* or *balance*, can intersect many corridors of learning, from language arts to science to math to music to social studies to art. There is something unifying and holistic, almost like Gestalt psychology' veneration of the whole for human perception or understanding (Perls, 1951). Beyond the myriad of components of oneself or one's problems, taking the metaperspective, can be a therapeutic experience in its inspiration of awareness.

The internal learning is achieved through coalescing external knowledge about the physical world. We learn a new notion by piecing together other disjunctive components. When input is multiple and scaffolded, learning becomes a synergetic experience that innervates a multiplicity, reflecting the complexities and heteroglossia of real life.

Conclusion

As teachers and administrators, we work daily amid these thresholds, as we thrive in these complex spaces in the classroom, bring them home when we read students' work, or create digital thresholds in our online instruction. I have found these spaces to be so exciting, full of the possibilities nestled amidst differences, that I can feel the energy invoked in the tension, like the strain between a proton and an electron, where unfathomable energy resides.



Figure 1: The Fight Between Carnival and Lent from:
https://www.thinkingfaith.org/articles/20140303_1.htm.

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Biographical notes:

Xiaodi Zhou received his bachelor's degree in psychology and master's degree in counseling from the University of Florida. He attained his PhD in English Education from the University of Georgia. His research is in the literacy behaviors of nonwhite children in the US, and how dialogic theory relates to those literacy endeavors, as well as the reciprocal relationship with their cultural identities. He currently is an Assistant Professor of Literacy Studies at the University of Texas Rio Grande Valley.