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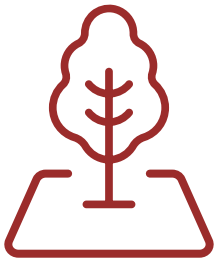

Land Acknowledgment

The editorial team of *SUURJ* acknowledges that Seattle University is located on the homelands of the Coast Salish peoples. We believe it is important to understand our place within the history of the land where we reside and to be aware of our participation in the occupation of this land. With this in mind, we share two examples of land acknowledgments from our own campus community, but we would also like to stress the importance of going beyond land recognition to stand in solidarity with Indigenous peoples to sustain their treaty rights, languages, and cultural traditions.

> We respectfully acknowledge that Seattle University occupies the homelands of the Coast Salish peoples "who continue to steward these lands and waters as they have since time immemorial. We recognize tribal nations and organizations who actively create, shape, and contribute to our thriving community at Seattle University and beyond. We, as an academic community, should be and are committed to doing our part to engage with and amplify the voices of Native peoples and tribes. We acknowledge our collective responsibility to advance proper education of Native peoples and tribes and call for further learning and action to support the Native people of this land."
>
> **– Seattle University Native American Law Student Association**

> We pay respect to Coast Salish Elders past and present and extend that respect to their descendants and to all Indigenous people. To acknowledge this land is to recognize the history of physical and cultural genocide and settler colonialism, which continues to displace Indigenous people today. It is to also recognize these lands, waters, and their significance for the resilient and wise peoples who continue to thrive in this region despite the consequences of displacement and broken treaties.
>
> **– Seattle University Indigenous Peoples Institute**

We believe it is up to each of us to actively resist the erasure of Indigenous people; whether it's through signing petitions to support federal recognition of treaty rights, donating our time or resources to First Peoples, or advocating for Indigenous rights through our elected leaders (to name a few actions), we all have work to do.

We call upon readers to learn more about the land they inhabit here: https://native-land.ca/

Additional Resources and Scholarship

Resources

Native Governance Center, "Beyond Land Acknowledgment: A Guide": https://nativegov.org/news/beyond-land-acknowledgment-guide/

Seattle University Indigenous Peoples Institute: https://www.seattleu.edu/indigenous-peoples-institute/resources/

Seattle University School of Law's Center for Indian Law and Policy: https://law.seattleu.edu/centers-and-institutes/center-for-indian-law-and-policy/ community-work/resources/

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Welcome to *SUURJ*

Welcome to Volume 7 of the *Seattle University Undergraduate Research Journal* (*SUURJ*). As a team, we are immensely grateful to have had the opportunity to grow professionally alongside one another, our faculty advisors, and this year's talented group of student authors. We feel honored to continue Seattle University's legacy of publication, giving new life and a global platform to undergraduate achievements whose merits may otherwise go unacknowledged. From civic science to poetry, this volume highlights a wide range of scholarship. Our authors have created a guide for urban campus native bee conservation, investigated potential alternatives to restrictive education policies in Florida, proposed equitable approaches to mental health crises without the use of police officers, prompted us to reconsider the philosophy of science, and reevaluated the function of stem cells in breast reconstruction.

We have chosen to publish work that engages with themes of sustainability, innovation, accessibility, inclusivity, and reformation in hopes of fostering a more just and humane future. Our thorough deliberations have ensured that each paper in Volume 7 speaks to these values in its own unique way. At a time when social adversity feels insurmountable, this year's journal is a testament to our collective resilience. We would like to thank each of our authors for facing the future with innovative resolve and you, our reader, for being a part of the conversation.

Many thanks,
The *SUURJ* Volume 7 Student Editorial Team

Core and University Honors Writing

The Seattle University Core curriculum emphasizes seminar-style classes, research-based inquiry, and revision-based writing practices. Core courses are often interdisciplinary, and they engage in assignments that are less-traditionally contoured than research projects in the majors. This Core curriculum, rooted in the principles and traditions of Jesuit education, sets Seattle University apart from other institutions of higher learning. Our University Honors program is an interdisciplinary set of academically rigorous courses for highly motivated students that places a strong emphasis on writing as a process, as students peer review and edit to produce scholarly work. Both programs begin in the freshman year, so including Core and University Honors writing in *SUURJ* allows us to celebrate writing at all stages of students' undergraduate careers.

The Value of the Nazîre: Comparing the Poems of Nejâtî and Bâkî in the Tradition of Ottoman Lyric Poetry

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Abstract

The main genre in the Ottoman literary tradition was lyric poetry, and the gazel was the most popular form (Andrews et al. 8). The gazel, like other traditions of lyric poetry, is a brief form of poetry (usually five to seven lines) that usually focuses on the speaker's personal emotions that are directed towards a beloved (Andrews et al., 8). By comparing two gazels written by the poets Nejâtî and Bâkî, this paper examines the poetic parallel (nazîre) as a literary form that is crucial to understanding the intertextual meaning embedded in the Ottoman literary tradition. This paper demonstrates how the transmitted tropes that characterize the Ottoman literary tradition as reactionary are best understood by analyzing the poems as connected pieces rather than separate entities. The poets who participated in this tradition utilized or alluded to the motifs and images present in the works of other writers to highlight the complexity of the lover's experience in a new way through the nazîre. This phenomenon established a unique characteristic in the Ottoman literary tradition: the simultaneous presence of admiration and competition. In his poem, Nejâtî often uses spinning or circular language in order to exemplify the confusion that the speaker experiences. Similarly, Bâkî parallels Nejâtî's early poem in a nazîre that uses tangible, circular imagery, such as a Ferris wheel, in order to display the lover's inner conflict in a new way. Both Nejâtî and Bâkî present dichotomous sensations that compliment each other in their poems in order to display a complex conception of love in each poem where passion and pain can be simultaneously experienced.

Introduction

Ottoman lyric poetry, a literary tradition that defies historical periodization labels given its expansive existence and complex development, lacks the examination in the literary studies field that it deserves (Andrews et al. 22). According to Walter G. Andrews, Najaat Black, and Mehmet Kalpakli in *Ottoman Lyric Poetry*: An Anthology, in which the poems discussed in this paper are collected, the Ottoman literary tradition is so infrequently represented in collections "of 'world' literature or culture or civilization that it might as well be invisible" (3). Andrews, the main editor of this anthology (which is the first and only Ottoman lyric poetry anthology in English) writes in his introductory essay that he "know[s] of no one who argues seriously that Ottoman Turkish poetry is not a neglected literary phenomenon" (3). Andrews also describes how in the West, poetry is a "peripheral art," but in Ottoman culture, "it was the central literary activity without rival or peer" (4). Thus, it is important to illuminate the valuable literary depth that exists in Ottoman lyric poetry as a central element of Ottoman culture. While Ottoman lyric poetry is often characterized by rhetorical situations that describe love and the relationship between the lover and the beloved, this literary tradition also utilizes unique tropes and images that invite an examination of how cultural context unveils literary meaning. For example, the sultans, intellectual developments, and social context that these poets engaged with were embedded in the poetry they produced. The "nazîre," or poetic parallel, is a common technique in Ottoman lyric poetry in which an author imitates and utilizes imagery and techniques that a contemporary or past author used in another piece (129). As Andrews and Kalpakli note in The Age of the Beloveds, nazîres "use the rhythm pattern, rhyme scheme, and key vocabulary of another poem" to amplify or modify the original poet's techniques in order to create their own poem (92). One notable nazîre written by Bâkî (b. 1526) parallels an earlier gazel produced by Nejâtî (d. 1509) (Andrews et al. 218, 239). In his nazîre, Bâkî takes Nejâtî's flaming and circular imagery, and repurposes it to align with the tangible urban imagery he witnesses in order to enhance the appealing illustration of the lover's turmoil. In this paper, I will examine these two poems to highlight the intertextuality and metaphorical connections in Ottoman lyric poetry. Through consideration of the poetic parallel, I will argue that the nazîre is a vital means of witnessing the transmission of themes and intertextual meaning in the Ottoman literary tradition.

"Sparks from My Heart Rise:" Bâkî's Parallel of Nejâtî in the Nazîre

Walter Feldman's essay, "Imitatio in Ottoman Poetry: Three Ghazals of the Mid-Seventeenth Century," discusses the nazîre as a form that spans throughout the Ottoman literary tradition and states, "Ottoman poems have almost always been discussed as individual items" (Feldman 42). In this paper, I hope to enhance discussions of Ottoman lyric poetry by emphasizing the value that comes with examining these two poems by Nejâtî and Bâkî jointly, rather than as individual entities. The most appropriate method of discussing the poems comparatively, rather than separately, is through the examination of the nazîre because the nazîre's direct references to the other poem makes the two poems inseparable. This goal of joint analysis is also supported by Feldman, who claims that nazîres have to be taken into account in the study of Ottoman lyric poetry in order "to determine whether there were 'seams' within the Ottoman literary tradition" and to examine how the poets "relied on or challenged earlier or contemporary poets" (43). The nazîre is a complex poetic form due to the possibility of an author challenging the other poet, admiring the poet, or expressing both motivations simultaneously. This complex form creates an inherent connection between two writers, and, more importantly, two pieces of literary art. As Alena Catovic explains in her essay, "The Rhetoric of Space in *Ottoman Lyric Poetry*," what makes the nazîre unique is that an "aesthetic of resemblance" is infused throughout the Ottoman literary tradition, allowing for "common characteristics" between many different poems to be understood and reproduced (87). Catovic notes that some of these characteristics include "the distance that separates the lover and beloved" and "the contrast between them in terms of superiority and inferiority" (88). This aesthetic of resemblance is similarly discussed in *Ottoman Lyric Poetry*, as the editors note that in the Ottoman literary tradition, poets "render common themes in unique and original ways" (Andrews et al. 8). This tradition's aesthetic of resemblance that makes the nazîre unique in comparison to other poetic parallels can be witnessed in Bâkî's nazîre "Sparks from my heart," which alludes to Nejâtî's poem "Spiraling, the sparks."

The main rhetorical situations are quite similar in both poems. The speaker—the lover, in this case— is solitarily lamenting their distant beloved and expressing an internal conflict or confusion that could have several implications: the speaker may be longing to be with their beloved, there may be an obstacle that is hindering their love, such as social positionality or distance, or the lover's affection may be unrequited. Thematically and emotionally, Nejâtî's poem expresses the submission of the lover to the beloved and the intense impact that the beloved has on the lover's thoughts, while Bâkî's nazîre reflects the lover's restlessness, pain, disappointment, and sorrow.

The first stanzas of both poems showcase similar images that depict the experience of the lover. Nejâtî begins his poem by claiming, "spiraling, the sparks / of my sigh / reach the skies" (43). Nejâtî begins with an image of a confused lover, looking up towards the sky. Similarly, Bâkî begins his poem with the line, "sparks from my heart rise / to the heavens turning" (97). The image of "sparks," either from the lover's sigh or heart, portrays the intense passion of the lover. Interestingly, Bâkî's choice of the word "heart" connotes the passion of love, and this passion is intensified by the use of the word "turning," which places the lover in a state of internal conflict or confusion. Nejâtî uses this twisting and turning language much more than Bâkî does, as it is included in the first five stanzas of Nejâtî's poem (Nejâtî 43). Thus, confusion and conflict are not just connoted in Nejâtî's poem but are central to the speaker's physical experiences. On the other hand, Bâkî still explicitly uses words like "turning," but he uses them less frequently throughout his poem. Rather, it is evident that Bâkî is inspired by the dominant presence of this twisting language in Nejâtî's piece and that Bâkî decides to express this swirling sensation through tangible images instead of linguistic repetition. This allows for Bâkî's poem to become more representative of the urban environment he is observing as opposed to Nejâtî's reliance on abstract imagery, linguistic repetition, and traditional images like "the curl" of the beloved's hair (Nejâtî 43).

While both poets continue constructing a nuanced depiction of the lover's passion, Bâkî's poem takes a sorrowful turn that is not evident in Nejâtî's piece. Nejâtî mainly focuses on the lover's constant reflection on the beloved and their longing to be with the beloved (Nejâtî 43-44). There is not an emphasis on sadness in Nejâtî's poem. On the other hand, Bâkî's poem shifts in tone quickly, beginning in the first stanza when he states that while the sparks "rise / to the heavens," the lover's "tears pour, spinning, / to the earth" (Bâkî 97). Bâkî creates a unique image that challenges dichotomy in two ways. First, he presents love and sadness—two things that generally oppose each other—as emotions that are experienced simultaneously by the lover. Second, he presents these emotions as "ris[ing] / to the heavens" and "spinning, / to the earth," which pushes the lover's emotions into two different directions simultaneously. Both poems take dichotomous images, such as love and sorrow or rising and falling, that would normally be considered separate experiences, and present them as simultaneous experiences in order to illustrate a complex conception of love.

The sorrowful tone created in the opening stanza of Bâkî's nazîre transitions into one of suffering in the next stanza, as he writes, "the heart / of the disappointed lover burns / turning, turning, like a magic lantern" (Bâkî 97). Again, Bâkî places dichotomous experiences—passionate love and painful suffering—in a simultaneous sensory experience. The word "turning" is used again to describe the "disappointed lover," further amplifying the lover's confused internal state. Similar to how Bâkî uses a simile to compare the disappointed lover to a burning magic lantern, Nejâtî refers to a "lamp / of the heavens" that "burns,

turning" (Nejâtî 43). Nejâtî continues his discussion of confusion with the inclusion of the word "turning" but also simultaneously introduces an image of a burning lamp that exists in the heavens, to where his sighs are directed. Bâkî relies on this image created by Nejâtî when introducing his own complex presentation of the lover's experience.

While it is evident that Bâkî relied on and admired Nejâtî's opening image of the lover sighing to the heavens with a burning heart, the rest of his poem uses original urban imagery that is not used in Nejâtî's piece, while still paralleling Nejâtî's circular and twisting language. For example, Bâkî renders an image of a "ferris-wheel weeping / spinning" and "the jeweler's wheel" that is "spinning / these pearls, these jewels," which "are Bâkî's tears" (Bâkî 97). The imagery in his poetic parallel is rooted in tangible buildings or objects, such as a Ferris wheel and a jeweler's wheel, which contrasts with Nejâtî's less physical imagery. Rather, Nejâtî illustrates the lover as someone who "surrenders his life / twisting, / twirling," the "pigeon returning / circles," and the "holy pilgrims" who "circle" around the "Kaaba" (43). Nejâtî's strategy with these depictions is to repeat circular imagery, such as "spinning," "twisting," and "twirling," in order to connote the confusion and inner conflict of the lover (43-44). Nejâtî does not rely on the description of confusion or conflict through emotional language, but, instead, he depicts the lover twirling after surrendering their life, a pigeon circling in flight, and pilgrims circling around the Kaaba. Nejâtî's imagery is less rooted in the urban environment like Bâkî's and is instead rooted in more abstract, religious, and natural imagery.

Bâkî is interested in taking the twisting and circular imagery in Nejâtî's poem and repurposing it into tangible, urban images that are inherently circular, such as the Ferris wheel. When examining the imagery used by both authors, Feldman's earlier statement about the possibility of both admiration and challenge in the nazîre is illuminated (Feldman 43). In this case, Bâkî admires the circular and twisting imagery that symbolizes the internal conflict of the lover in Nejâtî's poem, but Bâkî amplifies what Nejâtî does by including objects that are readily imaginable in his contemporary environment and inherently circular. This contrasts with Nejâtî, who uses words such as "twirling" and "turning" to apply them to subjects such as the lover, pigeons, and pilgrims that are not circular on their own (43).

This competitiveness is supported by scholarly commentary, such as in Andrews and Mehmet's book, where they note how the form of the nazîre was practiced "competitively" (Andrews and Mehmet 92). The competition present in this intertextuality fully has to do with poetic skill, rather than actual competition against each other for a beloved, because Nejâtî died before Bâkî was born. Yet, in the wider context of the nazîre form, Andrews and Mehmet note that the nazîre was often the form that a poet would use to directly compete with another poet for the attention of a beloved, as they would "[hunt] beloveds with gazels" (92). This type of direct competition is not the case in Bâkî's nazîre that responds to Nejâtî's earlier gazel, but this scholarly commentary does illuminate the practical and social scope of the nazîre as a literary form.

While it is apparent that both poets used contrasting imagery in their own poems, there are several specific instances where Bâkî uses similar imagery to Nejâtî. For example, Nejâtî refers to the beloved as having a "silver breast" and Bâkî describes the beloved as the "silver-breasted one" (Nejâtî 44, Bâkî 97). Nejâtî refers to the natural world extensively throughout his poem, such as when he references the "sun and moon" and the "pigeon" (Nejâtî 43). Bâkî is similarly inspired by the natural world in his nazîre, which can be seen in his description of "the eyes of the stars," or in his illustration of the moth and the flame (Bâkî 97). Both poets use natural imagery to display the complexity of the lover and beloved's relationship.

Nejâtî and Bâkî render complex images that would otherwise be considered dichotomous and express them as simultaneous experiences. Delight and death would usually be seen as dichotomous, yet, in his poem, Nejâtî writes, "with delight / he surrenders his life" (Nejâtî 43). This is another common technique that Bâkî admired in Nejâtî's poem. For example, Bâkî uses phrases such as "the grief of loving" and personifies a "weeping" Ferris wheel (Bâkî 97). Bâkî uses the image of a Ferris wheel that is typically found at a celebratory or joyful event, but he compares the sound that the Ferris wheel emits to crying. With "the grief of lov[e]," Bâkî characterizes love as being connected to desolate grief. These two descriptions highlight how this strategy of using sensations or experiences that are commonly seen as dichotomous and presenting them as simultaneous experiences ultimately contributes to an emotionally complex presentation of experiencing love.

Bâkî's choice to amplify imagery and language in Nejâtî's poem leads to simultaneous competition and admiration between them. For example, in the beginning of Nejâtî's poem, he refers to the "burn[ing]" and "turning" "heart of the lamp" (Nejâtî 43). Bâkî admires Nejâtî's introductory image of the burning lamp, which can be seen in the way Bâkî extends the image of fire throughout his poem, unlike Nejâtî. After Nejâtî refers to this image of the burning lamp, there is no further reference to a flame or burning sensation in his poem. On the other hand, Bâkî notices the image of burning and extends this imagery throughout his poem. This can be seen in several instances, such as when Bâkî refers to the "fire of your love," the "candle of your cheek," and the moth that "burns wing and feather / in the flame" (Bâkî 97). Bâkî's nazîre is exemplary because the reader witnesses his admiration of Nejâtî's poem and the reader is also able to see the ways in which he highlights and amplifies extended metaphors in Nejâtî's poem, like the circle and the fire. Bâkî adds additional complexity to the tone that already exists in Nejâtî's poem. While Nejâtî generally focuses on the passion of the lover and the contradictions that come with the lover's intoxicating love, evidenced in his reference to a "delight" in death and the "sigh" of the lover, Bâkî focuses on the lover's sadness in particular (Nejâtî 43). While this tone of sadness can be seen through the "tears" that pour to the earth in Bâkî's introductory image and his inclusion of phrases such as a "whirlpool of tears," the lover who "lament[s] until the dawn," and the "weeping eye," the differences in the poems' tones can best be witnessed in the final stanzas (Bâkî 97).

Bâkî ends his poem with an image of the lover's own tears, which are represented by the products of the jeweler's wheel he references at the beginning of the final stanza: "these pearls, these jewels, are Bâkî's tears" (97). This can be interpreted as the tears being the poem itself when considering Bâkî's reference to "these jewels" being his own tears. At the end of his poem, Bâkî again relies on a tangible image found in urban settings to reflect the confusion and inner conflict of the lover, expressed through circular and twisting language. On the other hand, Nejâtî concludes his poem with a scene of a "royal party":

> [A]t this royal party
> it would be pleasing
> for the musician to dance,
> before the Sultan,
> before the beloved . . . (44)

The majority of Ottoman gazels conclude with the poet referencing themselves by their pennames (Andrews et al. 8). With this traditional technique, the poets are inserting themselves into the story, associating themselves with the rhetorical situation, and emphasizing the closing stanza. While Bâkî is inserting himself into a sorrowful rhetorical situation in which each word of the poem is one of his tears, Nejâtî associates himself with the festive and passionate mood of the party, and the royal party itself. This is significant because it invites a discussion of reputation due to the royal party's connection with the Sultan, whom Nejâtî addresses directly in his poem when he states "it would be pleasing" to be "before the Sultan" at this royal party (44).

Cultural context contributes to the intertextual meaning of these poems. In nineteenth-century critic E.J.W. Gibb's chapter on Nejâtî in his book A History of *Ottoman Lyric Poetry*, he notes that even though Nejâtî was born as a non-Ottoman slave whose master adopted and educated him, Nejâtî was recognized in society as an Ottoman (Gibb 94). After becoming a skilled poet and celebrating "the accession of Bâyezîd II," Nejâtî was appointed as "Secretary of Divan" (a "title of the official secretary of a vezir or other high functionairy" [96n2]) in the service of Sultan Bâyezîd II's eldest son, Prince Abdullâh (96). Yet, after completing this period of service, establishing influential friendships with other accomplished poets like Mu'eyyed-zâde, and serving another one of Sultan Bâyezîd's sons, "we lose all sight of Nejâtî" after he "[falls] into poverty" (96). However, the editors of *Ottoman Lyric Poetry* demonstrate more about the history of Nejâtî to suggest that there is more to the story than what Gibb describes in his 1900 account (Andrews et al. 218). After concluding his courtly positions, Nejâtî retired to Istanbul where he was granted a pension, lived with a pupil named Sehî who became "the first Ottoman biographer of poets," and, at the end of his life, presented a gazel to "all his dearest friends," saying, "this is my farewell to you and to poetry" (218). Nejâtî certainly had an accomplished career, affirmed by Gibb identifying him as "the first

lyric poet of real distinction to appear among the Ottoman Turks" (Brown and Gibb 93). This status is interesting because the editors of *Ottoman Lyric Poetry* note how Nejâtî "attracted the attention of important patrons," especially considering his early start in presenting poems to Sultan Mehmed II, who preceded Sultan Bâyezîd II (Andrews et al. 218). Yet, Nejâtî cannot be compared to Bâkî, who the editors of *Ottoman Lyric Poetry* note is "considered by many to be the best of all Ottoman poets" and who was appointed to a few of the highest courtly roles such as "the military judgeships of the Eastern (Anatolian) and Western (Rumelian/European) provinces" (240-241). Sultan Süleymân, who was deeply connected to Bâkî, included Bâkî in his "intellectual and conversational circle," which identified him as the "supreme poet of the age" (240). Bâkî ultimately ended his life in sickness and anger about not attaining "the highest judicial position in the land," and he "died in a fit of temper at the clumsiness of a serving girl" (241).

This context compliments the situations expressed by both poets when considering how they discuss royal or hierarchical relationships within their poems. Bâkî had a direct and personal relationship with Sultan Süleyman, which provided him notable political and courtly positions, garnering him respect as a courtly poet (240). On the other hand, Nejâtî's direct royal relationships were confined to serving the sultan's sons (Andrews et al. 218). Thus, by Nejâtî inserting himself into the image of the royal party at the end of his poem, he is associating himself with the sultan. This is a rhetorical choice that Nejâtî is making by inserting his name into a courtly scene – a choice that Bâkî did not necessarily have to make because he was not seeking to be associated with the sultan. Bâkî already was directly connected to royalty. On the other hand, Nejâtî's inclusion of the royal party in the closing setting of his poem allows him to be directly associated with the courtly environment. This context is especially relevant when considering Catovic's notion of hierarchy being embedded in the lover and beloved's relationship in Ottoman lyric poetry (88). This courtly environment and the superiority of poets' reputations based on their relationships with the sultan could be a contextual inspiration for this frequent reference to the courtly environment in the Ottoman literary tradition.

Yet, this reference to the sultan should not be confused with the relationship between the sultan and his subject as a cultural analogy in the poetry. I will separate the two different literary techniques because the sultan-subject analogy is solely used to reference the lover-beloved relationship, in comparison to the reference or inclusion of the sultan in a poem having different meanings depending on the context of the particular poet. This technique of using a sultan-subject analogy is present in Nejâtî's poem when he refers to the beloved-lover relationship:

You rise, you dance
spinning,
I bow my head
I submit. (44)

This submission is a social metaphor that references real social hierarchies, such as the relationship between the slave and the master, or the sultan and the subject. As Matthias Kappler explains in his essay "The Beloved and His Otherness: Reflections on 'Ethnic' and Religious Stereotypes in Ottoman Love Poetry," the beloved is almost always "a cruel tyrant who makes the lover suffer" (Kappler 37). While Kappler notes that interpretations of this hierarchical representation of the lover and the beloved could have a "mystical dimension," the rhetorical technique is mainly rooted in the "rigid texture" of the hierarchical Ottoman court (37). Kappler's statement justifies why a poet like Nejâtî would have referred to this hierarchical relation in his depiction of the lover, as Nejâtî was participating in this hierarchical courtly environment, but definitely not as directly as Bâkî, which may be why Bâkî does not refer to the sultan or the royal party in his poem like Nejâtî does. This phenomenon connects to the argument I align with in this paper, which is that the depiction of love represented in Nejâtî and Bâkî's poetic choices are interconnected with the society that they observed, lived in, and wrote in.

Nejâtî's use of the phrase "I submit" when referring to the lover's submission to the beloved connects to Catovic's idea that a common characteristic in Ottoman lyric poetry is the description of the relationship between the lover and beloved through a hierarchical lens of "superiority and inferiority" (Nejâtî 44; Catovic 88). In Nejâtî's poem, the lover is claiming themselves as inferior and bowing—or submitting—to the superior beloved. Bâkî's poem is similar evidence of this common characteristic of hierarchy being embedded in the relationship between the lover and the beloved, as he refers to the beloved as an "idol" (97). This argument is reinforced by Andrews and Kalpakli, who note that "the gazel is obviously seen as one way for a person with poetic talent to attract a beloved" (92). This demonstrates how the gazel could be used literally in order to attract the beloved, and this can be enhanced even more in the nazîre form where poets are competing for the attraction of the beloved. The lover's conceived inferior status to the beloved is reflected in the lover lamenting and pleading towards the beloved.

Catovic states in her study that the two significant themes of Ottoman lyric poetry are "the distance that separates the lover and the beloved" and "the contrast between them in terms of superiority and inferiority" (88). While I have already discussed the hierarchy between the lover and the beloved, Catovic's notion of the distance between the two is an idea that should be considered when examining this nazîre. In both poems, the lover is described as isolated, and the most evident example of this distance between the lover and the beloved

in Nejâtî's poem is the image of the lover's "hopeful eyes," symbolized as "mirrors," that are "constantly watching the ones / who come and go" (43). Nejâtî depicts a lover who watches the beloved in the distance, hoping for the beloved's attraction or nearness. Bâkî similarly portrays this distance with the image of the lover who, "night after night on the bed of grief," "see[s] no sleep" and "lament[s] until the dawn" (97). The distance between the lover and the beloved is depicted as disappointing and desolate due to the lover's "turning" and "restless[ness]" as they lay alone at night, separated from the beloved and unable to sleep (97). While Bâkî's depiction of the distance between the lover and the beloved is as dejected and hopeless as the rest of his poem's tone, Nejâtî's general description of the lover's passion is reflected in his portrayal of the distance as well. Nejâtî's depiction of the lover's eyes as hopeful and constantly watching illuminates the active and hopeful passion of the lover and contrasts with Bâkî's desolate tone.

A final consideration in this examination of Bâkî's nazîre that reacts to Nejâtî's poem is the significance of gender ambiguity in the Ottoman literary tradition and its presence in these two poems. Andrews and Kalpakli identify the beloved as "androgynous and multiply gendered" and describe how this ambiguity serves as a "vehicle for expressing the desire of men (and women) for a new congruence between sexual desire and intellectual and spiritual companionship" (30). Though, it is important to recognize that this gender ambiguity is not necessarily a literary tool but, rather, an effect of the context of the poem. Gender ambiguity is naturally embedded in the Ottoman literary tradition because Ottoman Turkish does not use gender-specific language or gendered pronouns (Andrews et al. 14). This demonstrates the implications of translation in scholarship and translations of Ottoman lyric poetry in English, which often use binary-gendered pronouns. For example, the editors of *Ottoman Lyric Poetry* claim that they "were required to assign gender to the beloved" for the English translation, so they sometimes represented the beloved "as a woman" when they thought gender ambiguity needed to be avoided (14). It also demonstrates the uniqueness of the nazîre in comparison to other poetic parallels that use gender-specific language, such as poems in English. Aspects of Ottoman lyric poetry simply can not be understood without familiarity with its original language, where gendered language is not used. Yet, gender is not the sole implication of this language difference. Languages communicate entire worldviews and conceived realities, which means that the poem likely takes on a different meaning after translation. This is not to distract from the careful translation in *Ottoman Lyric Poetry*, but to recognize the essentially unavoidable difference in meaning when these poems have been translated.

While gender ambiguity is inherent in the Ottoman Turkish language, analyzing the gender-neutral language is still important. For example, Nejâtî claims:

[T]he black Damascus
of your curl
has destroyed
the Egypt of my heart. (43)

The hair "curl" cannot be applied to a specific gender, and Nejâtî states that this curl of the beloved causes pain to the lover and uses the analogy of Damascus battling with Egypt. This analogy of the beloved's curl as Damascus destroying the lover's heart also connects to Kappler's claim that many Ottoman lyric poems depict the beloved as a destructive figure that causes the lover pain (37). Bâkî still appeals to the circular imagery like Nejâtî but uses a different gender-neutral physical descriptor in his poem to refer to the "Stars / circling the candle of [the beloved's] cheek" (97). This gender ambiguity is interesting when considering that "there is an intellectual, refined, and spiritual component to the love of male beloveds" and that "it is offensive, both socially and legally, to express publicly one's attraction to a woman who is not one's wife" (Andrews and Kalpakli 56, 17). In heterosexual romantic relationships with someone who is not one's spouse, or homosexual romantic relationships, there is a social tension that challenges publicly acceptable forms of attraction. Thus, in the society that Nejâtî and Bâkî are writing in, gender identity and sexuality are intertwined based on the notions of what is socially acceptable. These two poems were not just pieces of literary art that participated in the Ottoman literary tradition, but they were also risks that could have had social and systemic implications due to the courtly roles of Nejâtî and Bâkî.

Conclusion

As stated in the introduction, Ottoman lyric poetry is a literary tradition that defies historical periodization (Andrews et al. 22). The editors of *Ottoman Lyric Poetry* note that E.J.W. Gibb, a previously mentioned nineteenth-century scholar, would often attempt to apply Ottoman political periods, based on sultan rule, to European notions of periodization such as romanticism (22). This insufficiently applies periodization definitions to a complex setting and tradition. This is not to say that there is no traceable development throught this period, as the editors note that after Nejâtî, the tradition began to undergo a "rhetorically powerful" shift, and they claim Bâkî contributed to this shift (22). Yet, the editors argue that this is not necessarily a development of narrowly defined periods but a unique phenomenon of poets "transcend[ing]" and developing a fascinating literary tradition (23). This unique phenomenon of lyric poetry was an essential aspect of Ottoman culture, a culture that Andrews claims was "(arguably the single most significant force) in the politics of East and West" for six centuries (3). It is vital to consider why an extremely impactful element of global history, the Ottoman Empire, has been essentially invisible in literary studies (22).

Examining the characteristics of this poetry begins with recognizing its "aesthetic of resemblance" that allowed for the poets' "transcend[ing]" of languages and techniques to occur (Catovic 87, Andrews et al. 23). The "aesthetic of resemblance" (the presence of common and reproducable characteristics) that permeates throughout the Ottoman literary tradition is most recognizable in the nazîre (Catovic 87). The nazîre written by Bâkî in reaction to Nejâtî's poem highlights the value of examining the poetic parallel. Nejâtî consistently uses circular and twisting language in order to present the confusion and inner conflict the speaker faces. Bâkî is ultimately inspired by this circular language and enhances it in his nazîre by applying to it urban images, such as the weeping sound of a Ferris wheel, in order to present love as linked with violent themes such as suffering and desolation. In the Ottoman literary tradition, poets allude to particular tropes used by past or contemporary poets, such as the sultan-subject relationship or rhetorical choices like Nejâtî's circular and twisting language, and repurpose them in the nazîre. The reactionary element of Ottoman lyric poetry cannot be fully understood without examining poems comparatively through the nazîre form. This reactionary element is one of many unique aspects of this literary tradition, and the editors of *Ottoman Lyric Poetry* note in their anthology that they hope their book is "a beginning" in scholarship on Ottoman lyric poetry (Andrews et al. 23). This literary tradition's value, as evident in this particular examination of these two poems by Nejâtî and Bâkî, can be witnessed in the tradition of the nazîre.

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Inefficacy of the Crisis Intervention Team Model

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Abstract

Following the murder of Joseph Dewayne Robinson in 1987 by Memphis, Tennessee police, community and civil organizers collaborated with the Universities of Memphis and Tennessee and the Memphis Police Department to organize Memphis PD's Crisis Intervention Team (CIT). Similar modes of the CIT model have been deployed nationally as a law enforcement-based crisis intervention strategy aiming to reduce lethality in police response to mental health crises. At least 2,700 communities around the United States utilize CIT methodology to provide mental health education and training for police officers, yet statistical evidence of police-related response, injury, and use of force with individuals experiencing mental illness crises undermines the CIT mission and goals. While systematic analyses of CIT training support officer-level outcomes, national police incident data confirms parallels between use of force and injury and individuals experiencing a mental health crisis. As a nationally deployed and largely unstandardized methodology, the CIT model seeks to reduce the risk of injury or death for people experiencing mental illness during emergency police interactions, yet its objective improvements in arrests, officer and citizen injury, and use of force during de-escalations remain unclear.

Introduction

Memphis, Tennessee police responded to a 911 dispatch from Joseph Dewayne Robinson's mother on September 24th, 1987. She reported that her son, who had a history of mental illness and substance abuse, was using drugs, engaging in self-harm, and threatening others (Rogers et al., 2019, p. 2). According to Memphis police on the scene, Robinson did not respond to their verbal cues and lunged at the officers. The officers proceeded to shoot him multiple times. Joseph Dewayne Robinson died on September 24th. He was 27 years old.

In response to Mr. Robinson's murder, community organizers and civil administrators collaborated with the Universities of Memphis and Tennessee and the Memphis Police Department, organizing Memphis PD's Crisis Intervention Team (CIT). Memphis's CIT model sought to reduce lethality in police responses with those experiencing mental and substance abuse disorders. Over 30 years later, similar modes of the CIT model have been deployed nationally as a law enforcement-based crisis intervention strategy. At least 2,700 communities around the US utilize CIT methodology, affirmed to provide mental health education and training for police officers (National Alliance on Mental Illness, n.d.).

University of Memphis researchers within the School of Urban Affairs and Public Policy, Department of Criminology and Criminal Justice, and CIT Center document the CIT Model's foundations within their 2007 report, "Crisis Intervention Team Core Elements," stating the model's basic goals to "improve officer and consumer safety" and "redirect individuals with mental illness from the judicial system to the healthcare system" (Dupont et al., 2007, p. 3). The report similarly outlines CIT functional roles, training, and curriculum guidelines, stressing the collaborative involvement of external mental health, law enforcement, and social justice advocacy groups in training officers for crisis intervention. Specifically, the sample CIT curriculum encompasses a 40-hour patrol officer training for self-selected officers with lectures, scenario-based and on site de-escalation and mental health training, as well as separate dispatch training (Dupont et al., 2007, p. 14-17). Still, statistical evidence of police-related response, injury, and use of force with individuals experiencing mental illness crises undermines the CIT model mission and goals. Nationally deployed and largely unstandardized, the CIT model seeks to reduce the risk of injury or death for people experiencing mental illness during emergency police interactions, yet its objective improvements in arrests, officer and citizen injury, and use of force during de-escalations are unclear (Rogers et al., 2019).

Counter Arguments

Within longitudinal law enforcement incident studies, the CIT model parallels positive effects on pre-booking jail diversion. One such study analyzed the outcomes of 1,063 incidents involving 180 officers across multiple police departments, with approximately 50% of officers receiving the 40-hour CIT training curriculum. Participating officers demonstrated "increased verbal negotiation" as the highest level of force used during mental health de-escalations; their outcomes also involved higher rates of mental health unit referral and lower rates of arrest (Rogers et al., 2019, p. 5). Despite these positive outcomes, the study found no disparities in use of force between CIT-trained and untrained officers. Without objective evidence of reductions in injury related to CIT training, the incident study fails to affirm CIT efficacy.

When statistically analyzed alongside the "liaison and diversion" and "street triage" interventions within mental health crisis response, the CIT model similarly presents as the best program in reducing re-offending and improving mental health outcomes (Rogers et al., 2019, p. 5). While the "liaison and diversion" approach focuses primarily on diverting individuals to mental health-trained staff, the "street triage" method involves prompt access to mental health services with localized "mobile crisis units" (Rogers et al., 2019, p. 5). Despite their differing interventions and goals, all three programs produce variable positive effects on policing incidents when compared to the untrained control groups within their studies. This study of mental health interventions utilized a screen of 29 databases, allowing researchers to focus their study and narrative synthesis on 23 studies. While researchers found a "positive impact" within the varying interventions, the lack of randomized controlled trials fitting their criteria made further conclusions impossible (Kane et al., 2018). Due to the lack of standardized reporting and measuring tools to assess intervention model efficacy, none of the above models provide objective evidence of improving criminal justice and health outcomes in their specified populations. Without quantitative comparisons demonstrating these outcomes, including reduced arrests and early mental illness identification, the CIT model cannot be accurately assessed as superior to other specialized interventions. Further, the CIT model likely received this positive reputation because it was the only model in the study offering both initial call and response and emergency patient assessments alongside specialized officer and mental health professional intervention (Rogers et al., 2019, p. 6). Within the context of modern police brutality, crisis intervention mechanisms and law enforcement responses must be analyzed longitudinally in their intent, population outreach, and outcomes. Perpetuating positive or ambiguous narratives regarding mental health crisis response overshadows continuous use of force against people experiencing mental health crises.

Systematic analyses of CIT training remain most effective when supporting officer-level outcomes. Qualitative surveys conducted within CIT-trained police bureaus affirm both

officer satisfaction and self-perception of a reduction in use of force. Such surveys reveal that CIT-trained officers perceive themselves as "less likely to escalate to the use of force in a hypothetical mental health crisis encounter" (Rogers et al., 2019, p. 6). Yet, these subjective surveys fall short of evidencing the CIT model success because they bear no greater statistical influence on recorded incidents and outcomes of police de-escalation.

Main Argument

Despite the intentions of the CIT model and its adoption across the country, US police incident data confirms an ugly reality: people with serious mental illnesses constitute a statistically significant percentage of suspects injured in police interaction and involved in use-of-force cases. One study examined a nonrandom sample of nine police departments in moderately sized US cities to understand disparities in experiencing police force and injury for people affected by serious mental illnesses using novel police use of force and suspect injury data from 2011 to 2017. Researchers found that people affected by serious mental illness are 11.6 times more likely to experience police use of force, and 10.7 times more likely to experience police-related injury than those unaffected by mental illness (Laniyonu & Goff, 2021).

While the CIT model sought to improve upon this reality, its implementation continues to elicit underwhelming results. A group of researchers examined the efficacy of the CIT model as implemented by the Portland Police Bureau by utilizing a three-year period of data from 2008 to 2011. 4,211 use-of-force incidents within Portland Police Bureau records revealed that people perceived to have behavioral health disorders are statistically more likely to experience police use of force, despite all responding police engaging in the bureau-wide CIT curriculum (Morabito et al., 2017). Why did the CIT model fail to improve use-of-force outcomes within the Portland Police Bureau? And how are people affected by serious mental illness 10 times more likely to experience this force, despite the rapid uptake of CIT training across the country?

Despite national CIT popularity, larger system and policy-level challenges undermine the model's successful implementation. Insufficient dispatcher training and regulation, inadequate access and availability of psychiatric emergency facilities, and CIT resistance within rural settings are some of the many obstacles presently affecting CIT efficacy throughout the country (Compton et al., 2010). Apart from limited state-wide police forces and their systemic flaws, United States police power resides with individual states.
Testimony recorded in the President's Task Force Report on 21st Century Policing further relayed difficulties with training and equipment for smaller police departments. Small, localized police departments employ the majority of US police officers, and these departments

exhibit limited standardization of protocols and resources. Local municipal boundaries and traditions interfere with the agendas of law enforcement agencies; community outreach to strengthen models like the CIT remains widely overlooked (Rogers et al., 2019, p. 3). The majority of small US police departments seem unable to deploy and operate under a CIT model that aligns with core elements of the Memphis approach, leaving mental health crises de-escalation in the background of policing response.

Meanwhile, both mental health and police militarization stand in the foreground of national politics and culture. Rising police brutality cases throughout the country parallel an increasing demand for universal mental health education and outreach. As these demands go unanswered, individuals affected by serious mental illness live in measurable danger. Regardless of its origins and intentions, the CIT model continues to fail this singular, targeted demographic.

Conclusion

Systematic analyses of the CIT support officer-level outcomes, including officer satisfaction and self-perception of a reduction in use of force. But the CIT model is not intended to appease its police officers. The CIT's foundation seeks to reduce lethality in police response with individuals experiencing mental health crises; the CIT model is meant to protect its citizens (Dupont et al., 2007). On a national level, people affected by serious mental illnesses constitute a statistically significant percentage of suspects both injured in police interaction and involved in use-of-force cases. Police incident data provides evidence suggesting that individuals experiencing severe mental illness are at higher risks for sustaining police-based injury and use of force than people with no perceived mental health disorders. This mixed evidence regarding CIT efficacy inherently concerns the ability of law enforcement to intervene and de-escalate situations involving a mental health crisis.

To see tangible improvements in crisis response, crisis intervention training and reform may take priority in law enforcement and healthcare communities alike. Police officers struggle to serve the individuals of their communities experiencing mental health crises, and use of force and injury statistics bear witness to this struggle. Radical crisis intervention training reform and standardization may address the disparities in police use of force for people experiencing serious mental illness, and training reform necessitates both communal engagement and longitudinal analysis of CIT educational outcomes. Alternative community-based responders can offer collaborative care in crisis intervention and healthcare-oriented insight within educational and training contexts. Responders within emergency response teams, composed of licensed counselors, clinical social workers, physicians, and EMTs, can offer specialized de-escalation with the necessary background in mental health crisis response.

Similarly, 911 diversion programs and mobile crisis teams can offer immediate stabilization, support, and treatment referrals for people in crisis, all without imposing risks of physical force and injury. Publicly advocating for and funding crisis intervention reform can prioritize the safety of individuals in mental health crises.

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Short Communications

This section consists of preliminary data, initial findings, and other brief investigations into any field of inquiry. While there are sometimes contributions in this section that come from the humanities, as an interdisciplinary journal, we want to be mindful of the ways in which science and empirically-based social science writing can differ from humanities and qualitative social science writing. Because publications in the sciences are often multi-authored, in which case student researchers might not be the first authors, we wanted to create a space where our science students' research could still be showcased. Science journals in many disciplines have a section like ours (called variously "short communications," "conversations," or "letters") where authors can publish independent work or roll out individual findings within larger research projects as they emerge. We have developed Short Communications on this model to serve our students in the various science and social science disciplines.

A Spectrum of Scientific Rigor: Reconsidering the Demarcation Problem from a Quinean Lens

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Abstract

The demarcation problem is a central issue in the philosophy of science, concerning what constitutes science itself and what distinguishes legitimate scientific disciplines from pseudoscience, a distinction that often defies straightforward answers. One proposed response to the demarcation problem is falsifiability; that is, if a theory can be falsified given certain observations, rather than adjusting its premises with ad hoc hypotheses, it is scientific in nature. However, in practice, a criterion of falsifiability fails to account for the realities of most scientific disciplines. This paper proposes a series of criteria distinguishing science from nonscience, based in part on several "virtues of hypothesis" proposed by scientific philosopher Willard Van Orman Quine. While a definitive boundary between science and nonscience may never be reached, these criteria are already somewhat inherent to the peer review process for publication of scientific work. They are founded in utility and relevance to scientific progress and provide an initial framework for distinguishing scientific disciplines based on relative rigor and merit.

Introduction

One of the central questions in the philosophy of science is that of the demarcation problem: How can we draw a line in the sand between science and everything else? This question may even be a prerequisite to other branches of the philosophy of science, for how can we discuss the characteristics of science and how it changes without determining what constitutes science in the first place? Some, notably social and political philosopher Karl Popper, have suggested the single criterion of falsifiability as an answer to the demarcation problem (Hansson), which is certainly a tidy solution and one that is likely to satisfy many scientific researchers. Falsifiability seems to easily discredit the fields many scientists would want to consider separate from science, like astrology, faith healing, or the like, deeming inclusion of such things in the scientific canon as demeaning the rigor and reputability of the scientific establishment. However, I will show that falsifiability is an insufficient and misleading principle in distinguishing between science and nonscience. In fact, the failure of falsifiability to accurately represent the true nature and objectives of scientific fields shows that there is no clear and unambiguous demarcation between science and nonscience; rather, scientific rigor can be viewed as existing on a spectrum, at which one end lies science and the other nonscience. This rough delineation can be characterized in part by several pragmatic principles put forth by logician and philosopher Willard Van Orman Quine, who posits that the legitimacy of a field or theory as science is increased by how well it helps us process our own sense experience and make useful predictions about the natural world.

The Demarcation Problem

Popper characterizes the demarcation problem as that of "drawing a line between the statements, or systems of statements, of the empirical sciences, and all other statements—whether they are of a religious or of a metaphysical character." He further describes nonscience as theories that "cannot claim to be backed by empirical evidence in the scientific sense" (Popper 9). Scientists and nonscientists alike may already have some intuitive structure in mind of what constitutes science and what does not. Certainly, popular opinion held by all but the most fringe proponents might call one discipline scientific (broadly, the fields of biology, chemistry, or physics, for example) and another nonscientific (artistic pursuits, religious beliefs, et cetera). Pseudoscience, then, can be seen as a nonscientific field, theory, or discipline masquerading as science, often with an ideological underpinning of some sort or even hints of conspiracy theorism. We might also suggest that science deals with the physical, concrete, or rational, rather than personal agenda or preference. However, such an intuitive understanding of what science is or is not, while perhaps useful in an everyday context, does not provide

a robust logical justification for the legitimacy of some fields and the illegitimacy of others. Looking to history, too, humans are not wholly objective, and what is deemed legitimate by either individuals or by the scientific establishment is often a relic of its time. Therefore, some means of logically evaluating what does and does not constitute science is necessary for both science as a field to progress and to have a sophisticated discussion of the philosophy of science.

Popper's Solution: Falsification

In order to understand why falsification fails as a solution to the demarcation problem, we must first discuss Karl Popper's views on falsification and understand their appeal to many scientists. To Popper, the distinction between science and pseudoscience was in whether a theory could be falsified—that is, whether it is possible to deduce expected observations based on a theory that could then be empirically contradicted (Hansson). Theories should be risky and forbid as many outcomes as possible, which lends to their credibility when tested. If falsified through conflicting observations, a theory is rendered pseudoscientific. Anything that attempts to justify contradictory observations by adding ad hoc, or as needed, assumptions to the original theory should be viewed with a great deal of scrutiny (Popper 8). To many scientists, Popper's view of science is a simple, elegant one, and it neatly excludes theories like astrology, Young Earth Creationism, or Freudian psychoanalysis that, if grouped in with science, might seem to delegitimize the scientific establishment (Thornton). For example, a proponent of astrology might use a person's birth chart to predict their behavior, and if this behavior does not arise, might add any number of ad hoc assumptions, effectively editing their theory in real time to adjust it to new data—perhaps that person's birth time or location is not precisely known, or the subject's moon or ascendant sign traits predominated over their sun sign, et cetera. Alternately, the predictions from such a discipline might be so broad and nonspecific that they could apply to any human behavior or personality. Since there is no observation that would neatly discredit astrology without it being able to be "saved" by ad hoc assumptions or generalities, astrology fails to be falsifiable.

However, falsifiability as a demarcation criterion is out of touch with the realities of scientific investigation, making it significantly flawed for several reasons. First, it is not representative of how real science operates on a day-to-day basis. Scientists frequently obtain measurements or make observations that are contrary to what a theory might suggest; however, it would be considered absurd, even delusional, for a researcher to propose that a well-accepted theory in their field had been falsified due to a set of data inconsistent with that theory. It is far more likely, or at least more readily accepted by the scientific community, that that data was just the result of incorrect technique or faulty instrumentation. Furthermore,

science would fail to advance in any way benefiting society or achieving some practical aim, if all effort was concentrated on refuting or falsifying theories. To overhaul an entire theory the moment a contradiction occurs would be a massive waste of effort, yet this is the manner in which Popper implies science should proceed to avoid ad hoc hypotheses that attempt to save a theory.

Second, any attempt to test a theory comes with a host of other auxiliary assumptions necessary to place observations in context (Godfrey-Smith 57-74). These assumptions may involve other theories that are necessary to put the tested theory in context, or they may consist of the unarticulated assumption that any necessary instrumentation works in the way we expect. No theory, or the expected observations we might deduce from it, exists in a vacuum. Therefore, no observation can be isolated and tested individually. As Quine explains, "our statements about the external world face the tribunal of sense experience not individually but only as a corporate body" ("Main Trends"). A simple, logical argument in the form of modus tollens (i.e., A⊚B, and B is false, meaning that A cannot be true) demonstrates that it is impossible to isolate a faulty premise in a series of linked premises if the conclusion is shown to be false. While a false conclusion may mean the original theory has been falsified, it could also mean that any one of the premises, including any auxiliary assumptions, were false. Therefore, it is rational for scientists to reject the idea of overturning a theory simply because of contradictory observations; with the addition of auxiliary assumptions, it is not deductively invalid to reject an auxiliary assumption (for example, the reliability of the measuring instrument) instead of the central theory.

Finally, concerns about the practicality and logical backing of throwing out a theory notwithstanding, there are scientific theories that have been clearly falsified yet still retain use in scientific disciplines. For example, Newtonian physics has been falsified by both Einsteinian relativity and quantum mechanics, yet basic Newtonian principles are taught to freshman physics students in universities everywhere. Likewise, the Bohr model of the atom is insufficient in how it explains the angular momentum of electrons. In its violation of the uncertainty principle, among several other issues, it has been thoroughly experimentally falsified. The Bohr model is still a staple familiar to every chemistry student at the college level. It is difficult to argue that in teaching these concepts, professors are promoting pseudoscience, in part because they are rarely presented as objective truth, but rather as a set of simplifying assumptions that make science easier to learn and conduct. I would also have difficulty saying that these theories are equivalent to one commonly understood to be pseudoscience, like astrology, or one with a clear ideological underpinning, like Young Earth Creationism: the anti-evolution, fundamentalist Christian belief that the earth is only 6000 years old. The prevalence of these now falsified models in modern science classrooms suggests that there may be theories that have been, in the most literal sense, successfully falsified but

retain great predictive power. This implies that science is not, as Popper might believe, a quest for ultimate truth, but instead a means of best understanding and interpreting the world around us.

Quine's Holism

To evaluate the quality or rigor of a scientific theory, Quine proposes several principles, which he calls "virtues of hypothesis." These are conservatism, generality, simplicity, refutability, and modesty. Later, he suggests a sixth principle, precision (Quine, The Web of Belief 42-66). I would add an additional concept, which overlaps with the previous six, especially precision: demonstrated predictive accuracy. While these principles are hardly the end-all in determining whether a hypothesis is to be considered plausible, they provide a practical starting point in evaluating a theory's functionality. They are not objective, easily quantifiable factors that allow us to cut off or eliminate theories when they don't meet these criteria; in fact, many theories might be lacking in one virtue but offer a compelling case for their own scientific nature due to alignment with others. Several of them are problematic if you subscribe to a view of science that aims for absolute truth, or even one that has the goal of achieving the best possible image of objective reality. Their virtue comes in the form of utility as they help to answer the following questions: Which characteristics of a theory indicate that it is something that will be useful for technological advancement, for making sense of perceptual input, or as a concrete starting point for further scientific research?

The first virtue, conservatism, concerns the degree to which a new theory conflicts with prior accepted ideas. Here, we revisit the first reason that falsifiability fails as a demarcation criterion: Even in the case of apparent falsification, it is impractical and potentially wasteful of time and resources to completely dispose of a previously held theory in favor of a new one. In Quine's view, the fewer accepted premises from a previous theory that are overturned, the better, and "The plausibility of a hypothesis varies inversely with the plausibility of the prior beliefs that it disallows" (The Web of Belief 44). That is, a theory conforms best to the virtue of conservatism when the prior beliefs it rejects are ones that seemed faulty or implausible to begin with.

The second and third virtues, generality and simplicity, have an interesting interplay with one another. How broadly a theory can be applied, or how likely it is that a theory will offer useful predictions in a wide range of contexts, is its generality. When repeatedly testing a theory via experiment, we assume some degree of generality in order to account for changes in the experimental setup or environmental conditions. Simplicity is more difficult to articulate and may be subjective based on language or personal understanding—what appears to be a simple, "elegant" explanation to one person may seem unnecessarily complex to another.

It might be better understood as follows: If general theories explain as many cases of an observation as possible, simplicity unites all those cases under a single theory. A preference for these two virtues is not easily logically justified, especially given the nebulous character of simplicity. A simple theory is not inherently better at prediction, even if one makes the case that there are "fewer ways...for it to go wrong" (Quine, The Web of Belief 46). However, generality and simplicity appeal to us as scientists and might feel more plausible. They avoid some of the pitfalls of ad hoc hypotheses, which, in grasping at straws to defend themselves against falsification, might attempt to add more highly specific and convoluted auxiliary assumptions to the theory.

Harkening back to Popper's demarcation criterion, Quine posits refutability as his fourth virtue of hypothesis. While defined in much the same manner, the distinction here is not that a theory's merit is entirely, unambiguously determined by whether it is falsifiable, but rather that falsifiability is one factor of evaluating scientific rigor. Like Popper, who considers astrology a clear example of pseudoscience, Quine also considers astrology lacking in this virtue to an extreme. The fifth and, to Quine, final virtue of hypothesis, modesty, shares some features with conservatism and might be as difficult to pin down as simplicity. An elaborate, bold, and extravagant hypothesis may raise the instinctual suspicions of scientists.

A Quinean View of the Demarcation Problem

Many of these original five virtues suggested by Quine are highly subjective, nebulous in nature, or in conflict with one another, so they can only provide a general guide of what constitutes science. In fact, there are theories or fields of science that are lacking in a few of these virtues. Take quantum mechanics, for example. It is hardly conservative in retaining prior assumptions about physics, or modest in what it proposes. The latter is particularly striking due to how many principles of quantum mechanics violate our basic understanding of how the natural world should work. Simplicity, too, seems difficult to concretely defend for quantum mechanics, when simplifying assumptions and models are necessary to explain most of the theory. Quantum mechanics is hardly general, either; for most macroscopic objects, Newtonian physics is more than adequate to describe motion and behavior, with any quantum effect on large objects so small as to be negligible and near impossible to measure.

The virtue of refutability might save quantum mechanics from tending towards the nonscientific end of the spectrum, but exemplifying one virtue out of five is not a glowing endorsement for one of the most well-accepted theories in modern science. Therefore, I believe that precision, which Quine suggests as a possible sixth virtue of scientific theories, is an implicit factor that many scientists use to judge whether a theory is scientific. Quantum mechanics involves highly specific values in its predictions, sometimes arriving with shocking

precision at the same empirically determined constants via multiple avenues of calculation. Its predictions about the natural world are not vague or up for interpretation, as predictions derived from pseudoscientific theories like astrology might be. They are numerical, specific, and "cannot be dismissed lightly as coincidence" (Quine, The Web of Belief 65). Precision, however, is not limited to numerical values, but rather concerns a general sharpening of the terms and ideas inherent to a theory. Precision may also enhance the refutability of a theory by offering more opportunities for a theory to be falsified.

A concern that might arise from such a holistic consideration of science is whether this means anything could be considered science, to some degree. If the data itself does not determine what constitutes science, does this not lead to extreme relativism, even denial of our own subjective sense experience? This concern might be exacerbated by the fact that Quine himself states that "The myth of physical objects is epistemologically superior to most in that it has proved more efficacious than other myths as a device for working a manageable structure into the flux of experience" ("Main Trends"). These concerns are not unfounded, because Quinean holism, if extended far enough, does posit that we cannot definitively know anything based on our data alone. As I have shown, scientific theories can have traits that push them towards a sense of scientific rigor, yet they cannot be neatly excluded based on these criteria. The concept of making pragmatic assumptions in order to best navigate experience is not a foreign one to us. At any given moment, we have no definite way of knowing that what we are seeing, hearing, and feeling is not just a hallucination; however, we proceed through life ignoring this possibility because it does not offer a practical means of understanding our sensory input. Likewise, all data could be explained by some wildly surprising ad hoc hypothesis that we have not even thought to consider, but this is not a sensible way to conduct scientific research, even if it cannot be logically refuted. For all his apparent relativism, Quine still has standards of what constitutes valid scientific research, stating that "A theory that is sustained only at the cost of systematic waiving is an undependable instrument of prediction and not a good example of scientific method" (The Web of Belief 18). There is nothing deductively unsound about this type of theory, yet Quine considers it an example of poor methodology for how it is likely to tend toward flawed, inaccurate predictions.

In the scientific community, these virtues of hypothesis, or pragmatic factors in theory evaluation, are built into the process of peer review, some more than others. Say that we have a study that is vague and unspecific (lacking in precision), attempts to reject prior understandings of science without a compelling reason to do so (lacking in conservatism), or claims a phenomenon that only happens at odd and specific times and has no predictive value (lacking in generality)—while we might not be able to easily claim such a study as pseudoscience without a clear demarcation principle, it is likely to be excluded from publication or presentation. Science has its own filtering system to avoid dissemination of

information with poor predictive power. While a demarcation as clean as Popper's may never be achieved by use of holistic Quinean principles, it certainly still allows us to make some distinction between good and bad scientific practice. Such a distinction is an integral part of the modern scientific establishment.

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Arsenic Removal from Drinking Water Using Enhanced Biochar

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Abstract

Naturally occurring arsenic, in the soluble form of arsenate, contaminates groundwater resources for millions of people worldwide (WHO, 2018). While there are several technologies available to remediate arsenic contaminated water, the most effective approaches are expensive to implement and maintain, especially for people who are living in poverty. This research studied an inexpensive method for removing arsenate from drinking water by using enhanced biochar. The treatment method was developed by simulating a process that could be adopted by a low-income family. Aspen wood chips were treated with a 10% (by mass) MgCl2 or MgSO4 solution and were then pyrolyzed in low emission cookstoves. Biochar from the MgCl2 and MgSO4 treatments were determined to have arsenic adsorption coefficients (Kd) of 36.7 and 53.2 L/kg, respectively. In column tests, enhanced biochars were able to achieve 95 percent removal of arsenate from 2 mg/L solutions. However, the treated water exceeded the 10 ug/L maximum contaminant level (MCL) for arsenate, and it averaged an unpotable concentration of total dissolved solids.

Introduction

Arsenic is a naturally occurring element in groundwater around the world. It is usually found in the form of either arsenite (As(III)) or arsenate (As(V)) (Amen et al., 2020). Arsenic is most toxic and mobile in the environment when it is in its reduced form as As(III), but under aerobic soil conditions, it takes the form of the less toxic As(V) species (Flora, 2014). Human exposure to arsenic generally occurs through drinking water, the consumption of food such as rice that has been grown in arsenic-laden water, or through the inhalation of contaminated soil or dust (Riaz et al., 2022). Arsenic is carcinogenic and exposure can cause short-term and long-term health issues such as skin lesions, cirrhosis, Haff's disease, and other chronic diseases (Amen et al., 2020; Gupta et al., 1978; WHO, 2018). The World Health Organization (WHO) has established a maximum contaminant level for arsenic in drinking water of 10 μg/L or 10 parts per billion (ppb) (WHO 2018). It has been estimated that over 200 million people are at risk to arsenic exposure from contaminated groundwater worldwide (Shakoor et al., 2015).

In the United States, arsenic contamination is a common problem that results from two main sources: arsenic leaching into groundwater from the soil and the continuous residual effects from the historical application of lead arsenate (PbHAsO4) pesticides for a variety of agricultural crops (Riaz et al., 2022). However, the United States is not the only country affected by arsenic contamination.

Bangladesh is on the priority list of countries with arsenic contaminated drinking water, where drinking water is already in short supply (WHO, 2018). For millennia, the people of Bangladesh have gathered water from rivers such as the Padma River, which is an extension of India's Ganges River (Britannica, 2022).The surface waters have increasingly become poor sources of drinking water due to industrial pollution, pathogenic bacteria, and viruses from animal waste (Haque et al., 2019). Beginning in the 1970s, to reduce the health risks associated with surface water sources, the United Nations Children's Fund (UNICEF) partnered with the Bangladesh government to install tube wells (aka groundwater wells or boreholes). With the help of private partners, hundreds of thousands of wells were installed throughout the country by 1990 (Hoque et al., 2006; Kahn, 1997; Smith et al., 2000). In 1993, researchers first discovered that naturally occurring arsenic from the soil was a significant threat to groundwater resources (Smith et al., 2000). With the majority of the population using groundwater as their primary source of drinking water, it quickly became clear that the systematic switch from contaminated surface water to 'safe' groundwater had resulted in the unintended poisoning of up to 77 million people (Smith et al., 2000).

By 2012, it was estimated that 39 million people (approximately 25% of the population) continued to be exposed to arsenic contaminated water in excess of the 10 ppb MCL (WHO, 2018). Drinking water treatment options for the removal of arsenic include various

technologies such as coagulation-flocculation, oxidation, reverse osmosis, and adsorption, among others (Nicomel et al., 2016). However, these options can be prohibitively expensive (Amen et al., 2020) and are not necessarily feasible in rural areas due to availability of resources and people with the knowledge to run them (Hasina, 1999).

In recent years, researchers have begun to study the removal of arsenic from drinking water with biochar. Biochar can be made by burning an organic waste feedstock such as wood, corn husks, or coconut shells. Biochar preparation usually begins with shredding or crushing the feedstock, followed by drying until it is ready to burn. The feedstock can burn in a kiln where it undergoes pyrolysis, which is heating between 550-750 °C with little to no oxygen present (Amen et al., 2020; Yakout 2017; Yang et al., 2020; Zhang et al., 2015).

Like clays, biochar surfaces tend to be negatively charged due to the presence of negative moieties such as carboxylic acid groups. These efficiently remove positively charged ions from water such as copper, zinc, or other metals. Because arsenic is usually present in neutral pH groundwater as the anion arsenate (AsO_4^{2-}) or arsenite (AsO_2^-) (Goldberg and Johnston, 2001), biochar surfaces must be modified or enhanced to a positive charge in order to have any significant removal of anions. Examples of biochar enhancement for positively charged surfaces include adding nickel and manganese oxyhydroxides, impregnating the biochar surface with iron, and treatment with calcium carbonate, among others (Amen et al., 2020). A study by Priyadarshni et al. (2020) which treated biochar made from rice husks with stabilized iron and copper oxide nanoparticles for arsenic removal from water concluded that pH, contact time, and interfering ions would determine adsorption efficiency. Critical reviews of studies using biochar for arsenic remediation further identified pyrolysis temperature, surface area, and porosity of the biochar as factors that would affect adsorption (Amen et al., 2020; Yang et al., 2020). The purpose of this research was to develop a method for removing arsenate from drinking water with enhanced biochar that would be inexpensive and that could be done in a rural area. For example, a family could gather and shred a suitable organic waste feedstock (e.g. wood chips, rice husks, etc.). They could then soak the feedstock in a brine solution of $MgSO_4$. In treating wood chips in $MgSO_4$ prior to pyrolization, the goal was to create a more positively charged surface on the biochar and increase the electrostatic attractions for the adsorption of arsenate. We chose magnesium sulfate because it is inexpensive and can be easily acquired around the world in the form of Epsom salts. After soaking in the brine and then drying in the sun, the feedstock would be burned in a low emissions cookstove. The biochar cookstoves as well as cooking can mitigate indoor air pollution (Whitman et al., 2011). The hydrolyzation process burns the treated wood chips at high temperatures in the absence of oxygen which effectively reduces the production of harmful carbon emissions such as carbon monoxide (Whitman et al., 2011). After cooking a meal on the stove, the biochar that remains would be used to treat

arsenic contaminated water. Developed by the Seattle Biochar Working Group (University Place, WA), the prototype for pyrolysis cookstoves was designed to produce low particulate emissions and replace open flame wood stoves that contribute to indoor air pollution and millions of annual deaths worldwide (Younger et al., 2022). Hence, the implementation of this overall process would address the human health challenge of arsenic poisoning. To assess the arsenic removal efficiency of the magnesium sulfate enhanced biochar, we conducted linear isotherm experiments to determine the enhanced biochar's adsorption coefficient (Kd), and we performed experiments with biochar-packed column filters.

Materials and Methods

To prepare the biochar, aspen woodchips (Small Pet Select, Ellensberg, WA) were soaked in a 10% magnesium sulfate (Mg◎SO◎_4) (San Francisco Salt Company, San Francisco, CA) solution for 24 hours. After being dried at ambient temperatures (Figure 1A), they were pyrolyzed in a biochar cookstove (Seattle Biochar Working Group, University Place, WA) (Figure 1B), which took an average of 40 minutes to thoroughly burn the char. The biochar was ground with a mortar and pestle and then sieved so that the granules were between 300-µm and 850-µm in diameter and could meet the American Water Works Association standard for carbon filtration media (Becker et al., 1974). The control biochar was prepared by soaking in tap water from Seattle Public Utilities and then dried, pyrolyzed and sieved in the same manner. Sieved biochar was then packed into three, 24in long, 3-in diameter, polyvinyl chloride (PVC) columns (Figure 2) each containing a Doulton SuperSterasyl (W9121200) ceramic candle filter (Doulton Water Filters, Newcastle-under-Lyme, UK), 1305 g of pea gravel, which was subsequently separated by 100-g of enhanced or untreated biochar with a 3-inch diameter mesh made from 1-mm of 304 stainless steel (Satinior, Chang'an Town, Dongguan Guangdongsheng, China). Columns were fed 1-1.5 liters of a 2 mg/L solution of arsenate in deionized water that was adjusted to pH 7.

Batch isotherm experiments with biochar and arsenic were performed by adding either 0.0, 0.1, 0.3, 0.5, 0.8, 1.2 or 1.6-g of enhanced (or control) biochar to 40-ml centrifuge tubes along with 40-ml of a 2 mg/L arsenate solution that was adjusted to pH 7. Feedstock for the isotherm experiments were treated using magnesium sulfate(Mg◎SO◎_4)or magnesium chloride (Mg◎Cl◎_2) (MilliporeSigma, Burlington, MA, USA) as described above. The samples were placed in a shaker table at 25°C and incubated at 135 rpm for eight hours. After centrifugation at 3000 rpm for 10-min and at 10,000 rpm for 5-min, the water samples were decanted into nitric acid-prepared bottles from Fremont Analytical Laboratories (Seattle, WA) which analyzed all samples for total arsenic using EPA Method 200.8 and inductively coupled plasma mass spectrometry (ICP-MS).

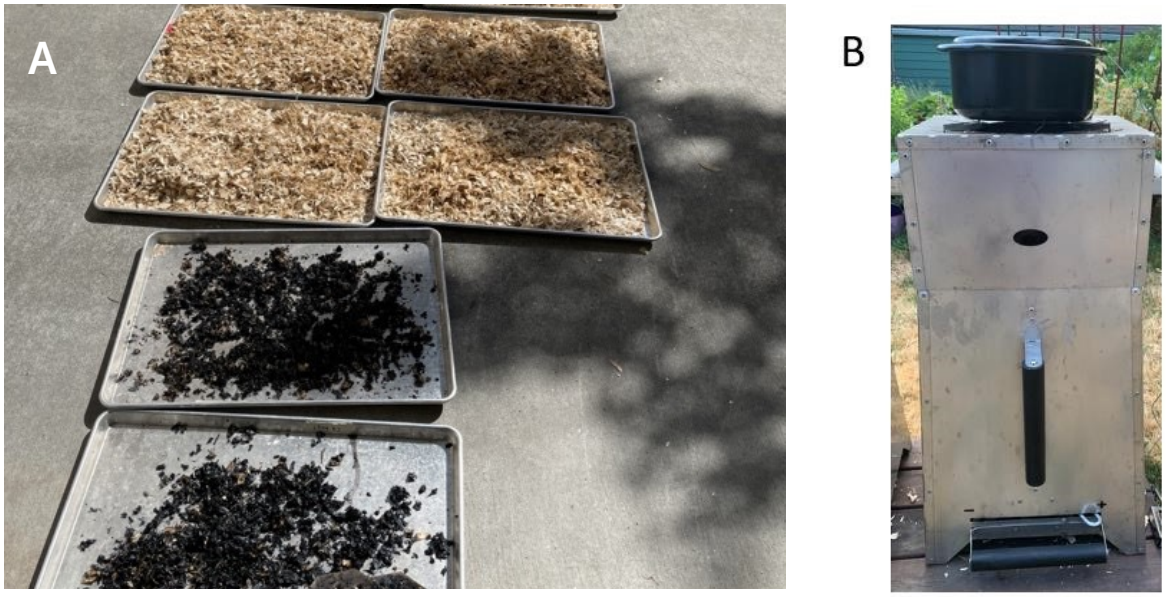

Figure 1 (A) Aspen wood chips drying outdoors and pyrolyzed biochar. (B) Low-emissions biochar cookstove.

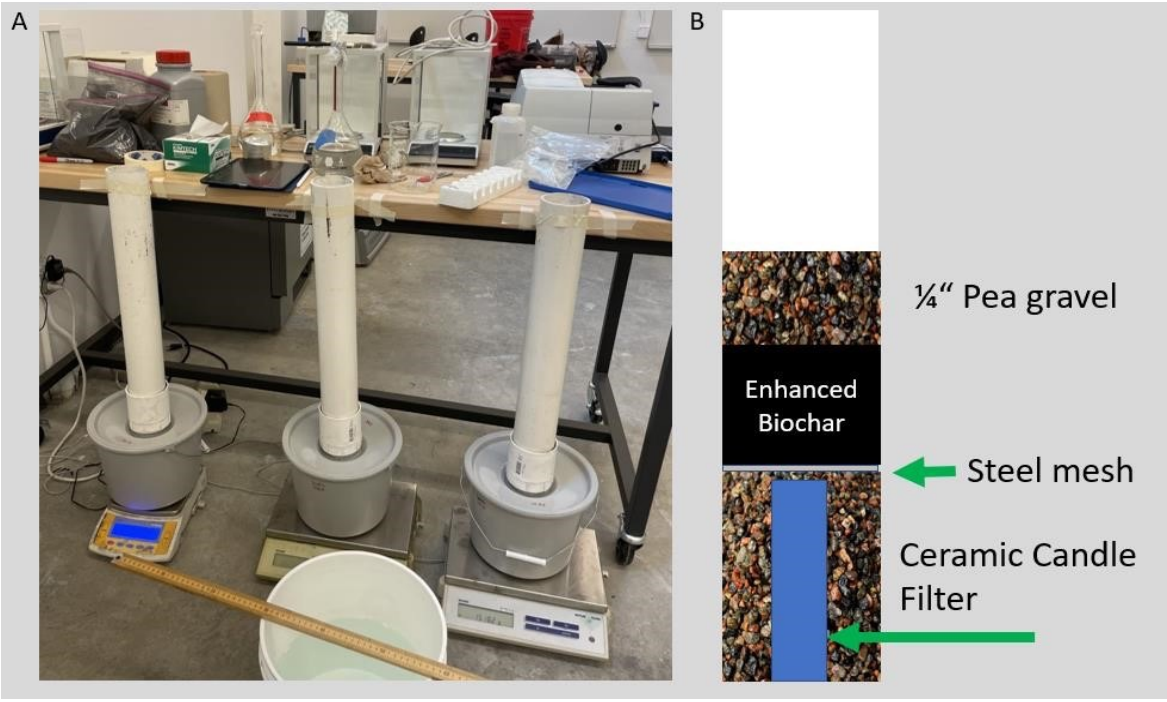

Figure 2 (A) Packed column filters and (B) filter media detail for each column.

Results and Discussion

The cookstoves yielded 20 to 30 percent biochar for the untreated and treated aspen woodchips, respectively (Table 1). The dried magnesium sulfate salts slowed the pyrolysis rate which resulted in the higher yields. These results indicated that enough biochar could be produced from a single 40-min cooking period (which we confirmed was long enough to prepare two cups of rice) to pack a single filtration column with 100-g of biochar. A linear adsorption isotherm was conducted to produce a graph to represent the variation in absorbance across the columns where the slope represents the adsorption coefficient. Results from the linear adsorption isotherm with magnesium sulfate (Figure 3) or magnesium chloride (Figure 4) enhanced biochar indicated adsorption coefficients (K_d) of 53.2 L/kg and 36.7 L/kg, respectively. The adsorption coefficient for the magnesium sulfate enhanced biochar was slightly higher but on the same order of magnitude as the magnesium chloride enhanced biochar. This slight advantage in adsorption combined with the greater availability and lower cost of Epsom salts would, thus, make magnesium sulfate (Mg◎SO◎_4) the preferred salt for producing enhanced biochar for the removal of arsenate.

Column tests showed that 100-g of untreated biochar could remove approximately 75 percent of the arsenate from a 2 mg/L solution, and 100-g of treated biochar was able to remove approximately 95 percent for a final concentration of 40 μg/L (Figure 5. In addition to exceeding arsenic's 10μg/L MCL, the treated water had levels of sulfate and total dissolved solids that were similar to seawater and therefore undrinkable (Table 2). The enhanced biochar's adsorption capacity for arsenic was approximately 0.015 g/g. This was on the low end of the range of adsorption capacities that have been reported for other biochar-based adsorbents (Amen et al., 2020; Yang et al., 2020).

Table 1 Biochar yields from 300 g of untreated (n = 17) and enhanced (n = 16) aspen wood chips at an average pyrolysis temperature of 450 °C.

Biochar Type	Average Yield Weight (g)	Percent Yield
Untreated	61.4± 15	20.5%
Enhanced with 10% $MgSO_4$	91.0± 27	30.3%

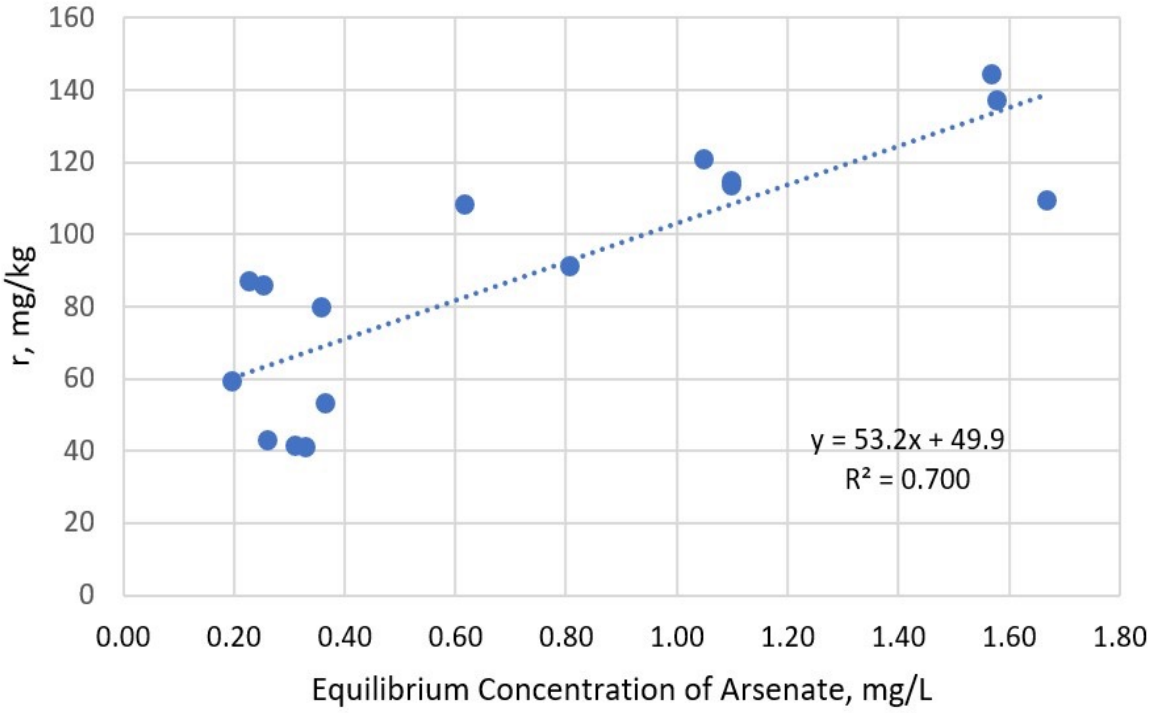

Figure 3: A linear isotherm for arsenate with biochar enhanced in a 10% $MgSO_4$ solution had an adsorption coefficient (K_d) of 53.2 L/kg.

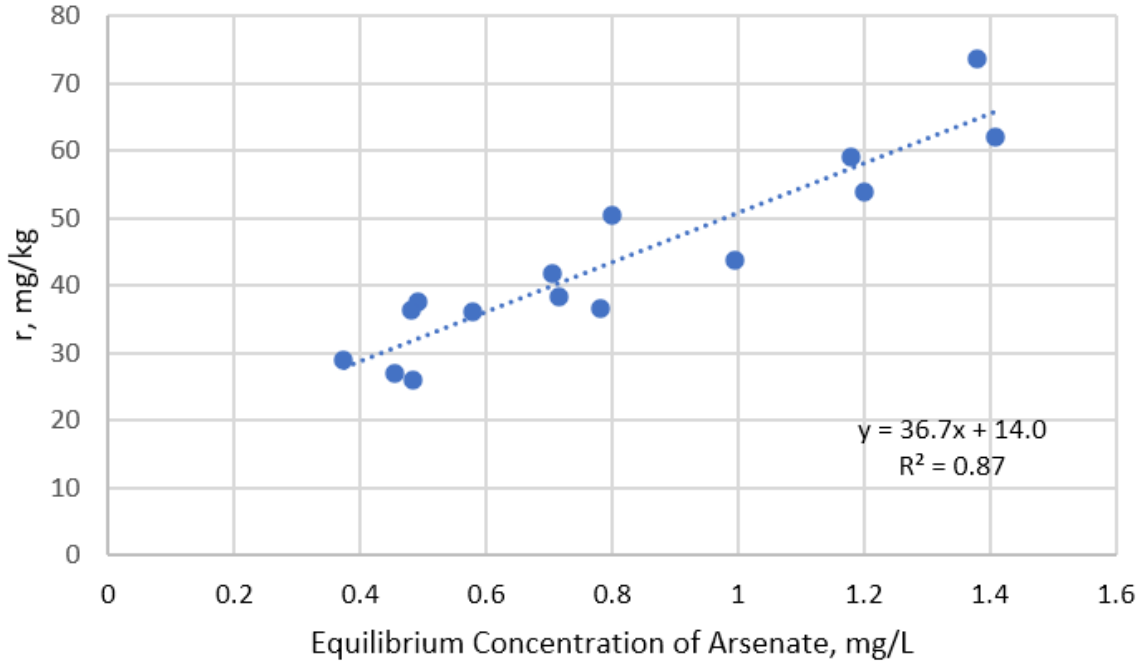

Figure 4 A linear isotherm for arsenate with biochar enhanced in a 10% 10% $MgCl_2$ solution had an adsorption coefficient (K_d) of 36.7 L/kg.

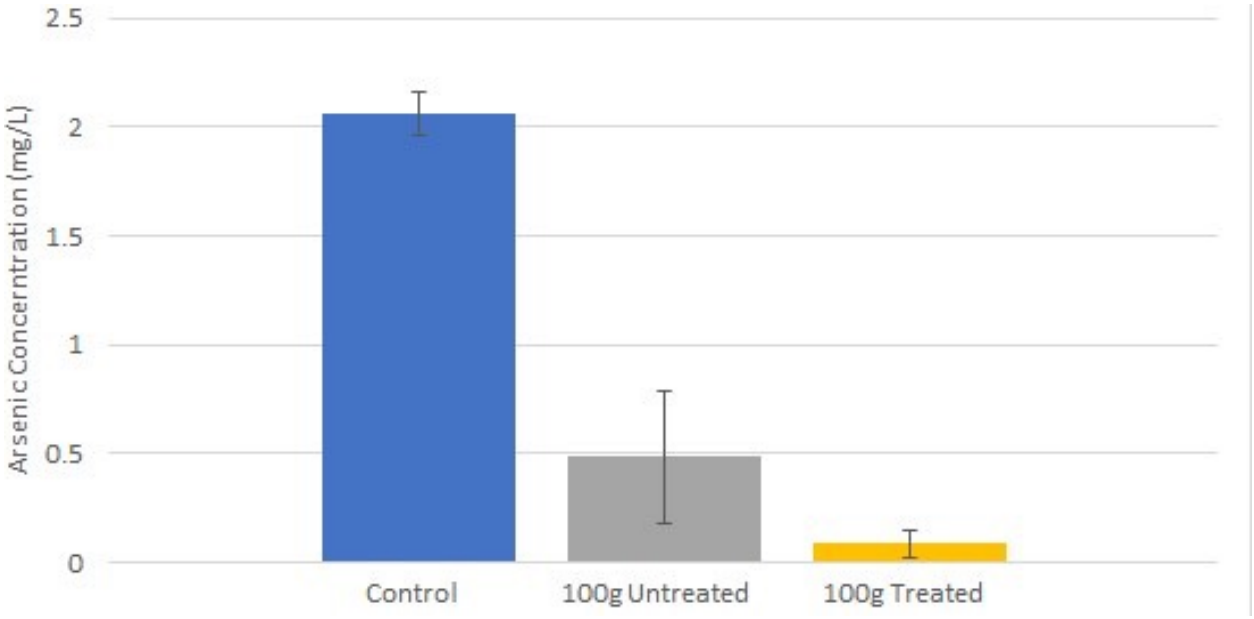

Figure 5 Columns with 100 g of untreated biochar had 75 percent removal of arsenate compared to 95 percent removal by biochar treated with a 10% $MgSO_4$ solution.

Table 2 Total dissolved solids for water filtered with untreated and treated biochar.

Biochar Type	Total Dissolved Solids (mg/L)
Untreated	2,072 ± 466
Enhanced with 10% $MgSO_4$	29,136 ± 16,587

Conclusions

Arsenic contamination of drinking water is a global issue that is particularly challenging for countries such as Bangladesh because modern treatment technologies can be too expensive for the average household to purchase. This research developed an arsenic removal process that could be implemented in rural areas for a cost of approximately $0.25 per liter (excluding the cost of labor), which is low even with the average income of someone in Bangladesh being 141.58 USD/month, according to Bureau of Statistics data for 2017 (Take-Profit.org, 2023). Experimental results indicated that enhanced biochar could achieve 95% arsenic removal, but the process could not meet the 10 ppb MCL needed to meet potable water standards. While effective at removing arsenic, the enhancement process increased the total dissolved solids concentration to unpotable levels. Because the MCL is so small and arsenic is so toxic, it is not

possible to achieve potable drinking water using simple enhanced biochar removal. It may be possible to use enhanced biochar to remove other contaminants with higher MCL such as fluoride, but arsenic remediation requires more advanced technologies such as reverse osmosis, oxidation, or coagulation-flocculation techniques, which all require drinking water treatment plants. Until a suitable, inexpensive water treatment process can be developed, arsenic removal from drinking water will need to be done with proven technologies. However, the issues with these processes remain the same: they are expensive and difficult to maintain. To help families (especially those in rural areas) who cannot afford to purchase more expensive treatment technologies, microfinancing strategies for community-level drinking water treatment systems could be implemented (Water.org, 2018).

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Associations Between Decreased Attentional Resources and Hand Function in Young Adults

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Abstract

Hand function is important for many everyday motor tasks and is commonly assessed using finger tapping tasks and the Grooved Pegboard Test. Age-related declines in attentional processes are well documented; decreased attentional resources, examined by increasing cognitive load with different types of dual task paradigms, may impair hand function. Many everyday activities also require coordination between both hands (i.e., bimanual dexterity). However, few studies have examined the effects of dual task type on unilateral versus bimanual dexterity. Thus, the purpose of this study is to examine the association between attention and manual dexterity in unilateral and bimanual tasks in young adults. Twenty-three healthy, right-handed adults (19-39 years) performed a unilateral tapping task by tapping with the left index finger on a touchscreen as quickly as possible. Participants also performed a bimanual task by completing the Grooved Pegboard Test with the right hand while performing the tapping task with the left hand. Two common types of cognitive dual tasks (visuospatial and non-visuospatial) were performed during the bimanual task to examine the effects of decreased attentional resources and differential effects of dual task type on bimanual dexterity. This study found the average number of taps was significantly lesser during all bimanual conditions compared to the unilateral tapping task ($p < .001$) and during the bimanual task with non-visuospatial task versus bimanual task with visuospatial task ($p < .001$). Results demonstrate that non-visuospatial cognitive tasks impair bimanual hand function to a greater degree than visuospatial tasks, indicating that non-visuospatial tasks may be beneficial to include in assessments of hand function.

Introduction

Manual dexterity is important for many daily activities such as typing, writing, and cooking. However, manual dexterity decreases with age (Heintz & Keenan, 2018), and impairments in manual dexterity are associated with difficulties performing everyday tasks of hand function (Kobayashi-Cuya et al., 2018). Attention is critical for many voluntary, goal-directed hand tasks. Cognitive dual tasks are used to examine the effect of decreased attentional resources on motor performance by increasing cognitive load (Heintz Walters et al., 2021; Keenan et al., 2017). Dual tasks ask participants to perform two simultaneous tasks, similar to many everyday functions (e.g., holding a conversation while driving). Two types of cognitive dual tasks are commonly used: visuospatial tasks and non-visuospatial tasks (Menant et al., 2014). Visuospatial tasks, such as imagining a star moving around a set of boxes, assess an individual's ability to mentally identify and manipulate objects in space (Baddeley, 2012). Non-visuospatial tasks, such as mathematical addition, assess an individual's ability to retrieve information stored verbally (e.g., numbers, names) (Baddeley, 2012). Two types of cognitive dual tasks have been shown to differentially affect motor performance. For example, gait speed in older adults was significantly slower with the addition of a visuospatial task compared to a non-visuospatial task, demonstrating that visuospatial tasks impair gait to a greater degree (Menant et al., 2014).

Many everyday tasks of hand function require coordination between hands, increasing task complexity when compared to unilateral tasks (Otte & van Mier, 2006; Petrigna et al., 2020). However, most manual dexterity tests are unilateral (e.g., the Grooved Pegboard Test and the Box and Block Test). Bimanual assessments of manual dexterity may be important to evaluate changes in hand motor control. Previous research has examined the effects of cognitive dual task type on motor performance (Menant et al., 2014), although it is unclear how dual task type influences upper extremity function (e.g., the ability to write and grasp objects). Furthermore, few studies have examined differences in performance regarding unilateral versus bimanual dexterity in young and older adults (Otte & van Mier, 2006; Petrigna et al., 2020). Thus, the purpose of this study was to examine the association between attention and manual dexterity in unilateral and bimanual tasks in young adults. Participants completed commonly used assessments of manual dexterity under unilateral and bimanual conditions with the addition of visuospatial and non-visuospatial tasks. Based on previous findings (Otte & van Mier, 2006; Menant et al., 2014), we hypothesized two outcomes: 1) a greater tapping performance, indicated by a greater number of taps, on unilateral versus bimanual tasks, and 2) the visuospatial task would impair bimanual dexterity to a greater degree than the non-visuospatial task.

Methods

Twenty-three healthy young adults (age: 21.8 ± 4.0 years; range: 19-39 years; gender identity: 10 males, 13 females) participated in this study. Written informed consent was obtained as approved by the Institutional Review Board at Seattle University. All participants were right-handed as measured by the Edinburgh Handedness Inventory (Oldfield, 1971). Exclusion criteria included a self-report of neuromuscular disorders, functional deficiencies, pain in the upper extremities that limits function of the arms or hands (e.g., difficulty performing everyday tasks, such as opening a jar), previous diagnosis of a disorder that may limit normal movement of the hands, or current use of medication that alters neuromuscular function. Vision was assessed using Snellen's handheld eye chart (Hallowell, 2008). Participants were asked to abstain from caffeine 12 hours before testing (Lorist, 1995).

Tests of Manual Dexterity

Tapping tasks and the Grooved Pegboard Test (Lafayette Instrument Company, Lafayette, IN) are two common measures of hand function (Wang et al., 2011; Rickards et al., 2018). The tapping task was designed based on the Finger Tapping Test done previously (Ashendorf et al., 2009; Otte & van Mier, 2006). Specifically, participants tapped on an iPad touchscreen (Apple Inc., Cupertino, CA) with their left index finger in a consistent location as quickly as possible for 30 seconds. No target was presented, thus removing the need to use vision across both motor tasks during bimanual task conditions (Petrigna et al., 2020). The number of taps was quantified by Tap Tool (McMenzie, 2015). The Grooved Pegboard consists of a board with 25 grooved holes arranged in five rows and 25 grooved pegs. To insert the pegs into the holes, each peg must be rotated to match its groove with the groove of the hole. Based on standardized procedures, participants were instructed to insert pegs one at a time and as quickly as possible from left to right and top to bottom (Wang et al., 2011). Prior to testing, participants practiced the task by filling the top row (Petrigna et al., 2020; Wang et al., 2011).

Cognitive Task Conditions

The visuospatial task used was based on Brooks' spatial memory task (Brooks, 1967) and visuospatial tasks previously used by Sturnieks et al. (2008), Menant et al. (2014), Peterson & Keenan (2018), and Heintz Walters et al. (2021). The task involved visualizing a star moving around four boxes arranged in a square. The sequence began when the examiner said "Start," followed by a series of four randomized directions that signified the star's movement (i.e., up, down, left, right, diagonal). The sequence ended when the examiner said "Location?", to which the participant stated the final location of the star. Prior to testing, participants completed five practice trials while viewing an image of the grid, followed by practice trials

without the image until three consecutive correct trials were performed. The non-visuospatial task, based on previous work by Menant et al. (2014), involved summing three single-digit numbers. The non-visuospatial task began when the examiner said "Start," followed by a series of four single-digit numbers (e.g., 5, 3, 1). The sequence ended when the examiner said "Answer?", to which the participant stated the sum of the three digits. Prior to testing, participants completed practice trials in which three consecutive, correct trials were required before proceeding.

Experimental Set-Up

Participants began with their hands resting on a table, shoulder-width apart. The iPad was placed in line with their left shoulder for each trial. For the unilateral condition, participants performed the tapping task as detailed previously. The average number of taps was calculated as the number of completed taps, divided by 30 seconds, averaged across two trials. The bimanual tasks consisted of the following conditions: 1) Grooved Pegboard + Tapping, 2) Grooved Pegboard + Tapping + Visuospatial task, and 3) Grooved Pegboard + Tapping + Non-visuospatial task. During bimanual task conditions, the Grooved Pegboard was placed in line with the participant's right shoulder (Fig. 1). The bimanual task conditions began when the examiner said "Go." Participants then simultaneously tapped as quickly as possible while completing the Grooved Pegboard Test. The trial concluded when the last peg was inserted into the Grooved Pegboard. During trials with cognitive task conditions (i.e., Grooved Pegboard + Tapping + Visuospatial task and Grooved Pegboard + Tapping + Non-visuospatial task), participants simultaneously tapped as quickly as possible, completed the Grooved Pegboard Test, and performed the cognitive task. Using a stopwatch, Grooved Pegboard Test completion time was recorded from the moment the experimenter said "Go," to the moment the last peg was inserted into the Grooved Pegboard (Wang et al., 2011). Bimanual conditions were randomized, and two trials were performed for each condition. The average number of taps was calculated as the number of taps completed, divided by the Grooved Pegboard completion time, averaged across two trials for each condition.

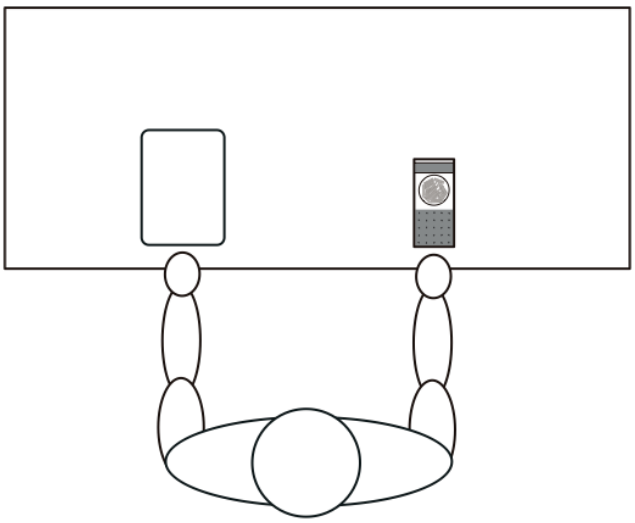

Figure 1. The experimental setup for the bimanual task. Participants sat with their fingertips rested on the edge of the table. The iPad was placed across from their left shoulder. The Grooved Pegboard was placed across from their right shoulder.

Statistical Analysis

A repeated measure ANOVA (Analysis of Variance) with statistical significance set at $p < 0.005$ was performed to examine differences in the average number of taps per second across conditions. All values are reported as mean ± SD in the text unless specified.

Results

The number of taps was significantly lower ($p < .001$) during all bimanual tasks, including Grooved Pegboard + Tapping (3.78 ± 0.90 taps/s), Grooved Pegboard + Tapping + Visuospatial task (3.77 ± 0.98 taps/s), and Grooved Pegboard + Tapping + Non-visuospatial task (2.44 ± 0.44 taps/s) compared to the unilateral tapping task (5.37 ± 0.68 taps/s) (Fig. 2). The average number of taps was significantly lower ($p < .001$) for the Grooved Pegboard + Tapping + Non-visuospatial task (2.44 ± 0.44) compared to the Grooved Pegboard + Tapping + Visuospatial task (3.77 ± 0.98) and Grooved Pegboard + Tapping (3.78 ± 0.90 taps/s). There was no significant difference ($p = 1.00$) in the number of taps for Grooved Pegboard + Tapping (3.77 ± 0.98 taps/s) versus Grooved Pegboard + Visuospatial task (3.78 ± 0.90 taps/s).

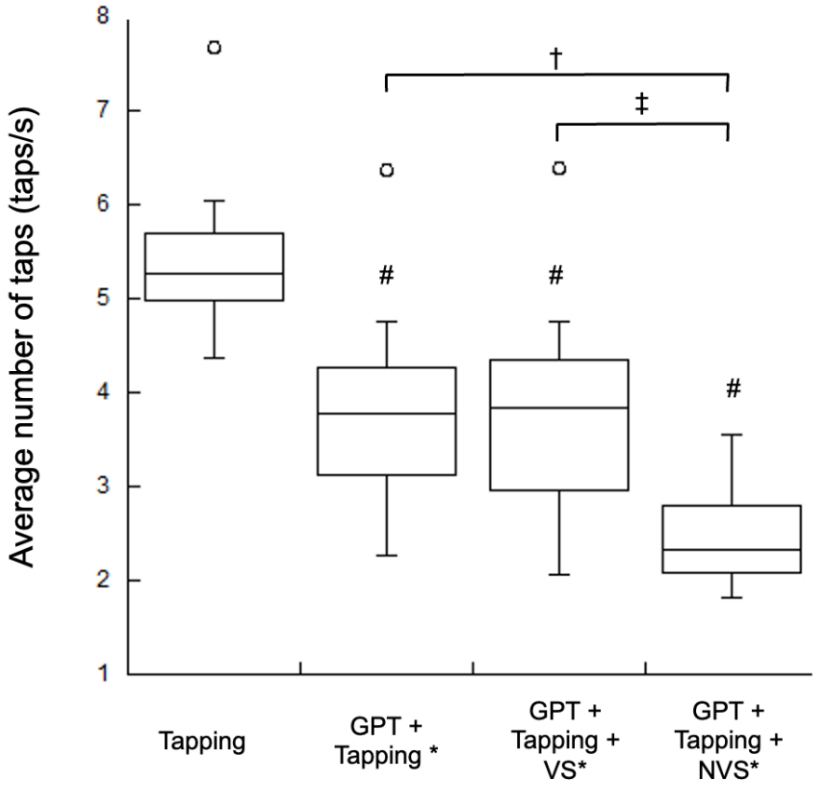

Figure 2. The average number of taps was significantly lesser for the unilateral task compared to all bimanual tasks (#$p < 0.001$). The average number of taps was significantly lesser for the GPT (Grooved Pegboard Test) + Tapping versus GPT + Tapping + NVS (non-visuospatial) (†$p < 0.001$) and the GPT + Tapping + VS (visuospatial) versus GPT + Tapping + NVS (‡$p < 0.001$). The graphed boxes indicate the first and third quartiles. The lines within the boxes indicate the median. The whiskers indicate the highest and lowest values, excluding the outliers. The circles indicate outliers. The asterisks indicate bimanual tasks.

Discussion

The purpose of this study was to examine the association between attention and manual dexterity in unilateral and bimanual tasks in young adults. The main findings of this study were differences in finger tapping performance in 1) unilateral versus bimanual task conditions and 2) visuospatial versus non-visuospatial task conditions. Compared to all bimanual tasks, hand motor performance was greater during the unilateral tapping task. Consistent with previous research (Otte van Mier, 2006), results demonstrate bimanual tasks impair hand function to a greater degree than unilateral tasks. This supports the idea that bimanual tasks demand greater access to limited attentional processes due to task interference between both hands (Schmidt & Lee, 2014). While many everyday activities require coordination between both hands, many tests of manual dexterity are unilateral. Thus, it may be important to include bimanual tasks in future assessments of hand function.

Finger tapping performance was impaired to a greater degree with the addition of a non-visuospatial task compared to a visuospatial task. Results contrast previous work that examined the effects of dual task type on gait performance in older adults, which found visuospatial tasks impaired older adults to a greater degree than non-visuospatial tasks (Menant et al., 2014). This suggests that the cognitive resources required for bimanual control differ from those required for locomotor control. Additionally, greater impairments in bimanual hand function with the addition of a non-visuospatial cognitive task compared to a visuospatial task have important implications for hand motor assessments. More specifically, non-visuospatial tasks may provide important insights into hand function important for everyday activities. Thus, an inclusion of non-visuospatial tasks may be beneficial in assessments of hand function by examining performance of a task of hand function (e.g. Grooved Pegboard Test, Tapping tasks, writing tasks) while performing a non-visuospatial task.

It is important to note the limitations of this study. The current study assessed bimanual dexterity using two common assessments of hand function. Unlike one's gait, hand movements do not follow a rhythmic pattern. Thus, a variety of approaches are used to assess hand function including the Box and Block Test and the Purdue Pegboard. As there is greater variance in hand movements, future studies could examine the effects of unilateral versus bimanual dexterity and the effects of dual task type using other assessments of hand function. Furthermore, attention is critical for many motor tasks of everyday function such as orienting an object, and attention is directly linked to eye movements (Heintz Walters et al., 2021). The current study examined the associations between attentional processes and manual dexterity using different types of cognitive dual tasks. However, simultaneous eye tracking recordings could further our understanding of how visual information is incorporated into hand motor control and changes in attentional processes. Deficits in attention and hand function are well-documented in older adults (Heintz Walters et al., 2021). Thus, future research could extend to the older adult population and examine the effects of dual task type on unilateral and bimanual dexterity in young versus older adults. Paired with finger and hand motion tracking and eye tracking, this could provide insight into age-related changes in hand function such as gross reaching and fine motor movement and attentional processes. Greater insight into hand movements may be applicable for developing interventions to improve hand function in older adults.

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Full-Length Research Articles

This section of the journal is dedicated to full-length research projects in any discipline. These might include a final essay for a class, a capstone project, a study abroad essay, an independent study, or a multi-authored paper for which the student contributor is the first author. We have chosen not to separate these essays into disciplinary divisions, but we do indicate the major field of study for each author. These essays have been chosen for their academic promise, for their participation in Seattle University's vibrant research community, for their fit with our mission and values, and for their representation of majors across the university.

Urban Campus Native Bee Conservation Guide

Breann Kniffen, Cell and Molecular Biology

Faculty Mentor and Faculty Content Editor: Heather Brown, PhD, Molecular and Cellular Biology

Student Editor: Riley Flanagan, English

Abstract

Around the world, there are nearly 20,000 species of bees, with roughly 3,600 of these species residing in North America (Xerces Society, 2015). However, nearly one in six bee species has already gone regionally extinct, while over 40% are vulnerable to extinction (Center for Biological Diversity, 2018). Agriculture, habitat loss, pesticide use, climate change, and competition and disease from non-native honeybees are just a few factors contributing to the loss of bees who are native to the Americas (Koh et al., 2015). While urban developments contribute to habitat loss, cities can aid in counteracting the effects of urbanization by creating garden refuges for bees (Wilson & Jamieson, 2019). With the help of urban campuses, cities can produce valuable habitats for supporting bee communities. This guide is intended to help improve urban campuses' native bee conservation efforts by providing resources and guidelines. It is important to note that this guide largely focuses on the Pacific Northwest region; however, there are resources provided throughout this document for other regions to modify and apply the same guidelines. Thus, the overarching aim of this project is to create a single document with the information and tools required for implementing and maintaining sustainable habitats for native bee conservation on urban campuses, monitoring, and providing public educational opportunities.

Introduction

While many efforts have been made towards the conservation of native bees, resources for implementing these practices remain difficult for the general public to navigate, which therefore hinders the efficiency and rate of the general public's involvement. Misconceptions surrounding native bees and conservation methods remain rampant among the public, further impeding conservation efforts. In order to solve the global decline of bees, it's going to take more than just scientists; it will require the aid of citizen science and the application of conservation practices in all settings, especially urban settings where food can be scarce for native pollinators. This guide is intended for any urban campus, whether educational, company-owned, or publicly owned, to use as a consolidated reference for the implementation of native bee conservation practices. There is a specific focus on the Pacific Northwest (PNW) region of WA due to native bees, such as the vulnerable western bumble bee (*Bombus occidentalis*), drastically declining in western Washington, and in hope of offsetting the threats cities pose to declining bee populations (Jepsen et al., 2014).

Conservation Status

It is estimated that there exist approximately 20,000 bee species in the world, many of which are at risk of becoming endangered, have become extinct, or remain ambiguous (USGS, 2020). Solitary bees, for instance, can be remarkably difficult to study with some being as small as a grain of rice. Moreover, it is estimated that nearly 10% of bee species in the United States have yet to be named or documented, adding to the uncertainty of status among species. Due to challenges in monitoring, the conservation status, distribution, nesting sites, and behavior of most solitary bees remain unknown.

However, even with the status of many bee species remaining unknown, data trends suggest a global decline among all species. Global studies found that an estimated 1 in 6 bee species are regionally extinct, while over 40% of current species are vulnerable to extinction (Center for Biological Diversity, 2018). Furthermore, roughly 28% of all bumblebees across Canada, the United States, and Mexico have fallen into the Threatened Category under the International Union for Conservation of Nature (IUCN) (Xerces Society, 2015). This has led to the rusty patch bumblebee being the first bumblebee to be designated as an endangered species under the US Endangered Species Act (ESA) in January 2017 (Thorp et al., 2013). As for solitary bees, an estimated "50% of leafcutter bee species and 27% of mason bee species are 'at risk'" (as cited in Xerces Society, 2015).

It has become increasingly evident that unless drastic efforts are taken to stop the rapid decimation of bee species, this decline won't end soon. However, there is still much that is unknown about native bees, making this task challenging to tackle and quantify.

While we know many native bee species are at risk of extinction, we still do not know the status of many species due to inadequate data collection and sharing. Furthermore, adequate and standardized methods for bee monitoring have not yet been established, as there is still debate about best practices. Despite the uncertainties, tangible actions must be made toward the preservation of native bee species to change their trajectory, and that begins with public awareness.

Importance of Native Bees

Although the general public acknowledges bees are important, the extent to which pollinators, especially native bee pollinators, contribute is frequently undermined. Insect-driven pollination is a critical part of both natural ecosystems and agriculture; without it, these systems would fail. Bees alone pollinate nearly 75% of the United States' fruit, nuts, and vegetables, equating to one out of every four bites of food being made possible by bees (Communications & Publishing, 2015).

Supporting the conversation of native bees not only prevents them from becoming extinct but also combats global warming. Pollinators fight climate change by aiding in plant abundance and growth, consequently cleaning air of carbon dioxide, purifying water, and preventing soil erosion via promoting root growth (USDA Forest Service, 2022). Bees may be small, but without pollinators, all of the Earth's terrestrial ecosystems, including the human race, would cease to exist (USDA Forest Service, 2022). With bees being considered the most efficient pollinators, and native bees pollinating around 80% of the world's flowering plants, their importance to not just humanity but the world is evident (Communications & Publishing, 2015).

Types of Native Bees

With countless bee species, it is easy to become overwhelmed by the thought of monitoring bees. Fortunately, citizen science utilizes groupings to distinguish bees into only a handful of groups, making the distinction of bees exponentially easier.

According to Hillary Sardiñas (2016), a former Pacific Coast Pollinator Specialist for the Xerces Society for Invertebrate Conservation, some of the major groups of native bees in the PNW region include sweat bees (Lasioglossum & Halictus), bumblebees (Bombus), miner bees (Andrena), mason bees (Osmia), leafcutter bees (Megachile), and cuckoo bees (Sphecodes, Nomada, Triepeolus, & Coelioxys). Each of these native bee species differs in taxonomy and plays specific niche roles in the environment. For instance, bumblebees have the unique ability to buzz pollinate by vibrating singular flowers at a frequency that dislodges pollen that would otherwise be locked within a flower, thereby making it attainable to bees. Other bees, such as

the sweat bee, are able to pollinate by climbing deep into flowers due to their tiny size, thereby accessing pollen that would otherwise be unattainable to other larger bee species (Sardiñas, 2016).

Figure 1 PNW major native bee groups. From "USGS Bee Inventory and Monitoring Lab." Photo credits, from left to right: Alexander, 2015; Croft, 2017a; Hernandez, 2012; Boo, 2017; Croft, 2017b; Boo, 2015.

Not only is there a variety of native bee species, but there is also an array of observed behavioral and nesting traits. Bees can be grouped based on their social and nesting behaviors as solitary, communal, eusocial, semi-social, or parasitic. It is important to note that the behavioral and nesting habits of species exist on a spectrum with solitary and eusocial on opposite extreme ends. Behaviors may vary for a variety of reasons, including time of year, geographic location, altitude, and other factors that are yet to be fully understood (Michener, 2007, as cited in Buckley et al., 2016).

Eusocial bee species are known as the "social" species of bee, demonstrating a hierarchical social construct. In eusocial species, the queen bee gives birth to worker offspring that perform and divide duties around the nest (Antoine & Forrest, 2020).

The only North American native bee that is truly social, or eusocial, is the bumblebee (Kiley, 2018). The bumblebee life cycle begins with a queen bee emerging from hibernation in the spring and searching for a suitable nesting site. As bumblebees are said to be "opportunistic nesters," they typically prefer existing cavities such as empty mouse burrows. The queen will then create pots or brood cells from wax to hold nectar and pollen, in which she lays and incubates her eggs. The eggs will hatch after four to five weeks, producing female worker bees that will take on various duties, including foraging and attending to the developing brood cells. These worker bees only live for approximately one to two months before they are replaced by more worker bees. The queen will continue laying eggs throughout the summer, steadily increasing the colony's size. Near the end of summer, new queens and male bees, called drones, will emerge from the nest to mate. The new queen bees will then find a new site in which to hibernate over winter while the rest of the colony dies. Due to bumblebees having an annual life cycle, they do not generally occupy the same nesting site for more than one year (Xerces Society, 2014).

Within this social spectrum, there are semi-social bees. Semi-social bees have two divisions of females: those that lay eggs and those that act as worker bees. Semi-social bees can often be characterized by colonies without a defined queen (Lavoipierre, 2013).

A minority of bee species, such as the cuckoo bee, composes the parasitic class. These parasitic bees invade other bee nests, often killing other bees or leaving their offspring behind to be raised by a host (Antoine & Forrest, 2020).

Solitary bees are classified as females working independently and individually to build their own nests and provide for offspring. Some solitary bees also live in communal nests where they live independently with one another, only sharing a nest entrance. The majority of North American native bees are solitary nesters, composing an estimated 90% of all North American native bees. Of the solitary nesters, 30% take up residency in abandoned tunnels and burrows, and 70% nest in the ground by digging their own tunnels (Xerces Society, 2015). As solitary bees lack colonies and social structure, they are characterized as non-aggressive and rarely sting. Only a few of the female solitary bees even possess a stinger and will still rarely sting when disturbed.

Despite these social differences, nearly all native bees have the same or similar annual lifecycle. With all bees undergoing an egg, larva, pupa, and adult stage, there are still some major differences between the lifecycles of solitary bees compared to those of bumblebees, or eusocial bees.

Solitary bees live for about a year and can be observed only in the adult stage of their lifecycle for about three to six weeks. For the rest of the year, most solitary bees go through egg, larva, and pupal stages all within a hidden nest (Xerces Society, 2015).

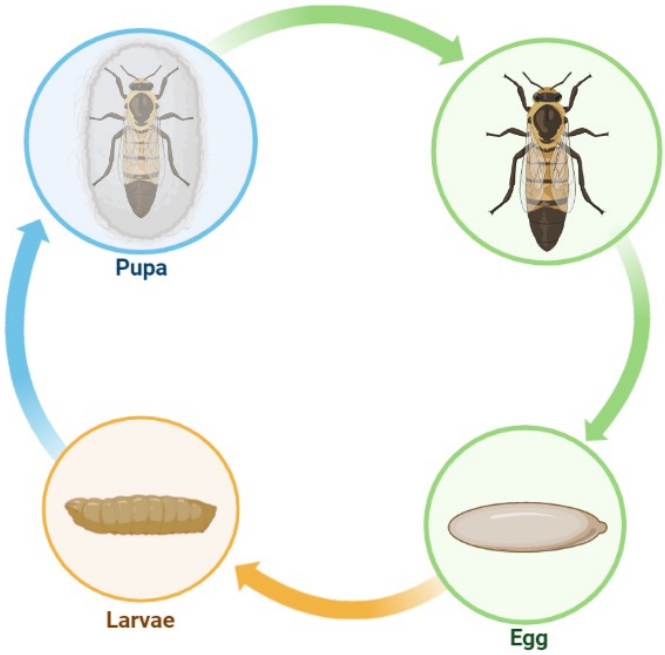

Figure 2 Lifecycle of most solitary bees. Many solitary bees emerge from their nests between early spring and mid-summer, at which point they will find mates. Female bees will then find a suitable cavity to construct a nest where they will create individual brood cells, each containing enough pollen to sustain one larva. An egg will then be laid in each brood cell before it is sealed off. Eggs will hatch into larvae over the summer and continue to develop throughout the winter into pupae until they are fully mature and ready to emerge as the next generation the following year. Only a few species of bees are able to produce two generations within one year.

Diversity, Abundance, & Richness

The richness of a bee population refers to the number of individual bee species within a given area, whereas abundance is the number of individuals belonging to each species. The third factor, diversity, is an assessment of both richness and abundance, which can be further characterized by phylogenetic diversity, which quantifies the evolutionary history within a community (Grab et al., 2019). Phylogenetic diversity can be thought of as the distance between species on a phylogenetic tree; the greater the distance, the greater the phylogenetic diversity. The distribution of species abundance indicates community structure and is widely accepted as a key component of biodiversity theory and research in the scientific community (Antão et al., 2021). Thus, as pollinators support biodiversity, their abundance and diversity are simultaneously used as indicators of the overall ecosystem health (Gillis, 2021).

There are several strong relationships between the diversity, stability, and resilience of an ecosystem as a result of bee diversity. Resilience refers to the ability of an ecosystem or species to recover after experiencing a stressor, whereas stability is the ability to withstand those stressors. Consider a windstorm: a tree's ability to withstand the wind is its sustainability, and if the tree were to fall over during the windstorm, the tree's ability to recover and continue growing would be its resilience. In the case of bees, maintaining biodiversity is imperative for the stability, productivity, and resilience of ecosystems (Engströma et al., 2020), all factors used in assessing ecosystem health.

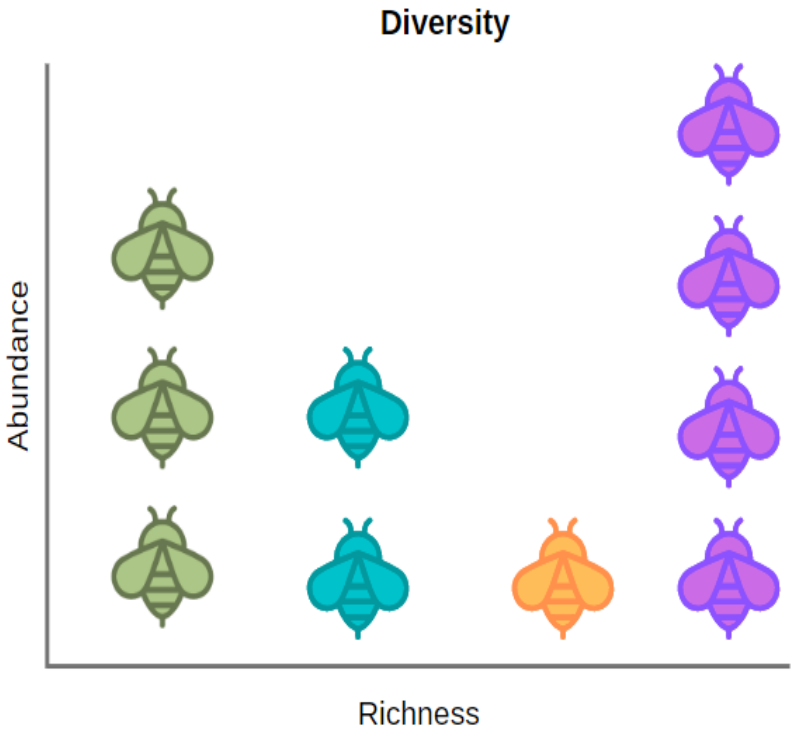

Figure 3 Richness is the number of species in an area (x-axis), as shown by the various colors (richness = 4). Abundance is the number of individuals per species (y-axis), as shown by the number of bees that are the same color. Species diversity describes a community's structure based on both richness and abundance.

Furthermore, studies have shown numerous relationships between bee biodiversity and the effects on crop quality and productivity. One such study found that as the ratio of agricultural coverage increases, bee species richness ($\beta = -0.28$) and phylogenetic diversity ($\beta = -0.34$) decrease; furthermore, as phylogenetic diversity increases, the number of seeds per fruit increases ($\beta = 0.12$), fruit weight increases ($\beta = 0.63$), and fruit malformations decrease ($\beta = -0.7$); moreover, as bee species abundance increases, fruit malformations decrease ($\beta = -0.52$) (Grab et al., 2019). One study found that as the number of apple seeds per fruit increased, the

percentage of misshapen apples decreased, weight increased, flesh firmness increased, calcium content increased, and in a few groups of apples the acidity increased (Buccheri & Di Vaio, 2005).

Overall, the diversity of bees plays one of the most influential roles in crop production and sustainability (Grab et al., 2019). Therefore, the monitoring of native bee species abundance and diversity is imperative for furthering our understanding of bees' vital role in ecosystems and what factors most affect them.

While there are many factors that influence bee diversity, abundance, and richness, recent studies suggest that the most crucial component is plant species richness and abundance (Gerner & Sargent, 2022). Gardens are able to support greater bee abundance and richness, and flower beds are able to support a greater diversity of bee species (Gunnarsson & Federsel, 2014), therefore, it is through the implementation of these resources and the increase of plant species richness and abundance that we can support bee conservation efforts, regardless of the degree of urbanization (Gerner & Sargent, 2022).

Reasons to NOT Buy or Import Bees

A simplistic solution to the declining bee population that has been frequently brought up is to merely buy bees, most commonly in the form of beekeeping. However, the notion that beekeeping is the solution to this global issue is a prominent lie that has been widely promoted to the public.

Native bees are specifically important to our ecosystems as they pollinate two to three times better than the more commonly known, but non-native, western honeybee (Apis mellifera) (Gashler, 2011). Native bees are also the primary pollinators for almost all plants (Communications & Publishing, 2015)! Honeybees were first brought over to the Americas by European settlers in the 17th century and have since been industrialized in the United States, creating inevitable stress on native bees.

While it is true that honeybees are heavily utilized in modern agriculture for crop pollination, the larger environmental picture is much less rosy when considering their impact on native bees. Honeybees can transmit diseases to native bees, destabilize natural ecosystems, and compete for the same resources as native bees (Center for Biological Diversity, 2020). Large-scale honeybee beekeeping has inevitably led to the misguided public understanding that honeybees are native, and that beekeeping will help "save the bees," when in reality, beekeeping honeybees can cause more harm than good and should not be seen as a viable solution to "saving the bees." Honeybees are incapable of supporting a healthy ecosystem. Not only that but, professor and conservation biologist Sheila Colla states that "beekeeping companies and various non-science-based initiatives have financially benefited from the decline of native pollinators" (McAfee, 2020). Misguided enthusiasm and support for the

upbringing of non-native bee species will only continue to harm native bees unless clear actions in support of native bees, backed by science, are taken.

While honeybees dominate the field when it comes to domesticated and commercially available bees, the Common Eastern bumblebee (Bombus impatiens) is exclusively reared and commercially available for pollination services in North America despite only being native to the eastern US and southern Canada (Bombus Task Force, n.d.). Regardless of the Common Eastern bumblebee not being native to the west coast, there are several reasons why our project refrained from the importation of commercial bumblebees and why we would advise others to do the same.

Robin E. Owen, from Mount Royal University, Canada, found that domestic bumblebees can unintentionally exacerbate detrimental effects on wild bee populations by spreading parasites and diseases. Despite having regulations that "screen" for microparasites, a majority of colonies shipped are still infected, with one study finding 37 of 48 colonies to be pathogen carrying. These microparasites are highly infectious and liable to spread very rapidly to wild bee populations, which can kill our wild pollinators or leave them permanently deformed and unable to fly (Owen, 2016). Either way, the consequences and risks associated with the importation of bees are simply too great when working with an already declining bee population. Thus, under the principles of nonmaleficence, which states that the primary concern is to do no harm, it is unethical for us to be engaging in the purchasing and importing of bumblebees.

Bee Monitoring

The rapid decline of our key pollinators creates a drastic need for wild bee documentation and monitoring. By monitoring wild bees, we can begin taking steps to determine conservational habitat types, impacts of human activities and landscaping practices on wild bees, and if efforts aimed at conserving native bees are producing beneficial results (Agrilinks Team, 2020). Moreover, it is important for us to understand how climate change and introduced bee species are changing the structure of bee communities, as these may provide insight about the future resilience of ecosystems with ongoing climate change. With the utilization of bee monitoring, a campus can assess its bee diversity and abundance, which is crucial for establishing a baseline of a campus's ability to support native bees. Furthermore, the creation of a baseline for a campus will allow for bee population fluctuations to be tracked over time, aid in assessing how landscaping practices are promoting or inhibiting bees, and help create a larger picture for general species trends. However, it is vital to utilize the correct sampling procedures to answer these queries. If the wrong methodologies are used, results may be invalid, and the resulting conclusions may be suspect, if not outright false and misleading (Agrilinks Team, 2020).

Campus Bee Monitoring

When comparing the effectiveness of various bee sampling methods, including observational records, targeted netting, mobile gardens, pan traps (blue and yellow), vane traps (blue and yellow), and trap-nests, it was found that observational records were most effective in capturing the abundance of bees. However, many observational practices are unable to distinguish finer details of bees on the taxonomy level. When capturing individuals to obtain taxonomic identification, targeted sweep netting was shown to vastly outperform passive sampling methods (Prendergast et al., 2020).

However, due to the cost of professional sweeping nets, difficulties employing the technique, large-scale accessibility issues, and possible risks to the monitors and the bees, we determined that for the purpose of citizen-based monitoring, it is best to use the transect method of collecting data through observation. When comparing other organizations' citizen science methodologies, the primary method utilized was strictly observational, as seen in the Xerces Society monitoring protocols (Ward et al., 2014), Washington State University's (WSU) native bee field guide (Bloom, n.d.), and WSU's citizen science guide to wild bees (Bloom & Crowder, n.d.). The Xerces Society was additionally successful in identifying that two 15-minute observations documenting abundance of native bees on flowers, ideally two to three weeks apart and during the height of the growing season, produce sufficient data to generate a good estimate of both abundance and diversity of bees visiting that particular site (Ward et al., 2014). Hence, one year's worth of monitoring over several plants and sites would be sufficient to produce a general representation of a campus's baseline for supporting native bee populations.

The aim of monitoring bees is to aid in our understanding of bee populations' overall health and to help us address areas in which we can assist conservation efforts. To help researchers in this endeavor and to identify your campus's native bee populations, join the first nationwide effort in native bee monitoring through the US National Native Bee Monitoring Research Coordination Network (see Appendix D). Through this network, bee monitoring volunteers can contribute data to several national projects. The Xerces Society has additionally created several bee monitoring tools, which include protocols, datasheets, and helpful identification tools for nearly every region within the United States (see Appendix D).

Citizen Science Training Resources

For bee monitoring to be successful on any urban campus, there must be a public outreach effort. Bee monitoring relies on citizen science and volunteer interest for the longevity and success of a project. Fortunately, there has been a great success in citizen scientists efficiently collecting data on native bees in urban settings; data suggest that with prior training and continued engagement, citizen scientists were able to efficiently collect accurate data

comparable to that of expert data collections (Mason & Arathi, 2019).

For volunteers to succeed in efficiently collecting data, there must be a training program prior to the start of monitoring that lasts approximately two hours and can be composed of numerous resources. For instance, the Native Pollinators of Western Washington and the Xerces Society provide exemplary videos for bee identification and the implementation of pollinator-friendly landscaping practices (see Appendix D). The Great Sunflower Project also provides identification bee-cards, which are an excellent resource for all skill levels in identifying bees based on physical characteristics, pollen transportation method, foraging type, and active seasons (see Appendix D). Each card also gives information about the species' food and nesting resources, along with a fun fact. For additional aid in identification, the Xerces Society has created a bee morphogroup cheat sheet that provides a great summary of the various characteristics belonging to each group (see Appendix D).

Volunteer Recruitment and Retainment

When recruiting volunteers, the largest component to having a successful outreach is being able to target a wide audience. To do this, the opportunity as well as details about what the volunteers will be doing need to be easily accessible and publicized. This can be done via social media, flyers/posters, emails, webpage links, or during community events. Hosting a community event is yet another way to spark public interest and involvement. Consider hosting bee-friendly gardening demonstrations with native plant seed giveaways or advocating at a public market booth.

Campuses in academic settings have additional options for aiding in the recruitment of volunteers. In university settings, bee monitoring could be offered as an undergraduate research elective. At Seattle University, this would be considered a 3990 BIOL elective credit that could range from one to three credits, depending on the student's time commitment, and offered Spring and Summer quarters. Secondary school campuses could make bee monitoring an activity for environmental clubs to engage in or could consider making a designated bee club that focused on a variety of conservation practices.

Once volunteers join the project, it is vital to retain volunteers by engaging with the volunteers' work and acknowledging their efforts. Supporting volunteers could include bringing in an expert in native bees for the first on-site monitoring. Many universities may be able to assist in the recruitment of an expert or may have connections or suggestions for how to get in touch with one. Other ways to keep volunteers engaged is by highlighting the impact their volunteering has. At the end of every season, show volunteers the data they collectively obtained and what this may indicate about the bees on campus. Volunteers can also be featured on social media as an acknowledgment of their efforts, as this both shows gratitude and helps to spread awareness of the project. Small tokens of gratitude, such as giving

volunteers native plant seeds as a thanks or issuing certificates of appreciation at the end of every season is yet another efficient way to keep volunteers involved. Lastly, the power of a bi-weekly newsletter is too often overlooked. Newsletters are a great way to send out reminders about monitoring dates, tips for bee identification, or other interesting and relevant research. The more communication there is with the public and volunteers, the greater the retention rate of volunteers and interest will be.

Landscaping

"Bloom gap" describes a period of two weeks or more when there are no plants in bloom per campus block from March to November. Although the terminology and the parameters of a bloom gap vary from resource to resource, our definition was decided based upon the ease of quantifying these parameters, location in the PNW region, and the average flight distance of bumblebees (which is about one-third to one mile (Schweitzer et al., 2012). However, it is important to note that flowering periods can vary from species, latitude, elevation, weather, and year-to-year variation, making the parameters of a bloom gap vary from location to location (Vaughan et al., 2006). In general, the aim is to provide abundant food resources to bees for the entire duration that they are active.

Studies have shown that food limitations related to bloom gaps have led to bumblebee nest failure, accentuating the need for providing reliable nectar and pollen supplies when bees are active from spring to late summer; in the PNW region, this is typically March to November (Schweitzer et al., 2012). Similarly, botanical diversity contributes to the diversity of bee species, which offers resilience to an ecosystem. Thus, by supplying plants with overlapping bloom periods for the whole season, we can aid in increasing bee abundance, diversity, and richness.

Charting Campus Bloom Gaps

Charting bloom gaps on campus is necessary for determining where there are food limitations, what those limitations are, and how to fix them with plants that provide overlapping bloom periods. This process begins with two major steps: mapping and identifying.

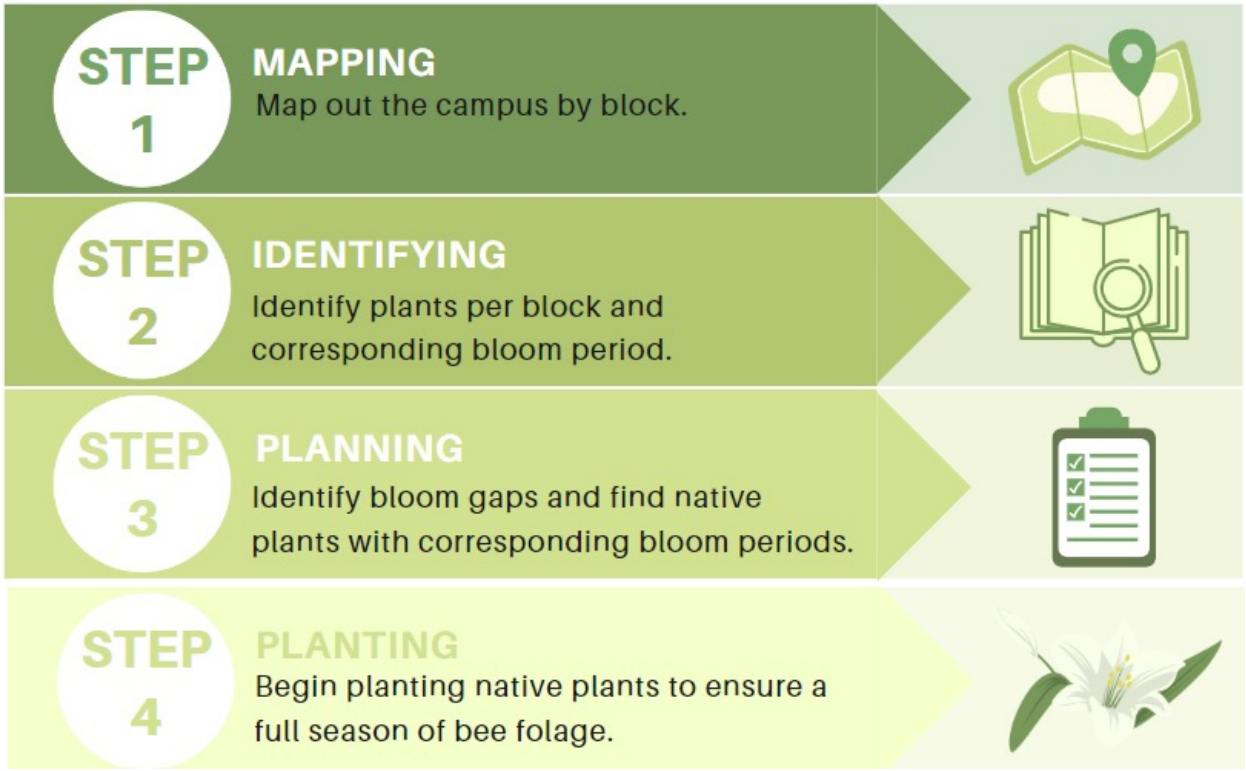

Figure 4 Four generalized steps for urban campuses to follow for improving landscape for pollinators

The simplest way to organize the location of plants on a campus is by creating a grid using block identifications that correspond to the desired campus map. Place letters on the y-axis and numbers on the x-axis, allowing for specific block locations to be identified in a numerical fashion and making it easier to identify plant locations based on the parameters set for a bloom gap (see Figure 6).

Once a grid system has been established it's time to determine what plants are already in these spaces and their associated bloom periods. Begin step two by filling out a Bloom Chart for each block (see Figure 5). For help identifying plants, there are several smartphone apps that are excellent resources for this: PlantSnap, PLANTA, and LeafSnap.

Each plant's bloom period can be identified via plant databases or by observing and logging what plants are in bloom over the course of a year. Both the Lady Bird Johnson Wildflower Center and the USDA Natural Resources Conservation Service offer phenomenal plant database centers for researching plant bloom periods and growing restrictions (see Appendix D).

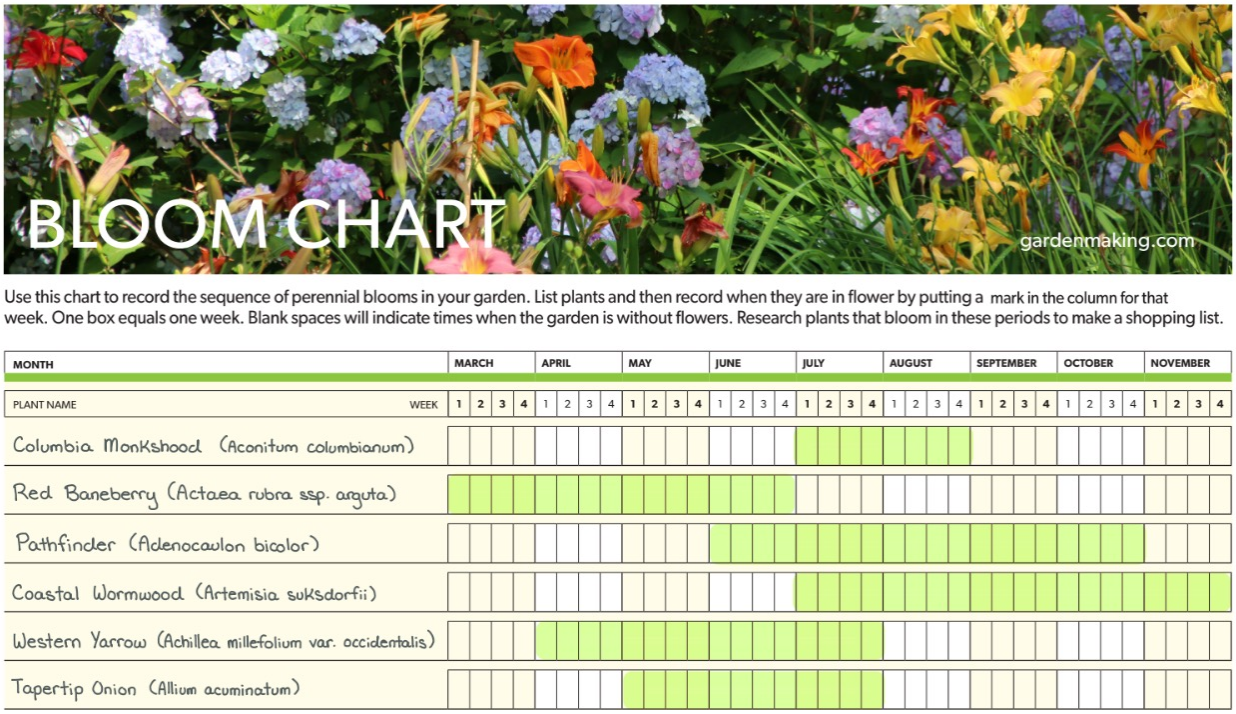

Figure 5 Example of a filled-out Bloom Chart used for identifying individual plants and their bloom periods. See Appendix A for access to the Bloom Chart pdf file. From GardenMaking.com, by Judith Adam, 2016.

The goal of using the bloom chart is to have at least three different plant species in bloom every month from March to November (assuming the region experiences cold months below 50°F from December to February). Each plant contributing to the Bloom Chart should cover a minimum of 10% of the total surveying area when consolidated. For instance, an individual strawberry plant is an insufficient contributor as it is not substantial enough to support various pollinators. But if there are several strawberry plants that, when combined, would make up at least 10% of the area, then the strawberry plant can be classified as a significant contributor and should be documented on the Bloom Chart.

For additional aid in mapping out the overall bloom gaps on a campus, a color-coded chart can be generated using the Bloom Chart data to visually represent what areas of the campus are in the most need of improvement.

Figure 6 Example map of Seattle University identifying bloom gaps by block via color. Light green indicates no bloom gap and sufficient foliage for pollinators all year around (March – November). Dark green denotes a one-month bloom gap; yellow a two-month bloom gap; orange a three-month bloom gap; and red anything with four or more months of bloom gaps.

Visual representations of data can be extremely beneficial when communicating with a wide audience about the conclusions of a campus's ability to sustain pollinators, and for practicality purposes when it comes to planning landscaping renovations.

Finding Native Plants

With the campus bloom gaps now identified by block, it's time to identify what native plants can used to fill those voids. The easiest way to go about this is by looking for native plants whose bloom periods correspond to the bloom gaps identified in the previous step.

An excellent resource for finding native plants for PNW gardening is the King County Native Plant List (see Appendix D). However, the list provided is inconclusive as it does not state the bloom periods of these plants. Thus, I have created a complimentary King County Native Plant Bloom Period Chart (see Appendix B) for all 150 plants that correspond to the native plants provided by King County. The King County Native Plant Bloom Period Chart can be used to easily identify PNW native plants and their blooming periods.

For the Inland Pacific Northwest region, the Pullman Plant Materials Center can be used to identify both native and non-native plants, which can aid in choosing plants that will close any remaining bloom gaps (see Appendix D).

If you do not live in the Pacific Northwest region, the Xerces Society for Invertebrate Conservation has compiled lists of native plants with blooming durations specific to various regions of the United States (see Appendix D). The USDA Natural Resources Conservation Service also provides a thorough plant list and indicates which plants are native to each state and habitat setting (see Appendix D).

Once the desired native plants have been identified, it's time to start purchasing plants and getting ready for gardening! But beware: while it may be tempting to run down to the store and buy plants to help supply food for the bees, there is a dark side to many mainstream nursery plants that is harming our bees.

As we all know, pesticides are harmful to the bees; however, neonicotinoids remain the most prevalent insecticide used in the United States and are annihilating entire ecosystems (Burd, 2021). Even low-level exposure to neonicotinoid pesticides can cause severe damage to bees, including "compromised immune system[s], altered learning, and impaired foraging, effectively exacerbating the lethality of infections and infestations" (Brown et al., 2013, p. 3). And these pesticides can be found on nursery plants at stores like Home Depot, Lowe's, and the Orchard Supply Hardware store. These garden plants expose bees to these deadly pesticides.

Unfortunately, these pesticides can't just be rinsed off with water as the toxins are taken up through the roots and leaves of plants and distributed throughout the plant, lasting in the plants for months to even years after the initial treatment. But there are preventative measures that can be taken to avoid the risk of exposure.

<u>Preventing Neonicotinoid Exposure</u>

- Ask your local plant nurseries about their pesticide practices before buying.
- Purchase organic plant starters and organic soil for your gardens.
- Buy untreated seeds.
- Use bee-friendly alternatives for unwanted pests, such as neem oil, Organocide® Bee

Safe 3-in-1 Garden Spray, or the Mighty Mint®.

- Buy from local nurseries who specialize in native plants.
- Spread the word and notify other gardeners of the dangers of neonicotinoids.

Landscaping Practices

While creating a foraging habitat is a vital component of conservation efforts, it does not always fully address the needs of all bee species. A foraging habitat entails floral plants that provide food resources to bees, while a nesting habitat can include a number of factors like providing suitable homes to bees. For instance, many landscaping practices focus on floral abundance but may limit available nesting resources to bees. With nesting resources being a primary limiting factor for most bee populations' growth and diversity, it is important to modify landscaping practices that reflect these needs in order to create an effective and holistic conservation approach (Buckles & Harmon-Threatt, 2019).

Landscaping Practices That Can Aid in Bee Conservation

- Leave areas of bare soil undisturbed and untilled.
- Refrain from adding organic matter to potential nesting sites.
- Provide grassy thickets.
- When winter comes, leave the leaves.
- Minimize ground disturbances.
- Check for dwelling bees before pruning perennials or moving logs and rocks.
- Mow at low speed when flowers are not in bloom, such as in the fall or winter.
- Avoid the use of pesticides or use bee-friendly alternatives (see "Ways Everyone Can Help").

For a full assessment of pollinator habitat in yards, gardens, and parks, see the Xerces Society Habitat Assessment Guide (see Appendix D).

Public Awareness

Public awareness is an essential component of every conservation effort. Not only does awareness increase enthusiasm and help to mobilize community involvement, but it also helps to consolidate local resources which can be utilized to make policy changes that strengthen conservation efforts. Raising awareness is the first step to making change, and the lack of public awareness is what hinders public involvement in conservation efforts and may be a contributing factor to the spread of misinformation.

Surveying Public Knowledge

The aim of surveying the community was to gain insight into what exactly can be classified as common knowledge and what is commonly misunderstood when discussing bees. Exposing common misconceptions and identifying common knowledge helped inform what information would be most beneficial when spreading awareness. Furthermore, as the conservation of bees is a societal effort, the support and public understanding of the issues is fundamental to stopping the decline of native bees. Without understanding, the problem cannot be recognized or addressed.

The survey results provided suggest several areas of common knowledge and several key misconceptions which are crucial for addressing how to best communicate conservation importance and practices involving native bees. With 46% of participants selecting that all native bees are hive-dwelling and 65% selecting that all native bees live in colonies, both of which are inaccurate, this indicates that there is either a lack of public awareness about the majority of native bees' social behaviors or a lack of common knowledge about the existence of solitary bees as a whole. Thus, it is advised that educational opportunities address the need to inform the public about solitary bees and the non-native status of the honeybee, as these were some of the broadest misconceptions observed. Not only that, but the notion that honeybees are native is major driver of the common belief that beekeeping is a conservation practice and beneficial for the bee populations, when, in reality, it is the exact opposite.

The results additionally revealed that educational signage may be one of the most beneficial methods of spreading awareness on an urban campus setting. In particular, displaying various strategies for how the general public can partake in bee conservation efforts proved to be beneficial for piquing engagement as approximately 83% of participants stated they would most likely use at least one of the listed conservation practices mentioned in the survey. Strategies mentioned in the survey infographic included details about alternatives for using pesticides (ex. Neem oil), providing water sources, growing native plants, providing bee housing/habitat, and buying organic and/or Bee Better Certified™ foods (see Appendix D).

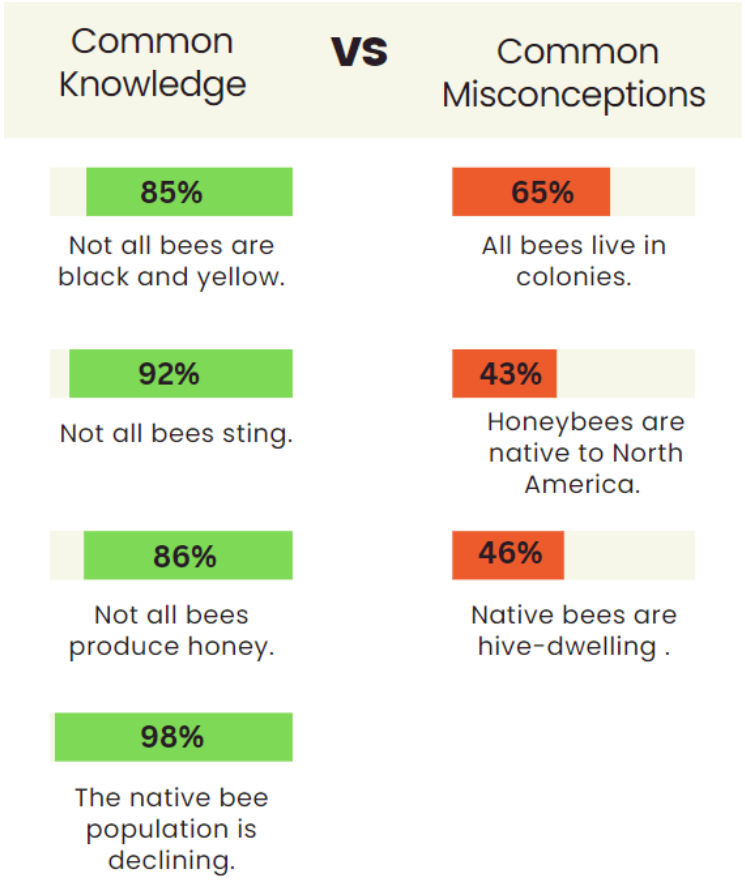

Figure 7 Generalized summary of survey findings. The survey was sent out to SU community members and when comparing the participant breakdown of survey submissions by school to the number of individuals enrolled in each school (Seattle University, 2021) it was found that survey results accurately depicted SU's demographic with the exception of the Alberts School of Business & Economics, and the College of Nursing, whom were both underrepresented in these results. Green indicates the percentage of participants who accurately answered the statements listed below them, and red denotes the percentage of participants who have the misconceptions listed below.

In sum, the data show that educational efforts should predominantly focus on breaking down the misconception that honeybees are native and that beekeeping is a viable conservation practice, as well as demonstrating the diversity of native bees and their varying needs.

Garden Considerations

Should a full pollinator-dedicated garden be implemented on an urban campus, there are several important factors to consider.

The first is accessibility to the area and to educational materials discussing native bees or pollinators. A vital aspect of creating a successful educational garden is to make the area an inclusive experience. Inclusive gardens should incorporate trails accessible to those with

mobility barriers and provide educational materials, such as signage, that can serve a variety of learning needs.

To create trails that are accessible to persons with disabilities, the trails should be firm and stable, as well as resilient to weather (USDA Forest Service, 2012). One method the Catoctin Mountain Park used for creating wheelchair-accessible terrain was to use WoodCarpet® Bonded 1, a natural product that contains no chemicals or artificial ingredients (U.S. National Park Service, 2021). A perk of this terrain design is that it provides both stable support and water drainage to avoid the trails from getting soggy, an important component for areas with frequent rain (Zeager Bros. Inc., 2022). Furthermore, wheelchair accessibility ramp requirements should always be major considerations when designing garden pathways to ensure safety and mobility for all guests to enjoy.

To provide accessibility for educational opportunities, both language and seeing impairments should be considered. A solution to language inclusivity is to provide QR codes on educational materials such as signage that link to the same information in various languages, especially those most prevalent in a given region. In the King County district alone, 170 languages are spoken, with Spanish, Chinese, and Vietnamese being the three most common following English (Felt, 2017). The same method of using a QR code can be used for those with visual impairments. Braille indicators can be placed on the signage next to a QR code that informs readers of the location of the QR code, which may then read out loud the sign's informational content upon scanning. Braille QR stickers can be easily purchased through the Braille House non-profit organization for as little as $3.30 a sticker (see Appendix D).

When accessibility is incorporated into garden layouts, it helps strengthen communities by supporting disability justice and equitable opportunities.

Suggested Signage

Signage can be used in numerous settings as an educational outreach tool capable of reaching a wide audience. When designing signage for campuses and urban gardens, my survey data indicate that there are three key points to emphasize:

1. Debunk common misconceptions.
2. Have an interactive aspect.
3. Provide methods for getting involved.

Some common misconceptions to tackle, according to the survey results, include stating that the honeybee is not native to North America, asserting the existence of solitary bees, and stating that most solitary bees are primarily ground-nesting dwellers.

Having an interactive aspect to the signage will not only contribute to the public's knowledge but will create an opportunity for the public to engage with the material and encourage the exploration of the campus. An interactive piece could include displaying images of the local plants on the campus that provide foraging resources to the bees from March to November (as seen in Figure 8). Not only does this demonstrate how the campus has worked to avoid bloom gaps, but it also gives people an idea of what they could plant in their yards to achieve the same goal and will allow people to actively search for these plants on the campus. Another suggestion is to include images of several types of native bees or pollinators, showcasing some of the region's diversity and providing people an opportunity to actively search for them on the campus.

Figure 8 Example signage. See Appendix C for access and for additional signage examples/options.

Lastly, it is important for both the longevity and outreach of the project that methods for getting involved are provided. Individuals who actively engage with the signage are more likely to get involved with the campus's bee monitoring compared to individuals who don't. Thus, it is the perfect opportunity to advertise how people can get involved in campus bee monitoring projects. Additionally, the survey suggests that providing information on how individuals can take action to help native bees is beneficial, as the majority of participants claimed that they would most definitely use at least one of the methods provided in the infographic.

The United States Geological Survey (USGS) Bee Inventory and Monitoring Lab has compiled an excellent photo catalog of bees that is in the public domain and is an exemplary resource for creating or editing educational signage and posters (see Appendix D).

Ways Everyone Can Help

When providing resources for how people can help partake in bee conservation, it is important to keep in mind varying financial statuses, accessibility to resources, and the practicality of the methods being provided. Here are just a few methods that provide people with tools to participate at a variety of levels:

- Plant Native Plants: Native bees have evolved to feed on native plants. Plant a large variety of plants to support a large variety of pollinators.
- Full Season of Bloom & Food: Select plants with overlapping blooming periods from March to November. This provides pollen and nectar throughout the entire season for bees to feed on.
- Provide Water: Provide a shallow dish of water such as a frisbee with marbles in it.
- Provide Nesting Resources: This can be as simple as leaving a dirt patch undisturbed in the yard or leaving plant stem clippings in the yard.
- Avoid Pesticides: Instead, use organic alternatives for unwanted pests, such as neem oil, Organocide® Bee Safe 3-in-1 Garden Spray, or the Mighty Mint®.
- Buy Bee-Friendly Foods: Buy organic foods when possible and look for foods, such as cherries, blueberries, and even Haagen-Dazs® ice cream, with the Bee Better Certified™ seal.
- Become a Bee Monitoring Volunteer: Share your findings with iNaturalist or download the Insight Citizen Science app to become a volunteer! This helps scientists monitor the abundance and distribution of bees. Or join the Friends of the Earth Bee Action campaign to petition retailers to stop selling neonicotinoid pesticides!

Conclusion

Urban campuses such as company property, public parks, and universities all play a vital role in the conservation of our native pollinators. The monitoring of native bees and enhancement of pollinator habitats and foraging resources are the first steps towards stopping the decline of our native bees. The initial steps of assessing a campus' ability to sustain wild bee populations should take approximately one year and another one or two years to improve it through the implementation of landscaping practices. While this guide focuses heavily on the PNW region of Washington state, it can also be utilized as a reference for other regions and altered to the specifications of the region. Through community education and involvement, we can begin to take the necessary actions required to stop the decline of our native bees and help save our ecosystems.

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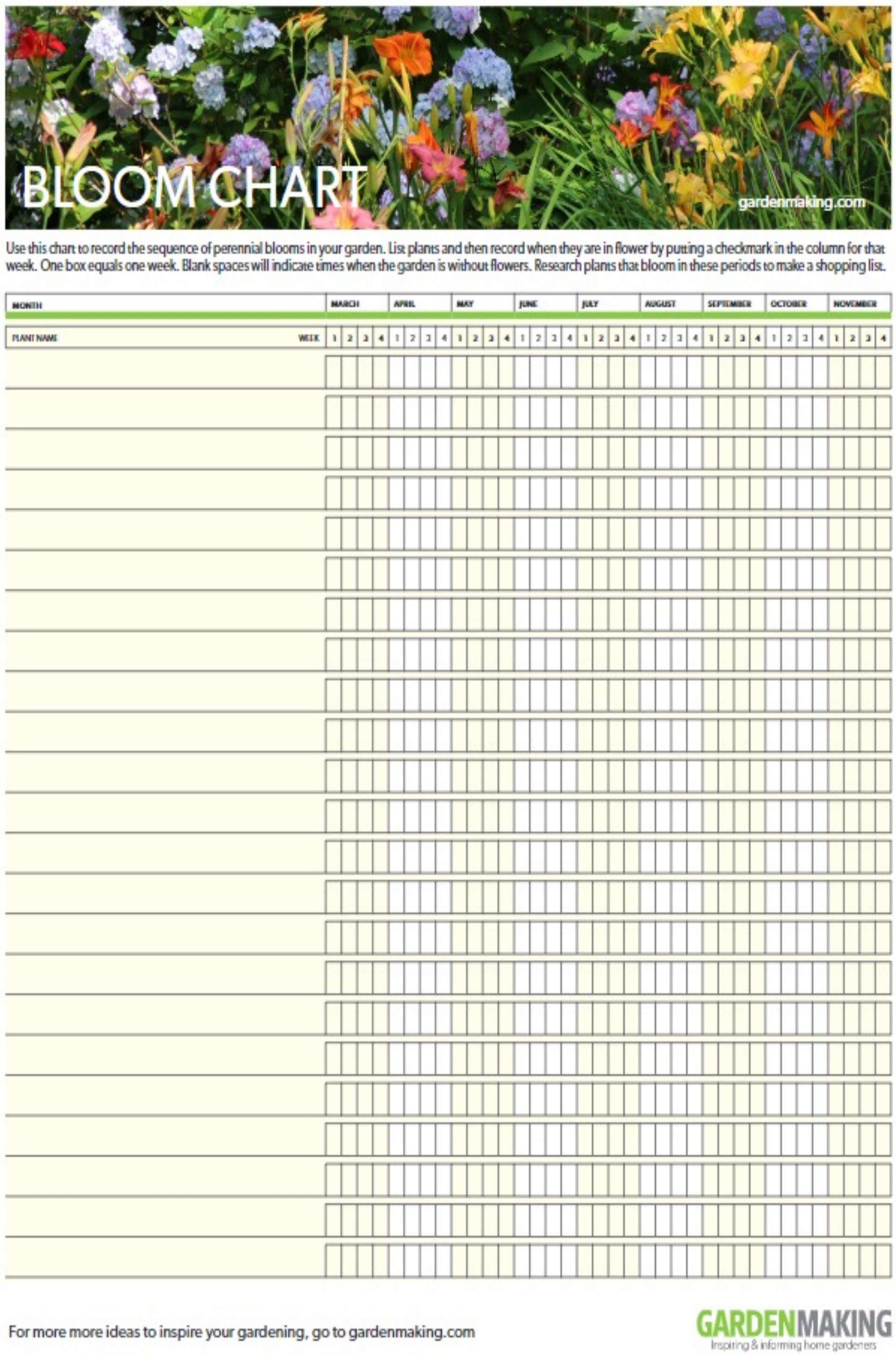
Appendix A
Step 1: Bloom Chart


BLOOM CHART

gardenmaking.com

Use this chart to record the sequence of perennial blooms in your garden. List plants and then record when they are in flower by putting a checkmark in the column for that week. One box equals one week. Blank spaces will indicate times when the garden is without flowers. Research plants that bloom in these periods to make a shopping list.

MONTH	MARCH				APRIL				MAY				JUNE				JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER			
PLANT NAME WEEK	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

For more more ideas to inspire your gardening, go to gardenmaking.com

GARDENMAKING

Inspiring & informing home gardeners

Figure A1 Bloom Chart. PDF Access Link: https://1drv.ms/b/s!Ar3A7iDzUFmTngq1nkvsjdqCuvHl (Adam, J. 2016).

Appendix B
King County Native Plant Bloom Period Chart

Bloom period information was derived from the Lady Bird Johnson Wildflower plant database (Lady Bird, 2022).

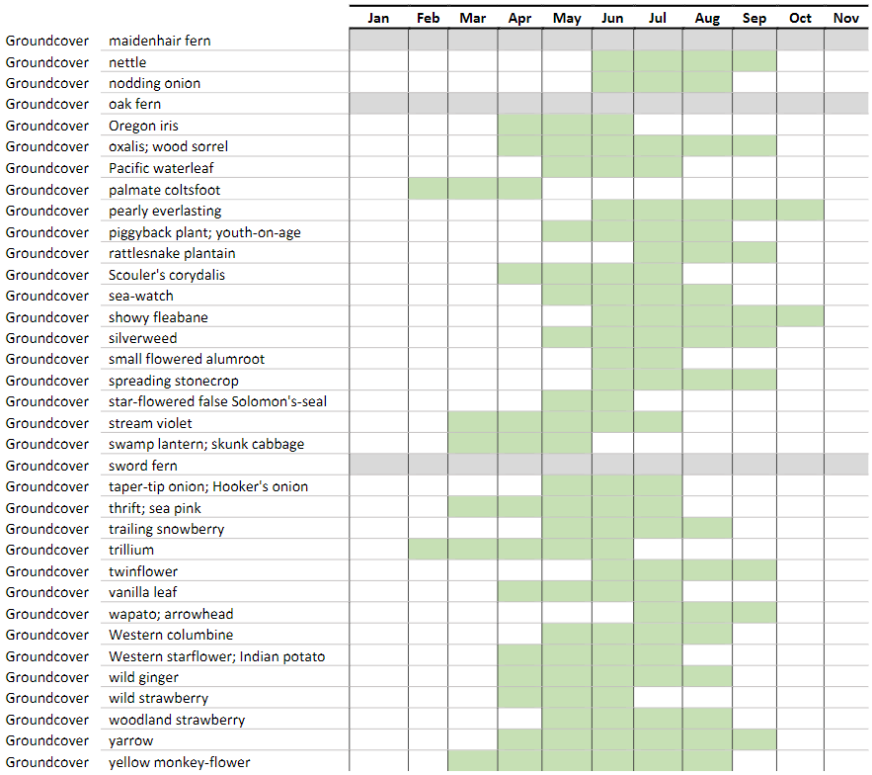
King County Native Plant Bloom Guide

(https://green2.kingcounty.gov/gonative/Plant.aspx?Act=list)

		Bloom Month										
Type	**Common Name**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
Tree	bigleaf maple				■	■						
Tree	bitter cherry				■	■						
Tree	black cottonwood				■							
Tree	black hawthorn					■	■					
Tree	cascara				■							
Tree	Douglas' Maple				■	■						
Tree	Douglas-fir				■							
Tree	gand fir				■	■						
Tree	Hookers willow			■	■							
Tree	madrone; madrona			■	■	■						
Tree	Oregon ash				■							
Tree	Oregon white oak; Garry oak			■	■	■						
Tree	Pacific crabapple				■	■						
Tree	Pacific dogwood				■	■	■	■				
Tree	Pacific willow			■	■	■	■					
Tree	paper birch				■							
Tree	quacking aspen				■	■						
Tree	red alder			■	■							
Tree	shore pine				■	■						
Tree	Sitka spruce				■	■						
Tree	Sitka willow			■	■							
Tree	slide alder					■	■					
Tree	vine maple			■	■	■						
Tree	Western hemlock				■							
Tree	Western redcedar				■							
Tree	Western white pine				■							
Tree	yew						■	■				
Shrub	blad hip rose				■	■						
Shrub	beaked hazelnut	■	■	■								
Shrub	black cap raspberry				■	■						
Shrub	black gooseberry					■	■					

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	blue elderberry											
Shrub	bog laurel											
Shrub	bog rosemary											
Shrub	devil's club											
Shrub	evergreen huckleberry											
Shrub	hairy manzanita											
Shrub	highbush cranberry; mooseberry											
Shrub	hybrid manzanita											
Shrub	indian plum; osoberry											
Shrub	low Oregon grape											
Shrub	mock orange											
Shrub	nootka rose											
Shrub	oceanspray											
Shrub	Oregon box											
Shrub	Pacific ninebark											
Shrub	Pacific rhododendron											
Shrub	Pacific wax myrtle											
Shrub	red elderberry											
Shrub	red huckleberry											
Shrub	red stem ceanothus											
Shrub	red-flowering currant											
Shrub	red-osier dogwood											
Shrub	salal											
Shrub	salmonberry											
Shrub	serviceberry; juneberry											
Shrub	snowberry											
Shrub	snowbrush; sticky laurel											
Shrub	spiraea; hardhack											
Shrub	stink currant											
Shrub	subalpine spirea											
Shrub	swamp rose; clustered wild rose											
Shrub	sweet gale											
Shrub	tall Oregon grape											
Shrub	thimbleberry											
Shrub	twinberry											

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	white spitea; shiny-leaved spirea											
Groundcover	beach strawberry											
Groundcover	bleeding heart											
Groundcover	blue-eyed grass											
Groundcover	bracken fern											
Groundcover	broad-leaved stonecrop											
Groundcover	bunchberry											
Groundcover	camas, common											
Groundcover	camas, great											
Groundcover	Cascade penstemon											
Groundcover	chocolate lily											
Groundcover	coastal gumweed											
Groundcover	columbia lewisia											
Groundcover	common harebell											
Groundcover	Cooley's hedge nettle											
Groundcover	cow-parsnip											
Groundcover	deer ferm											
Groundcover	Douglas aster											
Groundcover	edible thistle											
Groundcover	false lily-of-the-valley											
Groundcover	false Solomon's-seal											
Groundcover	farewell-to-spring											
Groundcover	fireweed											
Groundcover	foam flower											
Groundcover	fringecup											
Groundcover	goat's beard											
Groundcover	golden eyed grass											
Groundcover	goldenrod											
Groundcover	graceful cinquefoil											
Groundcover	Hendersons checker mallow											
Groundcover	inside-out flower											
Groundcover	kinnikinnik; bearberry											
Groundcover	kneeling angelica											
Groundcover	lady fern											
Groundcover	licorice fern											



		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Groundcover	maidenhair fern											
Groundcover	nettle											
Groundcover	nodding onion											
Groundcover	oak fern											
Groundcover	Oregon iris											
Groundcover	oxalis; wood sorrel											
Groundcover	Pacific waterleaf											
Groundcover	palmate coltsfoot											
Groundcover	pearly everlasting											
Groundcover	piggyback plant; youth-on-age											
Groundcover	rattlesnake plantain											
Groundcover	Scouler's corydalis											
Groundcover	sea-watch											
Groundcover	showy fleabane											
Groundcover	silverweed											
Groundcover	small flowered alumroot											
Groundcover	spreading stonecrop											
Groundcover	star-flowered false Solomon's-seal											
Groundcover	stream violet											
Groundcover	swamp lantern; skunk cabbage											
Groundcover	sword fern											
Groundcover	taper-tip onion; Hooker's onion											
Groundcover	thrift; sea pink											
Groundcover	trailing snowberry											
Groundcover	trillium											
Groundcover	twinflower											
Groundcover	vanilla leaf											
Groundcover	wapato; arrowhead											
Groundcover	Western columbine											
Groundcover	Western starflower; Indian potato											
Groundcover	wild ginger											
Groundcover	wild strawberry											
Groundcover	woodland strawberry											
Groundcover	yarrow											
Groundcover	yellow monkey-flower											

Figure B1 King County Native Plant List Bloom Period Chart. Access: https://1drv.ms/b/s!AhJXdJ0MImngbi_6TvVxjxcApyw?e=MmxWxU

Appendix C
General Exemplary Bee-Friendly Educational Campus Signage

This appendix consists of examples of bee-friendly educational campus signage which can be customized to individual campus' needs. No permission is required for the use or editing of the signage.

Figure C1 Example signage.

Figure C2 The template version of the Figure 8 signage can be accessed via Canva: https://www.canva. com/design/DAE-L2FEBT4/gUUtEbjuXqLTeXSNq_42rQ/ view?%20utm_content=DAEL2FEBT4&utm_ campaign=designshare&utm_medium= link&utm_%20source=publishsharelink&mode=preview

Appendix D
Additional Resource Links

- **The Great Sunflower Project Bee Flash Cards**
  www.greatsunflower.org/node/1143570
  Excellent resource for citizen scientists to practice bee identification.

- **The Great Sunflower Project Bee-Cards**
  https://tenstrands.org/wp-content/uploads/2020/09/Bee-Cards.pdf
  Provides field cards for bee identification and associated species characteristics.

- **Bee Better Certified**
  https://beebettercertified.org/
  Information about what consumable goods are Bee Better Certified.

- **Braille House**
  www.braillehouse.org.au/product/tactile-qr-code-indicator/
  Sells Braille barcode stickers for accessibility purposes.

- **Xerces Society Citizen Science Monitoring Datasheet: Native Bees**
  www.xerces.org/sites/default/files/2018-05/16-013_01_XercesSoc_Citizen-Science-Monitoring-Datasheet_Native-Bees_web.pdf
  Datasheets for citizen science native bee monitoring.

- **King County Native Plant List**
  https://green2.kingcounty.gov/gonative/Plant.aspx?Act=list
  List of native plants within the Seattle, WA, King County area.

- **Lady Bird Johnson Wildflower Center**
  www.wildflower.org/plants/
  Database for identifying native plants for any region within the United States.

- **Xerces Society Maritime Northwest Bee Morphogroups Cheat Sheet**
  www.xerces.org/sites/default/files/2018-05/17-016_01_XercesSoc_Citizen-Science-Monitoring-Guide_MaritimeNW-Cheat-Sheet_web.pdf
  Summary sheet of bee morphogroup characterization.

- **Xerces Society Maritime Northwest Citizen Science Monitoring Guide**
  www.xerces.org/publications/id-monitoring/maritime-northwest-citizen-science-monitoring
  Northwest (WA) bee monitoring guide for citizen science.

- **Native Pollinators: Garden & Habitat Restoration**
  https://youtu.be/zwnUTJjv6Os
  Educational video for implementing landscaping practices that are beneficial to pollinators.

- **Pullman Plant Materials Center**
  https://s3.wp.wsu.edu/uploads/sites/2061/2022/03/PPMCPlants4PollinatorsInTheInPNW.pdf
  List of native and non-native plants for pollinator habitat in the Inland Pacific Northwest, WA.

- **United States Geological Survey Bee Inventory and Monitoring Lab**
  www.flickr.com/photos/usgsbiml
  Public domain bee photos.

- **USDA Accessibility Guidebook for Outdoor Recreation and Trails**
  www.fs.usda.gov/sites/default/files/Accessibility-Guide-Book.pdf
  Provides requirements for creating accessible trails in outdoor settings.

- **USDA - Natural Resources Conservation Service**
  https://plants.usda.gov/home/stateSearch/stateSearchResults?resultId=89a85c69-c506-4084-a2e4-c34299d96767
  Native plant database for any region of the United States.

- **Xerces Classroom: North American Bee Diversity and Identification**
  https://youtu.be/_sOKGLn304s
  Educational YouTube video for bee identification.

- **Xerces Society Habitat Assessment Guide**
  https://xerces.org/sites/default/files/publications/19-038_01_HAG_Yard-Park-Garden_web.pdf
  Comprehensive list of landscaping practices beneficial to bees.

- **Xerces Society Pollinator-Friendly Native Plant Lists**
  https://xerces.org/pollinator-conservation/pollinator-friendly-plant-lists
  Native plant lists focused on various regions of the United States.

- **Zeager Bros. Inc. Landscaping & Recreation Surfaces**
  https://zeager.com/products/recreation/woodcarpet-system-1/
  Producer and provider of WoodCarpet® Bonded 1 pavement material.

Don’t Say Gay: An Examination of Florida’s Restrictive Education Policies and Potential Alternatives

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Student Editors: Nicole Beauvais, Katrina Manacio, and Luna Rivera Zapata

Abstract

Following the signing of Florida's HB 1577, also known as the "Don't Say Gay" bill, an influx of discriminatory and exclusionary bills were introduced across the country, reflecting a deeply concerning turn for education standards in the United States. The policy under scrutiny is the Florida bill by Governor Ron DeSantis that began this wave of harmful legislation, which has significant costs for queer and trans youth living in states considering similar regression in their education standards. The central part of the bill being scrutinized is the portion that denies educators the right to discuss gender identity and sexual orientation with third graders and younger while leaving older grades up to the school districts. The outright exclusion of queer topics and basic knowledge of gender identity and sexual orientation bars children in the United States from completely understanding themselves while simultaneously trapping queer children in environments with no access to safe spaces. These changes could perpetuate ongoing heightened rates of depression and suicide in LGBTQ+ youth, especially trans and gender nonconforming youth. Ultimately, positive alternatives must be introduced to support these marginalized communities in states where their safety and educational fulfillment are at severe risk. Three plans that would implement effective strategies positively impacting queer and trans communities include Nevada's AB 261, Oregon's LGBTQ2SIA+ Student Success Plan, and GLSEN's Common Core, each presenting unique alternative paths to exclusionary methodologies within Florida's "Don't Say Gay" bill. Through inclusive and intersectional policies that combat the original Florida decision, these states can see positive change with LGBTQ+ representative curricula and proper training for teachers in primary and secondary schools.

Section 1: Problem Definition

Introduction

Many Americans are familiar with the devastating acts of terror committed against the queer and trans communities in the United States; Florida is no exception to these occurrences. In fact, the deadliest terror attack since 9/11—and the deadliest act of violence against LGBTQ+ folks ever—was at Pulse Nightclub in Orlando, Florida with 49 people dead and 53 injured. Queer history is full of struggles for acceptance and liberation from oppressive societal norms, which are often reinforced by legal measures. In Florida, a 2008 citizen-initiated ballot measure resulted in the same-sex marriage and civil unions ban, later overturned by the landmark Supreme Court decision in Obergefell v. Hodges, which guaranteed the fundamental equal right for same-sex couples to marry. However, stigmatization and oppression still exist, especially for youth. In an opinion piece for the New York Times, Will Larkins reflects on a Halloween party from the previous October, where guys from their school surrounded them, shouting homophobic slurs and threatening the use of physical violence (Larkins, 2022). Larkins is also the president and co-founder of Winter Park High School's Queer Student Union and organizer of its Say Gay Anyway walkout. The Say Gay Anyway walkout responded to HB 1557, also known as the "Don't Say Gay" bill, Florida's latest homophobic and transphobic legislation, marketed under family values and parental liberties. The casual but harmful bullying Larkins outlined at the beginning of their story reflects the experience of most queer and trans youth in the United States, and Florida's bill will result in infinitely harmful consequences for LGBTQ+ children in its schools. This bill will remove any discussion of sexual orientation or gender identity from the classroom setting until third grade, and after third grade, school instruction must fall within vague, age-appropriate, state standards (Diaz, 2022). For Larkins, the place they felt comfortable expressing their distress and sadness was in school, as their teacher was able to be a source of comfort and safety (Larkins, 2022). While this situation occurred in high school, limiting a school's ability to teach or embrace queer and trans students at a young age will result in failure to address homophobia and transphobia within both primary and secondary schooling. While 72% of Americans believe homosexuality should be accepted by society, legislation and movements attempting to limit exposure and resources for LGBTQ+ Americans continue to grow following Florida Governor Ron DeSantis' signing of the "Don't Say Gay" bill (Poushter & Kent, 2020). The problem grows as Alabama, Ohio, and Louisiana seek to mimic the concepts and framework of the anti-queer legislation passed in Florida. With states determined to carry out concerted action against queer and trans communities, this paper aims to provide policy alternatives to present inclusive and effective planning in pre-implementation or already implemented stages of development. To adequately address the gravity of these issues, this paper will address the historical and contemporary

consequences of exclusive policymaking on the wellness and success of LGBTQ+ folks; then, it will offer and evaluate multiple policy alternatives, determining the most suitable programs.

Background and History of the Problem

Queer and trans movements for equal rights and liberation from oppressive systems have pioneered landmark national and state policy changes, one of the most significant recent achievements being the legalization of same-sex marriage in 2015. From the early 2000s until 2015, LGBTQ+ activists focused on gaining the equal right to marry their partner, and since that accomplishment, progressive policymaking has concentrated on anti-discrimination bills. Beyond anti-discrimination policymaking, many movements focus on trans exclusion in healthcare and further education on queer and trans topics for youth. In 2021 alone, there were 34 bills introduced in 21 states prohibiting healthcare for transgender youth, and there were over 50 submitted seeking to exclude transgender youth from athletics (American Civil Liberties Union, 2021). Though not all were adopted, these actions reflect the constant threat to queer and trans safety and acceptance in the United States.

For youth in the United States, there is a significantly limited capability to combat potentially harmful and hostile policies when survival depends on familial and societal acceptance of one's identity. Without social power and the stability of living within societal norms, queer youth face considerable mental and physical hurdles. In 2021, 42% of LGBTQ+ youth seriously contemplated committing suicide, including more than half of transgender and nonbinary youth (Paley, 2021). The Trevor Project further ties affirmation of transgender and nonbinary folks, such as respecting pronouns and allowing them to change legal documents, to lower suicide rates, reflecting the necessity of safe and supportive spaces for LGBTQ+ children and teenagers. With numerous bills introduced each year to limit access to healthcare and social activities, trans children are particularly vulnerable to discrimination.

On the positive side, legislative attempts relating to nondiscrimination protection, healthcare protection, and allowing updated gender markers on IDs similarly entered states in 2021. For example, Washington State signed into law legislation protecting the trans community, RCW 74.09.674, preventing exclusionary practices against gender-affirming surgeries. Through positive legal developments, queer and trans youth can grow into a more accepting world, where 43% of trans youth have not been bullied on school property (Roberts, 2020). These attempts to protect queer and trans youth are the beginning of establishing a better environment for young LGBTQ+ people, and it is essential to prevent discriminatory or targeted bills in the process.

Problem Analysis

In primary and secondary education, queer and trans youth face significantly more difficulties than their straight, cisgender peers—ranging from higher rates of suicide to healthcare exclusion. During 2021, the Trevor Project reported that 52% of transgender and nonbinary youth considered suicide, while 20% followed through with at least one attempt, which is a statistic easily worsened by discriminatory education standards that normalize the othering of queer folks (Paley, 2021). In Florida, the "Don't Say Gay" bill will perpetuate the ongoing issue of LGBTQ+ discrimination by prohibiting the discussion of sexual orientation and gender in school, a place that simultaneously harbors oppression and provides safe spaces. This bill will prevent educators and third-party instructors from providing necessary education and access to information for youth questioning their identities or who are already confident in them, banning any education on sexual orientation and gender identity in kindergarten through third grade (Parental Rights in Education, 2022). Though the bill excludes educators from providing teaching on sexual orientation and gender identity, the only exception is with authorized parental consent applied on an individual basis; however, this ignores the likelihood that a young child or teenager may be unwilling to talk with their immediate family about these topics, especially within an unsafe home environment. Without the option to ask, for students, or the opportunity to educate, for teachers, the "Don't Say Gay" bill will, in effect, eliminate one potential safe place that exists outside of a student's household influences. In 2021, 29% of gay and lesbian youth and 31% of bisexual youth reported being bullied on school property in the United States (Roberts, 2020). Simultaneously, more than 75% of LGBTQ+ youth reported facing discrimination based on their sexual orientation or gender identity at least once in their lifetimes, reflecting significant experiences their straight, cisgender peers are less exposed to (Paley, 2021).

The necessity of an accepting school environment directly connects to the potentially dangerous or harmful home environments many LGBTQIA+ students cannot escape. Only one in three LGBTQ+ youth found their home to be identity-affirming, and half found affirming spaces in their schools, reflecting the significant harm of the restrictive "Don't Say Gay" legislation (Paley, 2021). Discriminatory and targeted government actions against the queer and trans communities often occur in the United States; however, it is likely that the institutional and individual silencing of educators to prevent identity-affirming spaces within schools can increase bullying, limit general understanding of queerness, and result in worse mental health for LGBTQ+ youth.

Affronts to the LGBTQ+ community and attacks on their rights have existed since the conception of the Western binary gender. HB 1557 is yet another attempt to enforce a gender binary and a heterosexual norm on society. The bill was filed in the Florida House on January 11, 2022, which began the process of bringing it into law. After moving through both the House

and the Senate, the Florida governor signed the bill on March 28, 2022. In the following weeks, representatives in Alabama, Ohio, Louisiana, and Texas claimed to add legislation mimicking HB 1557 to their list of priorities (Jones & Franklin, 2022). Discrimination and oppression of LGBTQ+ people is a consistent concern in the United States; however, the achievements of more equitable and just societal standing over time have allowed targeted issues to rise on the priority list of queer activists. Today, not only is protecting an educator's capability to instruct on sexual orientation and gender identity for youth a necessity, but policy implementation must simultaneously ensure that public education includes LGBTQ+ history and perspectives. With these priorities facing attacks in multiple states, it is a heightened concern that queer and trans rights will face rollback in the future due to this wave of conservatism. These issues have always been essential to confront, and now they are even more pressing due to the circumstances of the growing support for "Don't Say Gay" bills.

Florida's bill and its consequences substantially affect three central communities: LGBTQ+ youth; straight, cisgender youth; and educators. Within these three groups, queer and trans students will bear the brunt of the harmful consequences, with potentially fewer safe spaces and less access to necessary information. Straight, cisgender students may live with no direct consequences on their individual identities; however, the dehumanization and erasure of queer communities act as a steppingstone for aggressive racist, sexist, or xenophobic legislative action. Additionally, without trusted educators able to teach on topics they might not typically encounter, these students may lack a grounded and empathetic approach to injustices and discrimination faced by queer folks. Early exposure to queerness can eliminate biases and exclusion, increasing the chances of LGBTQ+ folks feeling accepted and safe around their peers. While this representation is a first step in one aspect of a child's life, it can also be a building block to confront the anti-queer sentiments expressed outside of schools, but it will not overhaul the systemic discrimination that roots these biases in American perspectives (Escayg, 2018). Educators face the most extensive systemic changes, as they will need to adjust to new guidelines and restrict themselves from supporting queer and trans students in any official manner surrounding their identities. These shifts can change the outcomes and achievements of these students, with queer youth potentially entering insecure and volatile environments. Within the LGBTQ+ community, people of color and socioeconomically disadvantaged households can face even more significant obstacles as there may be fewer opportunities to educate externally, and racial discrimination will intersect with gender and sexuality discrimination. These communities face unique cultural and economic intersections with queerness that may harm a child attempting to express their identity, largely due to the ongoing systemic exclusion and oppression of ethnic and racial minorities. While the bill itself affects most educators and students within Florida, lower income communities and individuals do not have the education flexibility, such as tutoring and private school, or the

mobility to move households across state lines to fill education gaps.

While HB 1557 is generally known as the "Don't Say Gay" bill, its official name is the Parental Rights in Education bill, and this is the framework from which proponents defend the potential consequences of their legislation. Through the lens of being "for the parents," this attempt to limit LGBTQ+ discussions and the freedom of educators succeeds in presenting itself as returning power to individual households. This framing can allow supporters to view opposition as attacks on the home and parent rather than as defenses of the LGBTQ+ community. While there is no legislative opposition to HB 1557 in Florida, states like California have required LGBTQ+ inclusion in history and social sciences through the FAIR Education Act passed in 2011 (S.B. 48, 2011). Over the following six years, state leaders developed the history and social sciences framework, which begins in kindergarten, creating a more inclusive curriculum by teaching LGBTQ+ history (Prescott, 2021). These curriculum adjustments and inclusive textbooks reflect the diverse families and individuals that make up humanity. Legislation that creates inclusive texts, course-required readings, and open dialogue for educators is the most widely available structure to combat the "Don't Say Gay" bill and its mimics. Eliminating the opportunity to form an education reflective of queer and trans communities perpetuates historical homophobia and transphobia, simultaneously ignoring the potential systemic solutions to queer bullying, mental health concerns, and high suicide rates by removing safe spaces.

Section 2: Alternative Generation

Recently, the signing of Florida's HB 1557, more commonly known as the "Don't Say Gay" bill, by Governor Ron DeSantis sparked a nationwide debate on systemic homophobia within primary and secondary education. This Florida legislation restricts sexual orientation and gender identity teaching, entirely removing queer topics from kindergarten through third grade. The bill proliferated into similar state policies, with twelve additional states proposing or signing similar discriminatory laws (Jones & Franklin, 2022). While exclusionary bills are on the rise, queer organizations and progressive states pave the road for inclusivity in education, with seven states implementing curricula with LGBTQ+ identities represented in textbooks and teachings (Movement Advancement Project, n.d.). The Gay, Lesbian, and Straight Education Network (GLSEN), an organization that works on forming inclusive policies and resources for K-12 education, includes inclusive curricula as one of four core supports to improve school climates for LGBTQ+ youth (GLSEN, 2022). The following section examines three alternatives to provide more equitable and inclusive programs, confronting the rising adoption and implementation of anti-LGBTQ+ policies.

Current and Emerging Alternatives

Alternative 1: Nevada's AB 261

In May 2021, Nevada passed Assembly Bill 261, which "revises provisions governing education to provide diversity and inclusivity in the academic standards and curriculum," providing a liberating and progressive stance on marginalized peoples' representation in primary and secondary school academic material (A.B. 261, 2021). Beyond supporting the LGBTQ+ community, the bill included Indigenous peoples and nations, persons with disabilities, racial and ethnic minorities, immigrants and refugees, and various religions. This intersectional support for a wide range of disadvantaged communities sparked immediate endorsement from GLSEN, supporting Nevada's bill as a "model for other states," seeking to promote similar legislation (GLSEN, 2022). While other states similarly approached education laws through an intersectional lens, Nevada's implementation mandates that the outlined inclusionary material be included from kindergarten through twelfth grade, whereas other states do not require specific teachings throughout the entirety of public schools. While Nevada's bill was passed too recently to discern its effectiveness, California passed similar legislation in 2011, positively impacting queer and trans students. According to the Los Angeles County Office of Education, California's Senate Bill 48 resulted in over 50% less bullying, and LGBTQ+ students felt more likely to make positive contributions at school (Herczog, 2022). Inclusionary instruction and material directly combat the lack of policies and practices that affirm LGBTQ+ youth, as well as the failures to implement protections already passed into law.

Outside of state resources, federal funding for the support of inclusive curricular standards is available through the Every Student Succeeds Act (ESSA). This program has a broad purpose, and while the LGBTQ+ community is not the highlighted target, states can leverage the funding to support academic programs, staff training, and the collection of data on queer and trans experiences. In attempting to understand the impacts of inclusive curricula, education agencies provided minimal data, which GLSEN reflects in their report on states' ESSA usage, finding no states reported data on outcomes for LGBTQ+ students (GLSEN, 2021). The application of the ESSA could significantly benefit the implementation of programs such as Nevada's AB 261, providing funding for both academic opportunities and research on policy impacts.

Alternative 2: Oregon's LGBTQ2SIA+ Student Success Plan

Like Nevada, Oregon's LGBTQ2SIA+ Student Success Plan works towards an intersectional approach to reframing education institutions with a predominantly localized lens. In the adoption and creation of this bill, the government intentionally reached out to its queer student community in Oregon for advice and recommendations in the process. To

understand the shortfalls of the state curriculum and the school environments, they surveyed and anonymously interviewed LGBTQ+ students. Unlike most states, the Oregon legislature clarified the inclusion of two-spirit Indigenous peoples in their gender identity education, as this is a significant nonbinary gender for some Indigenous nations (LGBTQ2SIA+ Student Success Plan, 2021). The bill's particularity and thorough nature reflect the state's efforts to delve into local necessities rather than focusing on broad or vague topics, which are essential to impact Oregon's queer communities positively. In developing the plan, students were asked what made them feel safe, which resulted in answers such as "gender neutral bathrooms" and "not assuming my partner's gender," reflecting diverse areas needing improvement and change (LGBTQ2SIA+ Student Success Plan, 2021).

This alternative presents the groundwork for effective and meaningful collaboration between the affected community—marginalized folks—and the state's policy developers. Unlike Florida's HB 1557, this alternative would seek to understand the specific needs of the LGBTQ+ communities in Florida and adapt education programs and instruction in response to the collaborative effort of students, advocacy groups, and government. Through community-based feedback and localized understanding of issues, Oregon presented a reframing of state curricula that accounted for an Indigenous conception of gender and addressed queer students' concerns.

Alternative 3: GLSEN's Common Core

While not technically a specific policy proposal for consideration in any state, the GLSEN Common Core and Social-Emotional Learning (SEL) Guidelines set basic standards for intersectional queer inclusion in education that provide the framework for implementing policies and material on LGBTQ+ topics. GLSEN curates material in three subject categories: English Language Arts (ELA) and Literacy, History, and Social Studies. Additionally, the SEL program independently covers Science and Sexual Health Education. The programs split the material into grade ranges for different ages and grade-appropriate levels of understanding, such as the SEL's attempt to eliminate the normalization of a false binary in sciences (GLSEN, 2019). For elementary level education, science courses will attempt to highlight diversity in the various animals' genders and family structures, whereas third grade through eighth grade will ensure the representation of intersex individuals in biology or natural science courses (GLSEN, 2019). For the Common Core's ELA and Literacy program, GLSEN provides a lesson for elementary schoolers called "Pronouns: Little Words that Make a Big Difference" that teaches the basics of pronouns and each individual's ability to choose pronouns with which they identify (GLSEN, 2019). Each of the provided lessons attempts to expand on the strict and narrow approaches to gender identity and sexual orientation that Florida's HB 1557 covers by restricting queer education under the guise of parental freedom.

Despite the robust material and planning offered by GLSEN, no states are actively pursuing overhauls of curriculum to fill the gaps that permit exclusivity in schooling. Their Common Core and SEL highlight the need for change; however, they still encourage instructors to consider the steps they take as individuals to teach LGBTQ+ content respectfully and meaningfully. One aspect lost in most policy implementation is the independence and individuality of educators and school staff, and GLSEN understands this, as students need to feel safe and protected around their teachers while being taught this information. Ultimately, this design for inclusive policy implementation sets out all-encompassing material and texts to set education core standards reflective of the LGBTQ+ community, easily adaptable by state agencies.

Additional Alternatives

Outside of the previously mentioned Nevada, Oregon, and California, three additional states have legislation including LGBTQ+ topics in state curricula, including Illinois, Colorado, and New Jersey. Of the six total states, Nevada's implementation methodology seems to potentially be the most effective, as it mandates inclusion from kindergarten through twelfth grade. However, the other states each make unique choices that offer alternative policy design options. Colorado's HB19-1192 does not layout new inclusion aspects; rather, it creates a fund to support content specialists attempting to implement the new material more effectively. In the most recent session, the fund had $37,000 allotted to support their state programs, which could be significantly improved ("Inclusion of American Minorities," 2019). Illinois reflects aspects of Oregon's policymaking process and reflects Colorado's content focus on social sciences, as it forms the Illinois Inclusive Curriculum Advisory Council from various advocacy groups to curate the year's content. In 2019, New Jersey was the second state to sign an LGBTQ+ inclusive bill into law, yet it remains the loosest in terms of expectations for change and demand of the state education agencies. New Jersey's Inclusive Curriculum Law falls shorter than others on grade ranges and allows for more independence from school districts on implementation specifics. One unique aspect of their process is a pilot program across twelve schools, which could allow for researchers to collect data on policy effectiveness (Knox, 2020). Ultimately, the "Don't Say Gay" bill sparked mixed reactions, including governors who quickly signed similar policies into law across the south and significant national resistance from the LGBTQ+ community.

There are potential solutions through the funding and support of alternative schools, which provide more individualized settings than traditional public schools. These programs are not widely available and have many fewer participants; however, a study found that LGBTQ+ participants scored higher on exams and had higher engagement rates in these alternative schools (Phillippi et al., 2020). In the Village Program in California, LGBTQ+

students maintained high retention rates (62%), and in the 2013 to 2014 school year, LGBTQ+ students' GED scores increased by 18.2% (Phillippi et. al., 2020). The availability of more specialized schools can act against statewide bills that target public school education, which potentially create dangerous and unsustainable environments for queer and trans students. These alternatives reflect the resistance from the LGBTQ+ community, as it is proven that restrictive and discriminatory policies such as the "Don't Say Gay" bill significantly harm the current and future well-being of queer students forced to adhere to such standards.

Section 3: Evaluation of Alternatives

Methodology

Each policy alternative will be judged by the following criteria, further defined below: equity, political feasibility, effectiveness of content, and complexity of the proposal. This policy analysis has determined these qualities to be the most relevant and necessary to evaluate education policy solutions, particularly those related to gender identity and sexual orientation. Each criterion will be evaluated on a scale of 1 to 5 (see Table 1).

Table 1 Evaluative Scale. This table depicts the evaluative scale that each policy alternative is judged on. One ranks very low, while five ranks very high.

Evaluative Scale				
Very Low	**Low**	**Moderate**	**High**	**Very High**
1	**2**	**3**	**4**	**5**

Evaluative Criterion One: Equity (Weighted)

As they exist now, education standards surrounding gender identity and sexual orientation vary state by state. While some states outright ban and exclude discussion of queer and trans topics in schools, other states have made significant progress toward inclusionary policies, with some mandating LGBTQ+ subjects in education materials. According to the Trevor Project, of the LGBTQ+ youth who attempted suicide in the past year, 12% reported having an affirming school, while 18% reported non-affirming environments (Paley, 2021). The 6% bump in circumstances where a school is not affirming reflects the dire need for equity while introducing and implementing policy on gender identity and sexual orientation within education. Due to the priority and value of equity, this category will be valued at double the three other criteria.

Scoring

A policy option will score a five if it deeply considers the intersectional nature of identity and must incorporate inclusive curriculum standards with apparent and respectful representation of sexual orientation and gender identity. Options that maintain the status quo or regress in the inclusion of LGBTQ+ topics will score a one. Those that break the status quo with small steps in specified areas of study or provide broad curriculum modifications without involving intersectional practices will receive a three. Each of these can be measured through modification in educational content and readiness of the educator to provide these lessons.

Evaluative Criterion Two: Political Feasibility

Since the federal government has minimal influence on education standards in the current system, policies are left to state discretion and preferences. Given the individualistic nature of education within our national system, political feasibility is the second essential criterion to measure this inconsistent area of policymaking in the United States. According to a study conducted by the American Institutes for Research in 2009, the 2001 No Child Left Behind requirement to set proficiency standards resulted in significantly varying expectations nationwide. In this sense, a policy option must be considered politically in the state one wishes to address an issue; furthermore, it must pass fully intact, deviating from neither purpose nor methodology.

Scoring

A policy option will be considered a five if the state's political atmosphere can accept its contents without any modification or restraint of its integral mission. The option will be considered a one if it meets neither of the primary expectations: political acceptance and authentic intent. The score will be a three if it can achieve one aspect fully or both aspects to a lesser degree.

Evaluative Criterion Three: Effectiveness of Content

In any field of service, the effectiveness of a program or practice is essential. For education policies, students are the recipients of these mandates and standards, creating their most formative experiences that will pave the way for their futures. Under this evaluation, effective policies must have content that reflects their purpose, and it must address the issue stated in the problem definition.

Scoring

A policy option will receive a five if the implementation process results in a curriculum reflective of the mission and works to eliminate or solve the original problem. It will receive a one if it fails to provide a process and curriculum that will effectively implement the purpose of the proposal into education standards. It will receive a three if the process or the curriculum is completed but it fails to cover all grades or subjects in its implementation.

Evaluative Criterion Four: Complexity of the Proposal

Given the case-by-case nature of education policy, schools and their districts have different access to resources even within states. Ultimately, efficiency and applicability are negatively impacted by the "additional resources poured into drafting, proposing, rewriting, defending, and enforcing" laws, especially as the topic expands with each new layer added (Scheffler, n.d.). Rather than increasing the complexity and length, it would be more effective for this proposal to limit costs and maximize material availability for implementation.

Scoring

To score a five, the proposal should limit its complexity and provide clarity in the steps it takes to achieve the policy's mission. A policy option will score a one if it is incredibly complex, lacks universality, and fails to create a single plan for statewide expectations. If it remains simple but with no clear plan, or vice-versa, it will receive a three.

Table 2 Evaluative Criteria Matrix. This data depicts the three policy alternatives rated through the evaluative criteria described in this section. Each alternative is evaluated through the four criteria: equity, political feasibility, effectiveness of content, and complexity of proposal. These categories are rated out of five points. The "Equity" category is weighted, doubling its original score since it has greater significance when it comes to understanding the policy.

	Equity SCORE x2	Political Feasibility	Effectiveness of Content	Complexity of Proposal	Total
Alternative 1: Nevada's AB 261	**7**	**3**	**2**	**3**	**16**
Alternative 2: Oregon's LGBTQ2SIA+ Student Success Plan	**10**	**2**	**4**	**3.5**	**19.5**
Alternative 3: GLSEN's Common Core	**9**	**2**	**5**	**5**	**21**

Recommendations

This analysis of the policy alternatives and the ranking of the proposals through the evaluative criteria supports GLSEN's Common Core proposal being implemented, while Oregon's LGBTQ2SIA+ Student Success Plan should act as a supplemental framework for educators and policymakers. Since the GLSEN option only scored 1.5 points higher than the Oregon plan at 21 points overall, it was difficult to discern which proposal would balance impact, accessibility, and ease of implementation. While all three plans, including Nevada's AB 261, scored high for equity due to the nature of each proposal, they varied much more in the other three criteria.

Given that these policies are alternatives to "Don't Say Gay" bills, the locations where these alternatives would be offered could easily reject or fight against such equity, which would require extensive campaigning and community activism to reinforce support for these alternatives. However, being the most vague and interpretive, Nevada's proposal scored

highest in political feasibility, reflecting the benefits of hiding intent behind generalized moral aims. On the other hand, in Florida, the primary state of focus, there is significant movement from the populous and corporations for more inclusive practices, prompting the potential acceptance of these standards following the next gubernatorial election cycle. This constant push and vocal activism against discriminatory bills lays the political groundwork for these policy proposals, boosting potential scores. Though Nevada's policy seems the most politically feasible, it fails to match GLSEN and Oregon in approach and execution.

In terms of content, Oregon and GLSEN are much more in depth and organized in their information and steps to implement an inclusive curriculum. GLSEN scored highest with a 5 out of 5, as this was the only option to provide grade-by-grade examples of instructor practices and potential course material. A lesson called "Identity Flowers" for upper elementary schoolers encourages students to engage with and explore their own identities such as race, culture, ability, family structure, religion, and spirituality (GLSEN, 2022). These comprehensive and thoughtful practices come directly from a source founded with the intent of an LGBTQ+ inclusive education, reflected in their age-appropriate mature content. There is less clarity on specific materials for Oregon, but the proposal includes an action plan to include ethnic studies in the curriculum and provide the necessary training for faculty on an "intersectional lens" (LGBTQ2SIA+ Student Success Plan, 2021). Ultimately, the effort to include lesson plans and training manuals from GLSEN places it as the gold standard for inclusive, comprehensive education content.

From the "complexity" perspective, Oregon is detailed, lengthy, and provides additional planning that could significantly improve the experiences of LGBTQ+ youth, such as funding for health and civil rights services. However, this policy is not ideal when proposing an alternative in states that initially introduced blatant attacks on identity, which implies a hesitancy to approach intentionally inclusive planning. The GLSEN Common Core has a narrower focus on curriculum, instruction, training, and general practices for intersectional environments. This more selective focus, and the detailed materials provided, led the GLSEN approach to score another 5 out of 5 on the evaluative criteria.

Returning to the equity criteria, Oregon scored a 10 out of 10 due to its systemic approach to restructuring education and student life in the state. Though these steps are necessary and optimistic, they broaden the scope of the policy beyond the capabilities of alternatives for this issue in states where "Don't Say Gay" bills continue to be introduced. The potential benefits of a supplementary bill or future implementation beyond the GLSEN Common Core are that they would provide significant additional functions and funding that the common core does not clarify. These potential future benefits highlight Oregon's policy as a future guideline to expand upon initial inclusive education bills. While both Oregon and Nevada provide positive forms of implemented policies, the GLSEN Common Core reflects

innovative and refreshing perspectives on education while providing extensive materials and information for any willing to engage with intersectional inclusive practices.

Discussion

There were significant hurdles and turnarounds in discovering a problem and then finding solutions for the issue, as discovering the limited available resources and alternative solutions prevented streamlined work. The most significant difficulty arose after discovering which relevant and current policy issue to discuss. This study ultimately focused on the "Don't Say Gay" bill in Florida due to the immediate backlash and the surprising wave of copycat bills across southern states. This bill coincides with the polarization of politics, the rise of extremism in the United States, and the particularly harmful extremism implemented by conservative groups and leadership, often rooted in white supremacy and toxic masculinity. While this issue more directly connects with toxic masculinity, gender norms, and false binaries, there is a deeply interconnected nature between these topics and white supremacy as they all trace back to European Colonialism, American Imperialism, and Christianity. As mentioned, the "Don't Say Gay" bill coincides with the rise of extremism, in this case, conservative extremism, as these extremists feel attacked by equity and liberation of oppressed peoples. Hence, extremism on the opposite side similarly entered the spotlight recently, and research and policymaking reflect that contemporary shift. Of the six states to implement inclusive bills around gender identity and sexual orientation, five introduced theirs after 2019. California introduced its bill in 2011. While this contributed to the intrigue and significance of the topic, it simultaneously made it difficult to find any solid research on these inclusive education practices. This is in part because California was the only state that implemented practices, though meager, in 2011, yet was still better than the other forty-nine states. Without dedicated studies of these programs and their impacts, critics, conservatives, homophobes, and transphobes can quickly push back against these policy proposals by targeting their lack of proven impact.

Additionally, the two policy proposals from Oregon and Nevada had no data on implementation, as Nevada has yet to clarify their particular process and Oregon's only available resources surrounded their policy plan and implementation process. While both states provided the necessary information, it would have been more effective to have access to information on specific materials or student experiences reflective of the policy outcomes. If this research were to be redone, mapping the proposal's plan multiple times and gathering information before even beginning to write the problem definition would significantly aid the understanding of each topic. Overall, the alternative solutions and the experience of searching for problematic policies broadened the study of public affairs to include more in-depth research and analytical writing.

Conclusion

In 2022, the "Don't Say Gay" bill was passed in Florida, sparking both outrage from queer communities across the country and fervor in those supporting similar policies. This bill excludes discussion and education on gender identity and sexual orientation for third grade and under, with local decision-making for grades above three. Despite this hostile policy and its consequences for children in Florida, some states and organizations already have alternative solutions to such discriminatory legislation. Of the six states, Oregon and Nevada provide two positive options, with Oregon emphasizing issues specific to Oregon residents while Nevada moves steadfastly by mandating inclusion into its public education. The most balanced alternative between comprehensive content and ease of implementation is the GLSEN Common Core, providing grade- or age-specific material and advice on incorporating intersectionality into education at all grade levels. This policy analysis recommends the implementation of the GLSEN Common Core with the Oregon LGBTQ2SIA+ Student Success Plan as a comprehensive supplemental program. Each program has the potential to boost the education experiences of all students; however, improving the school environment can create affirming safe spaces for LGBTQ+ students, saving and enriching the youth's lives.

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Curricular Innovations to Promote Systems Thinking in a General Chemistry Laboratory Course

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Abstract

Systems thinking is a perspective and set of skills used to examine the dynamic complexities of an entire system and to make predictions about system behavior. Systems thinking is of interest to educators because of its unique potential to enhance students' critical thinking and problem-solving skills, therefore developing scientists who are capable of addressing many of the complex problems facing our world today. Utilizing previously published pedagogical tools, revisions and additions that promote systems thinking were made to a general chemistry laboratory unit. Through these curricular innovations, students defined systems thinking and employed many systems thinking skills throughout the laboratory unit. Students were surveyed after completing the laboratory unit, and their responses were analyzed to assess the utility of the curriculum revisions and inform subsequent revisions.

Introduction

It is widely accepted that scientists operate within the context of a highly interconnected and dynamic world, most often focusing their investigations, even their entire careers, on the complexities of a singular system. Systems are characterized by a set of recurring themes: boundaries, components, interactions, functions, feedback, purpose, and cycles between equilibrium and chaos (Ho, 2019). The intricacies and significance of systems are easy to imagine when one considers even just a few examples: the human body, the economy, or plastic recycling. The ability to understand and contextualize systems is essential to making sense of our ever-changing and interwoven world.

The most pressing of contemporary scientific challenges are deeply rooted in complex systems; thus, the development and refinement of a robust systems thinking skillset is a necessary investment in the next generation of scientists. Arnold and Wade (2015) define systems thinking as a "set of synergistic analytical skills" that enhance system comprehension and recognition and are especially useful in predicting behavior or manipulating system behavior to a desired outcome (p. 675). Alternatively, York et al. (2019) describe systems thinking as a "holistic approach" that emphasizes the interconnection of system parts and their resulting patterns or behaviors (p. 2720). The exact definition of systems thinking has not reached consensus in academic circles, but in essence, systems thinking is the toolbox utilized to examine the dynamic complexities of an entire system and to make predictions about system behavior.

Gradually, students of science expand their knowledge of systems multidimensionally—they are exposed to new systems as their grasp on familiar systems becomes more thorough. Historically, educational systems achieve this learning outcome through a reductionist approach, the idea that complex systems can be understood solely through studying each of their component parts (Orgill et al., 2019; Fang & Casadevall, 2011). Reductionism has earned its role in the classroom by virtue of making complex scientific concepts more digestible, and many disciplines have employed this approach with great success. However, contemporary understanding of the emergent properties of dynamic systems has led to the conclusion that systems are more than the sum of their parts; therefore, extrapolations from the pieces to the whole cannot be made reliably. Much like a puzzle piece does not accurately depict a puzzle's picture, neither can a components' behavior be expected to predict system behavior. Relying solely on a reductionist approach, students often struggle to apply their knowledge to our interconnected world; systems thinking is one tactic for addressing this difficulty. Systems thinking is not designed to replace reductionist methods of teaching and learning, but should instead complement them (Orgill, et al. 2019).

Systems thinking has been widely acknowledged as the next step for science education because of its ability to enhance students' critical thinking and problem-solving skills while increasing topic engagement. A systems thinking approach for the chemistry classroom is "context-based," linking curricular topics and ideas to global challenges that feel relevant to students (Talanquer, 2019). Adjusting the lens through which chemistry is taught—changing the emphasis from the pieces to the system—can have a tremendous impact on student learning. Pazicni and Flynn (2019) assert that a deeper understanding of chemistry is facilitated by systems thinking skills through the ability to provide holistic and transferable knowledge. Systems thinking skills are nurtured in the classroom through model building, concept map design, behavior prediction, or analysis of knowledge boundaries while incorporating environmental, social, and economic influences (Jegstad & Sinnes, 2015). For these reasons, a systems thinking approach to activities and lessons naturally creates space for collaboration, discussion, and reflection, which has been theorized to positively impact student learning and engagement (Jacobson & Wilensky, 2006). And yet, learning about systems poses special challenges; complex systems are cognitively taxing due to their expansive nature and convoluted interactions (Hmelo-Silver & Azevedo, 2006). Therefore, integrating systems thinking effectively requires an intentional and tailored approach.

Although benefits of teaching systems thinking have been well-characterized, wholly incorporating systems into introductory classes remains a daunting task for educators. Often, the development process places a huge burden on educators as it involves extensive research on systems that are beyond the scope of a typical introductory course. Furthermore, to incorporate systems thinking successfully, educators must identify relevant opportunities for inclusion of illustrative systems, design questions or activities, and ensure cognitive load is manageable for students. Luckily, materials have been developed that help educators kickstart this process.

The Characteristics Essential for Designing or Modifying Instruction for a Systems Thinking approach (ChEMIST) table, a tool developed for the evaluation and design of new systems thinking curriculum, maps pillars of systems thinking to demonstrable skills (York & Orgill, 2020). Designed for educators, the table proves useful for identifying systems thinking opportunities in existing chemistry curricula.

Additionally, the Systems Thinking Hierarchical Model provides instructors with a visual representation of sequentially developed systems thinking skills (Orion & Ben-Zvi-Asser, 2010; Orgill et al., 2019). This graphic can serve as a baseline for building curriculum with the essential steppingstones to high-order systems thinking skills, which are depicted in Figure 1.

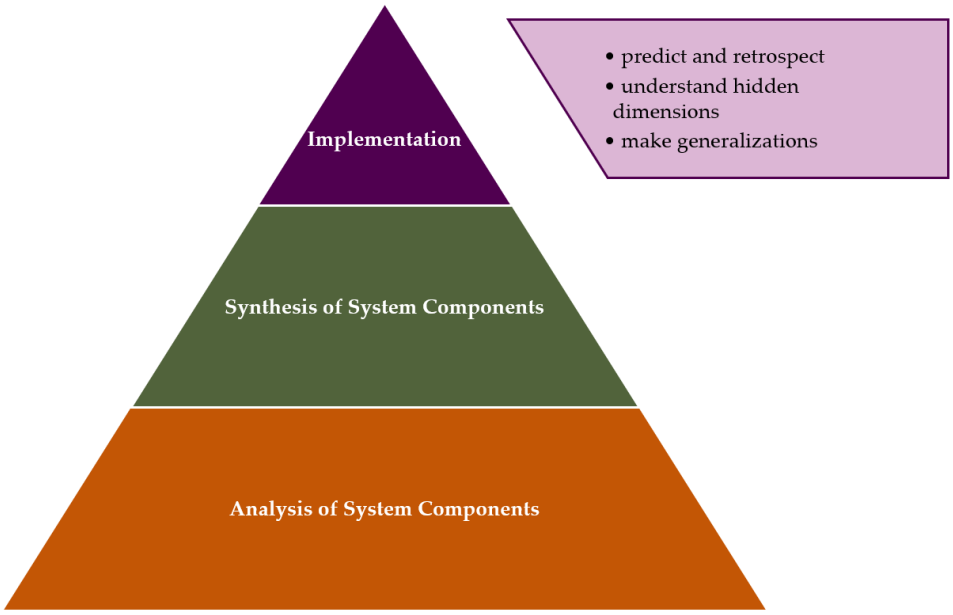

Figure 1 Adapted version of the Systems Thinking Hierarchical Model pyramid (Orgill et al., 2019). Descriptions of Implementation sublevels are provided to the right of the pyramid.

Given the importance of systems thinking in the chemical sciences, we sought to redevelop the general chemistry laboratory experience according to the following pedagogical aims:

- Intentionally cultivate students' systems thinking skills, with emphasis on higher-order skills
- Explicitly introduce the concept and definition of systems thinking
- Effectively communicate the importance of being a system-knowledgeable and system-oriented scientist

Using the aforementioned educational tools, areas in the general chemistry laboratory curriculum where systems thinking could be enhanced were identified. Based on this assessment, existing homework assignments were revised and an entirely new activity focused on the pedagogical aims stated above was designed. Finally, student responses to the new materials were analyzed and a survey was administered in order to gain insights that could be used to inform and further refine future instruction.

Methods

Instructional Context

Students enrolled in General Chemistry II lecture and laboratory at Seattle University participated in the revised laboratory experience. In Winter Quarter and Spring Quarter, there were 85 and 29 student participants, respectively.

General Chemistry laboratory units typically consist of three components: pre-lab questions, in person laboratory experience, and post-lab reflection questions. The purpose of post-lab reflection questions is to prompt students to engage more deeply with concepts and skills developed in the lab and to connect them to their broader learning context in chemistry.

Evaluation of Existing Activities

The first step in the revision process was to analyze existing instructional materials for characteristics of systems thinking using the ChEMIST table (York & Orgill, 2020). If questions did not prompt systems thinking in their current form, they were categorized as such. If questions were determined to prompt systems thinking, they were linked to one or more of the skills on the ChEMIST table and were ranked on a scale from "less holistic, more analytical" to "more holistic, less analytical." Questions that were determined not to prompt systems thinking or fell into the "less holistic, more analytical" category then became targets of improvement and were workshopped to emphasize more systems thinking skills.

Revisions

Curricular revisions were executed by two chemistry educators and an undergraduate researcher. The goals of the revision were to better support students' development of systems thinking skills and to explicitly introduce students to the concept of systems thinking. Using the process above, an appropriate laboratory unit was decided upon. This unit analyzed Seattle municipal tap water samples, allowing for natural integration of systems thinking instruction into an existing lab experience. In this Water Quality Analysis unit, students were tasked with measuring the temperature, chlorine content, conductivity, pH, alkalinity, and hardness of tap water. Because these characteristics are influenced by the larger context of the Seattle municipal water system and the seasonal water cycle, this lab provided a clear opportunity to help students uncover the underlying systems at work. Two major changes were made to the Water Quality Analysis unit:

- Existing post-lab reflection assignments were edited to intentionally target systems thinking skills.
- A guided inquiry activity was developed to explicitly engage students with the topic of systems thinking. Students completed this activity during the second laboratory period of the unit.

Refer to Figure 2 for contextualization of these laboratory components into the unit schedule.

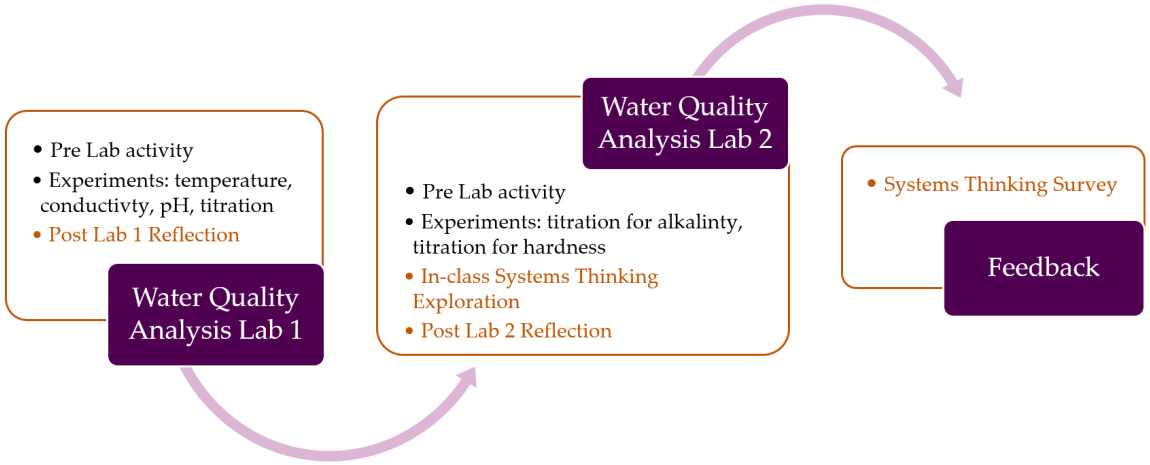

Figure 2 Laboratory unit schedule and description of events, with new or revised components indicated in orange.

Revision by Systems Thinking Hierarchical Model

To revise existing questions, the Systems Thinking Hierarchical Model (Orgill et al., 2019) was utilized as a framework. Frequently, questions identified for revision demonstrated skills represented in the "Analysis of System Components" level of the pyramid. From there, either the synthesis or implementation region was chosen as a target outcome. The descriptive categorization, provided by the sublevel descriptions included in the Systems Thinking Hierarchical Model (Orgill et al., 2019), inspired further structure for question revision. The ChEMIST table (York & Orgill, 2020) was used as needed to provide concrete examples of behaviors that model systems thinking skills.

Design of a POGIL-like Activity: Systems Thinking Exploration

To contextualize the reorientation of the lab toward more and higher-order systems thinking skills, a guided inquiry activity utilizing the learning cycle was designed to introduce students to the definition of systems thinking. An exploration of systems thinking was designed with the Process Oriented Guided Inquiry Learning (POGIL) model in mind, which uses a model, or figure, to direct students through a learning cycle (Simonson, 2019, p. 9). The format and question progression were based on the classical pillars of POGIL: exploration, concept invention, and application. Thus, the activity was designated "POGIL-like" (Simonson, 2019).

Instructional Implementation and Data Analysis

Five faculty, including one co-author, were involved in facilitating the activity over two quarters of general chemistry laboratory, which were held Winter and Spring Quarter of 2022. After initial implementation and response review from Winter Quarter 2022, revisions to the

activity were made for Spring Quarter 2022. A summary of these edits and revisions can be found in the Results and Discussion section.

Student Perception Survey

A Likert scale survey was used to assess students' perceptions of the revised laboratory unit. In total, 91 students participated across two academic quarters. Questions were used to evaluate previous exposure to systems thinking, perceived relatedness of systems thinking to the Water Quality Analysis lab, and relevance of systems thinking to students and scientists.

Thematic Analysis of Student Responses to New Activity

To better understand how the new guided inquiry activity functions to support students' understanding of systems thinking, thematic analysis of student responses to the following selected questions was performed:

- With the knowledge that systems thinking emphasizes the importance of the upper levels (A, B, C, etc.) of the pyramid, can you deduce the definition of systems thinking?
- Why is systems thinking an especially important skill for chemists and biologists?
- What is an example of a topic from class that required you to understand the cyclic nature of systems?
- In your experience, what do you need to know about a system to make a prediction about its future behavior?

Each of the three authors independently analyzed student responses for emergent themes. The authors iteratively discussed results from individual analyses until a common set of themes emerged.

Human Subjects Oversight

The Seattle University Institutional Review Board has determined the study to be exempt from IRB review in accordance with federal regulation criteria.

Results and Discussion

Given the importance of systems thinking for future scientists and healthcare professionals, we sought to enhance students' awareness of and engagement with systems thinking skills in the general chemistry laboratory curriculum. To accomplish this goal, we started by using previously published tools to critically evaluate an existing laboratory unit using a systems thinking lens. Having identified areas to improve systems thinking awareness and skills within the unit, we revised existing questions, added new questions, and designed

a new guided inquiry activity to be included as part of the laboratory unit. The revised laboratory unit was implemented in five lab sections. Student responses to activity questions and a survey were analyzed in order to understand strengths of the curricular changes and areas for improvement. Finally, a second round of revisions were made in response to the data analysis and revised materials and were subsequently used in two lab sections. The following section provides a detailed description and analysis of the curricular revisions made.

Evaluation of Existing Activities

As described in the methods section, the ChEMIST table was used to categorize each existing post-lab question according to the analytical–holistic spectrum of systems thinking skills. As a result of this analysis, one question was added to the Post Lab 1 Reflection and one question was edited. Six questions were added to the Post Lab 2 Reflection. All new and edited questions aimed to better develop students' high-order systems thinking skills. A complete version of the ChEMIST table analysis and curricular revisions can be found in Appendix A and Appendix B, respectively. Selected examples are described in detail below.

Revisions

Post Lab 1 Reflection

In the original Post Lab 1 Reflection, students were given the typical ranges of ground and surface water conductivity, then asked to extrapolate the source of Seattle tap water based on their measured conductivity data. First, we identified that skills required to complete this question mapped to the essential ChEMIST table characteristic of "Examine the relationships between the parts of a system and how those interconnections lead to cyclic system behaviors" (York & Orgill, 2020). However, answering this question only required simple comparison of measured and reported values, so we determined it to be less holistic and more analytical. Steps were taken to elevate the level of systems thinking skills required to successfully complete the assignment. The final product was an expansion into two questions—one leading question (revision [R] in Table 1) and one holistic question (insertion [I] in Table 1). Detailed description of curricular improvements can be found in Appendix B. Systems thinking skills targeted before and after revisions are highlighted in Table 1 below.

Table 1 Post Lab 1 Reflection improvements mapped onto an adapted version of the ChEMIST Table (York & Orgill, 2020). Revisions and Insertions are represented by R and I, respectively, while newly represented systems thinking skills are marked with stars and those that were elevated by revision are represented by arrows. Reprinted (adapted) with permission from York, S., & Orgill, M. (2020). ChEMIST table: A tool for designing or modifying instruction for a systems thinking approach in chemistry education. *Journal of Chemical Education, 97*(8), 2114-2129. https://doi.org/10.1021/acs.jchemed.0c00382. Copyright 2020 American Chemical Society.

	Systems Thinking Skills		
Essential Characteristics	**Less Holistic** (more analytical)		**More Holistic** (less analytical)
Recognize system as a whole, not just as a collection of parts	Identify the individual components and processes within a system **R** →	Examine the organization of components within the system	Examine a system as a unified whole
Examine the relationships between the parts of a system and how those interconnections lead to cyclic system behaviors	Identify the ways in which components of a system are connected ★ **R**	Examine positive and negative feedback loops within a system	Identify and explain the causes of cyclic behaviors within a system
Examine how system behaviors change over time	**I** → Identify system-level behaviors that change over time	Describe how a given system-level behavior changes over time **R** →	Use system-level behavior-over-time trends under one set of conditions to make predictions about system-level behavior-over-time trends under another set of conditions

Post Lab 2 Reflection

Insertion 1. Edits to this section focused on developing students' ability to analyze the cyclic nature of systems. Seven entirely new, sequential questions were added and two were deleted. In-depth analysis of Seattle Public Utilities (SPU) publicly available water quality data revealed a seasonal trend in the alkalinity measurements (City of Seattle, 2022). Scientists at SPU confirmed that the trend has natural origins, so pedagogical content was designed around the connection between seasonal cycles and alkalinity. Elevation of cyclic systems thinking skills through assignment revision can be tracked in Table 2. Appendix B reports the series of questions developed.

Insertion 2. A more straightforward approach to utilize higher-order systems thinking skills was used in the next question where students were asked to recognize a "hidden dimension" of the system. In their responses, students noted various examples, including wastewater treatment, pollution, rain acidity, climate changes, and the properties of the pipes that distribute municipal water.

Insertion 3. Finally, to serve as a reflection and an explicit connection to the Systems Thinking Activity that was completed during the laboratory period, students were again shown the Systems Thinking Hierarchical Model and asked to identify a skill from the model that they used in the reflection assignment. A summary of the skills they identified is reported in Figure 3. The most reported response was the "ability to understand cyclic nature of systems," which falls under the broader "synthesis" skills in the pyramid. This reflects the corresponding aim we hoped to target, which promotes the belief that students are absorbing ChEMIST table content; however, these responses could be attributed to the investigation of cyclic trends in the preceding questions. "Hidden dimensions" as a popular response is unsurprising because it was mentioned explicitly during the activity. Identifying relationships was also a common response, unsurprisingly, as this activity included proposing relationships between alkalinity and conductivity, water availability and season, and alkalinity and dam passage of water.

Design of a POGIL-like Activity: Systems Thinking Exploration

Two main pedagogical goals guided the development of the activity. First, students were prompted to produce the definition of systems through a learning-cycle investigation of the model. Afterward, students would deepen their understanding of systems thinking skills by exploring their association to a real-world model. This activity, which can be found in its entirety in Appendix C, was implemented during the Water Quality Analysis Lab 2 period, after students had been prompted to consider a municipal water system as part of the Post Lab 1 Reflection. Refer to Figure 2 for a visual aid of the chronological systems thinking exposure from student perspective, with curricular additions and revisions included in orange.

Table 2 Post Lab 2 Reflection improvements mapped onto an adapted version of the ChEMIST Table (York & Orgill, 2020). Reprinted (adapted) with permission from York, S., & Orgill, M. (2020). ChEMIST table: A tool for designing or modifying instruction for a systems thinking approach in chemistry education. *Journal of Chemical Education, 97*(8), 2114-2129. https://doi.org/10.1021/acs.jchemed.0c00382. Copyright 2020 American Chemical Society.

	Systems Thinking Skills		
Essential Characteristics	**Less Holistic** (more analytical)		**More Holistic** (less analytical)
Examine the relationships between the parts of a system and how those interconnections lead to cyclic system behaviors	Identify the ways in which components of a system are connected	Examine positive and negative feedback loops within a system	Identify and explain the causes of cyclic behaviors within a system

Revision of POGIL-like Activity Based on Student Responses

After receiving Winter Quarter data, student responses were analyzed and the activity was updated. Confusion about the distinction between the terms "regions" (i.e. analysis, synthesis, and implementation) and "levels" (the explicit skills) in the pyramid was common in responses, so the pyramid figure was labelled, and the questions were revised to more clearly reflect the updated figure. Additionally, the following question was added to subtly remind students of the critical reductionist learning outcomes that serve as building blocks for systems thinking skills:

> As you explored in Question 2, the systems thinking model is depicted as a pyramid because each level is contingent on the skills below. In an introductory course like general chemistry, what part of the pyramid would you expect to focus on?

For ease of distribution and data collection, the activity was adapted from a paper handout to a Canvas quiz. On the application problems, students now had to select one representative skill from a dropdown, whereas on paper they could identify a variety of targeted systems thinking skills. This adjustment limited the variability in student responses, but overall trends stayed consistent.

Student responses to the survey administered at the end of Winter Quarter also informed revisions. Evaluations of the usefulness of systems thinking varied greatly between sections. When asked if systems thinking was critical to understanding chemistry, students in one lab section had a notably higher response of "strong agreement" (64% "strong agreement" compared to the average across sections of 35%). After discussing these findings with this section's facilitator, we were able to identify two factors that were likely influential: familiarity level with facilitating POGIL-like activities and the utilization of first-hand research examples. In response, a robust facilitation guide was developed to provide direction for instructors and improve consistency across lab sections. This guide, which can be found in Appendix D, included a brief background on and formal definition of systems thinking, a typical structure for POGIL-like activities, and direction for facilitators to prepare personal examples of ways they've relied on systems thinking skills during their careers.

Data Analysis

The following thematic analysis and survey analysis deal with data combined for both quarters, unless otherwise mentioned.

Thematic Analysis of the POGIL-like Activity: Systems Thinking Exploration

Thematic analysis of student responses to the concept invention question and a selection of the application questions (Table 3) revealed that overall, students were fairly good at identifying the core pillars of systems thinking. Specifically, many students recognized the emphasis on relationships between parts and the importance of these skills for understanding systems. Most answers fell under three overarching themes: orientation tool, metacognitive tool, and predictive tool.

Orientation Tool. Students acknowledged uses for systems thinking that included characterizing the whole system versus components, getting to know the system, and exploring complexities. In essence, these applications of systems thinking are ways that systems thinking can be used to orient oneself with the system. Students also noted that systems thinking skills are essential for predicting future system behavior.

Metacognitive Tool. Students recognized systems thinking as a tool for assessing their own knowledge of a system, or a metacognitive tool. They proposed that systems thinking could be used to identify gaps in knowledge or areas for improvement. The frequency of this response could be due to the format of the application questions in the activity, where students were given hypothetical scenarios and asked to identify the skills of the pyramid that were utilized.

Predictive Tool. Students defined systems thinking as the skillset required for making predictions about a system. This response again could be attributable to the design of the activity. The question asking students to define systems thinking explicitly tells students that "systems thinking targets the upper levels of the pyramid," and one of the skills in the implementation section of the pyramid is "prediction."

Table 3 Themes and sample responses identified for select questions on the Systems Thinking Exploration.

Question	Common Response Themes	Sample Response
With the knowledge that systems thinking emphasizes the importance of the upper levels (A, B, C, etc.) of the pyramid, can you deduce the definition of systems?	Metacognitive tool	"ST is used to deduce your level of understanding and advance it"
	Predictive tool	"ability to apply known aspects of the system in a broader sense and use those applications to predict future system behavior"
	Orientation tool	"A method of analysis that organizes individual components of a system to better understand the structure, relationships, and trends of said system"
Why is systems thinking an especially important skillset for chemists and biologists?	Real systems are connected beyond memorized pieces	"Because organisms and ecological environments are made up of systems. Also, [chemists and biologists] need to be able to apply their basic knowledge to new situations."
	Helps digest real world complexity	"…knowing how to apply what you learning lectures in lab to real life"
	Reflects the scientific process	"[they] need to understand exactly what they're analyzing to create more accurate hypotheses."
In your experience, what do you need to know about a system to make a prediction about its future behavior?	Relationship between parts	"How each part works, which part influences the others, and which way the cycle or direction of a process goes"
	Past behaviors and patterns	"You need to know its past behavior, its deviations from the norm, and what causes these deviations.

Survey

A survey was developed to assess progress toward the project goals. The following Likert Scale questions (I–V) and free response questions (VI–IX) were included:

I. I was familiar with the term "systems thinking" before studying it in the context of the Water Quality Analysis lab and associated activities and assignments.
II. The Water Quality Analysis lab helped me strengthen my systems thinking skills.
III. Systems thinking allowed me to better understand the chemistry concepts covered in the Water Quality Analysis lab.
IV. I believe systems thinking is critical to understanding chemistry.
V. Systems thinking skills are necessary for contemporary scientists.
VI. If you have been introduced to the term "systems thinking" previously, what was the context? If not, please respond with N/A.
VII. What concepts or classes could be enhanced by applying systems thinking?
VIII. Where do you foresee yourself applying systems thinking skills in the future?
IX. Do you have any feedback about the Water Quality Analysis lab and accompanying systems thinking activity?

Student Likert scale responses to questions I–V are summarized in Figure 4. The survey was administered optionally, yielding N=91 participants total across both quarters of instruction. The Winter Quarter cohort was much larger (N=66) than the Spring Quarter cohort (N=25), so data were combined for analysis purposes unless otherwise stated.

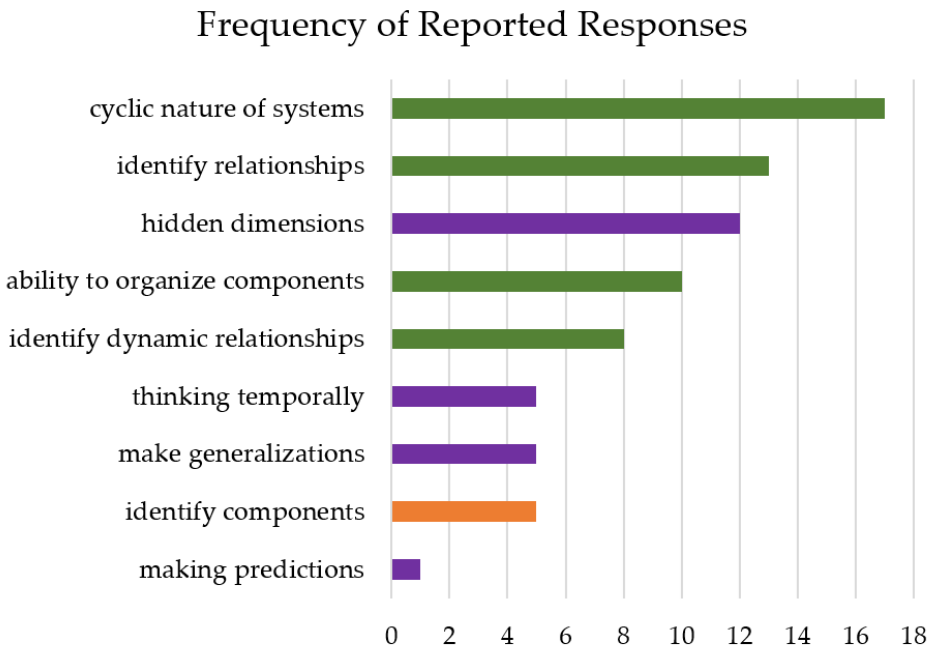

Figure 3 Number of times the following systems thinking skill was identified in response to the activity. Responses that did not name a specific skill were excluded, resulting in N=76. Purple, orange, and green represent skills associated with the respectively labelled levels in Figure 1, with purple representing highest-order systems thinking skills.

When asked for feedback on the activity (question IX), some students noted the Systems Thinking Exploration felt like common sense; however, only 10-20% of students reported familiarity with systems thinking (question I). Of those who reported familiarity, previous exposure was noted (question VI) mostly in previous science classes, particularly biology. A sense of familiarity with systems thinking could be evidence that context-based education in the sciences is becoming more prominent; increased practice and exposure to systems builds the foundation for systems thinking regardless of explicit introduction.

Of all students who participated in the activity, nearly 83% acknowledged that participating in the Water Quality Analysis lab strengthened their systems thinking skills (question II). Students' previous exposure to the Systems Thinking Hierarchical Model pyramid and their practice applying systems thinking skills make them credible assessors at the point of taking the survey. Thus, this reflects positively on our first aim: to intentionally develop more and higher-order systems thinking skills. Positive evaluation on this survey

question coupled with a use of self-identified systems thinking skills (Figure 3) serves as evidence that students' growth as systems thinkers was facilitated by practice with mid- and high-level systems thinking skills during this laboratory module. General approval of the question II statement reinforces the idea that students respond well to systems-based and real-world examples.

In the Winter Quarter cohort, 69% of students believed systems thinking was an asset to their understanding of the chemistry concepts covered in the laboratory unit (question III). After revisions, the Spring Quarter cohort reported 100% agreement or strong agreement. Based on this improvement, we deduce that the revisions positively impacted student experience. Overall, responses indicate comprehension of the importance of systems thinking to solving complex problems like the ones posed.

The importance of being a system-knowledgeable and system-oriented scientist was communicated effectively through the activity, as evidenced by more than 80% of students agreeing or strongly agreeing that systems thinking is critical to understanding chemistry (question IV). Many students pursue science because of the promise of positively contributing to integrated system problems like healthcare inequity, pollution, or clean and renewable energy. Although students recognize the importance of systems in science, the majority of these students had not heard of "systems thinking." Now, with a definition in hand, they do affirm the importance of the skillset. Our second goal of providing language made this possible. Between Winter and Spring Quarter, there was a large increase in students "strongly agreeing" with the statement, from 34% to 48%. Every student (100%) in the spring cohort "agreed" or "strongly agreed" that systems thinking skills are necessary for contemporary scientists (question V). This was a large improvement over the roughly 85% in the previous quarter. Curricular revisions and the addition of the implementation guide are theorized to be the cause of these improvements in student evaluation.

Further, students could envision themselves applying systems thinking skills across broad horizons of scientific domains. When asked which concepts or classes could be enhanced by systems thinking (question VII), each of the following was mentioned by name at least once: mathematics, physics, biology, environmental science, computer science, "STEM" in general, and any class with a laboratory component. Students recognize the integral nature of systems to science. Students were easily able to think of situations where they will use systems thinking in the future (question VIII), including but not limited to the medical field or other work sectors, current events, coding (model building), future research, and college- or career-related projects.

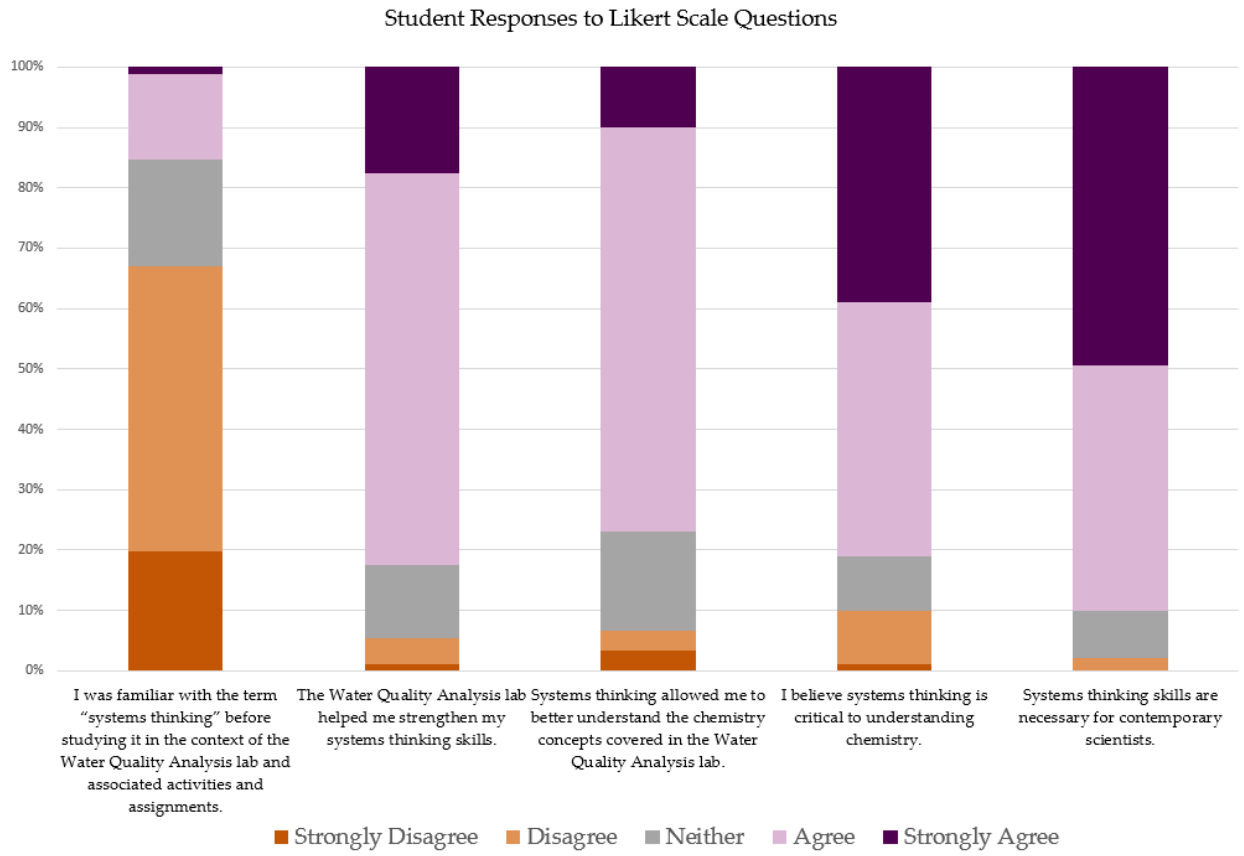

Figure 4 Summary of student responses to Likert questions included on survey (N=91).

Conclusion

In this study, we modelled how previously published tools can be used to support curricular revision and novel implementation of an activity designed to develop systems thinking knowledge and skills in General Chemistry laboratory. As such, the processes described here can serve as a guidebook for educators interested in designing systems thinking activities for their classrooms or laboratories. Furthermore, instructors are called to use and adapt our guided learning activity, the Systems Thinking Exploration, which can be useful in a variety of disciplines at the instructor's discretion.

Using previously published tools, the ChEMIST table and the Systems Thinking Hierarchical Model pyramid, we identified areas in a General Chemistry laboratory unit where systems thinking could be enhanced, resulting in a series of revised and new post-lab questions and a new guided inquiry activity. All new and revised materials sought to enhance three pedagogical goals: 1) intentional development of students' systems thinking skills, 2) explicit introduction of systems thinking, and 3) effective communication of the importance of being a system-knowledgeable and system-oriented scientist. Progress towards each of these pedagogical goals is summarized below.

Intentional Development of Students' Higher Order Systems Thinking Skills

All new and revised materials are intended to prompt students to put systems thinking skills into action. Evaluation of new and revised questions using the ChEMIST table suggests that students are prompted to engage in systems thinking through completing the revised Water Quality Analysis unit. Furthermore, survey results indicate that the vast majority of students (82.4%) agreed that their systems thinking skills had been developed through the course of completing the laboratory experience.

Explicit Introduction to the Concept and Definition of Systems Thinking

With less than 15% of students noting past introduction to the term "systems thinking," explicitly introducing all general chemistry students to the term and definition marks a significant gain. Thematic analysis of student responses to the Systems Thinking Exploration shows that, in general, students arrived at a relevant and meaningful definition of systems thinking.

Communicate the Importance of Being a System-Knowledgeable and System-Oriented Scientist

By the time of survey implementation, 81% of students subscribed to the belief that systems thinking skills are necessary for contemporary scientists. Students' ability to recognize a wide variety of fields, careers, and classes that could utilize systems thinking speaks to success in regard to this aim. Notably, students also agreed that systems thinking improved their understanding of chemistry concepts, which speaks to the utility of systems thinking in reinforcing foundational knowledge.

Future Directions

Although evidence presented indicates progress towards stated pedagogical goals, improvements can be made in order to more fully support students in developing systems thinking skills. In the way the water system is defined in our lab, water is only investigated at its natural source and its municipal source. In the current activity, students are not prompted to investigate the process by which wastewater returns to the natural system. As a result, our students are not investigating a complete system. In future iterations, we should define the water system in the water quality laboratory activity as beginning and ending at the natural source. By broadening these restrictive system boundaries, our activity can better represent "system-like" behavior. For example, alkalinity and conductivity, while exhibiting cyclical behaviors, do not demonstrate regulatory behaviors or feedback responses as system elements typically do. When we consider the complete system, we can likely find examples of feedback regulation and other emergent characteristics within our water system.

To close the loop on our water quality lab activity, there is opportunity to prompt students to consider the fate of water after it is poured back down the drain. This could be connected to wastewater treatment, return of water into the Puget Sound, and even evaporation through the water cycle. Connecting back to the ecological and environmental impacts of our own human interaction with the water system would draw attention to an important systems thinking characteristic in the ChEMIST table that we have not yet addressed: "identifying the interactions between a system and its environment, including the human components of the environment" (York & Orgill, 2020).

Going forward, we plan to apply this approach to other aspects of the chemistry curriculum at our institution and encourage others to do the same. An unintended positive impact of this project was the exposure to systems thinking many chemistry faculty received through facilitation of the guided inquiry. This serves as a strong network to rely upon for our next goal: we plan to explore how the new Systems Thinking Exploration functions in other course contexts in an attempt to intentionally build systems thinking across the chemistry curriculum.

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Appendix A
Annotated ChEMIST Table

Table A1 Reprinted (adapted) with permission from York, S., & Orgill, M. (2020). ChEMIST table: A tool for designing or modifying instruction for a systems thinking approach in chemistry education. *Journal of Chemical Education, 97*(8), 2114-2129. https://doi.org/10.1021/acs.jchemed. 0c00382. Copyright 2020 American Chemical Society.

Essential Characteristics	**NO Systems Thinking Skills Required**	**Less Holistic (More Analytical)**		**More Holistic (Less Analytical)**
Recognize a system as a whole, not just as a collection of parts.			"Refer to the maps presented by your instructor (and also posted on Canvas) showing Seattle's regional water distribution system. While Seattle can draw from a variety of sources, what is the most likely watershed source of the water that you collected?"	
Examine the relationships between the parts of a system and how those interconnections lead to cyclic system behaviors.	"Groundwater typically has a much higher conductivity (300-700 μS/cm) than surface water, because the water absorbs ions as it moves through underground mineral surfaces. Given your conductivity measurement do you think Seattle's water is from a surface or groundwater supply?"	"…how and where was the water cleaned and treated before you sampled it?"		
Identify variables that cause system behaviors, including unique system-level emergent behaviors.			"…alkalinity and hardness analyses have some overlap in what they measure. What is the chemical component that they both measure? In what way are they different?"	

Examine how system behaviors change over time.		"For each of the four analyses you completed (temperature, chlorine, pH, conductivity), do your results match what SPU has previously reported on their drinking water website?"		
Identify interactions between a system and its environment, including the human components of the environment.				

Appendix B
Description of Activity Revisions

Post Lab 1 Reflection

Revision (R in Table 1)

The goal was to lead students to develop a hypothesis explaining why ground water has higher conductivity than surface water. A diagram depicting water accumulation in an aquifer was provided. The diagram modelled part of the water cycle and the diffusion of water through layers of soil. Students were then asked to deduce whether ground water or surface water would have higher conductivity. This question served a foundational purpose for the next added question and required mid-level systems thinking skills. Based on principles of equilibrium and diffusion, students should be equipped with adequate foundational knowledge to develop an appropriate hypothesis and thus demonstrate the ability to "examine the organization of components within a system" and "describe how system level behavior changes over time" (York & Orgill, 2020). Additionally, revisions brought in a new systems thinking skill altogether: "identify the way in which components of a system are connected" (York & Orgill, 2020). Before this edit, skills relating to cyclic nature of systems were not targeted. Therefore, in Table 1, the incorporation of this systems thinking skill is represented as a star.

Insertion (I in Table 1)

The ultimate goal was to prompt students to demonstrate the ability to "use system-level behavior over time trends under one set of conditions to make predictions about system-level behavior over time under another set of conditions" (York & Orgill, 2020). Students were provided conductivity data from City of Madison Public Utilities, which they were told sources water from an aquifer. Then they were asked to compare Madison's data to the data students collected during lab and reason whether Seattle's tap water was sourced from groundwater or surface water. To correctly reason through this, students must have correctly interpreted that the rise in conductivity of ground water over time is due to water interaction with soil. They must then extrapolate that this phenomenon is much reduced for surface water, resulting in lower conductivity. Finally, comparing real conductivity values of water sourced from an aquifer to their own Seattle tap water conductivity measurements, they would be prepared to make an appropriate prediction. From an instructional lens, conductivity was considered "system-level behavior," thus Madison and Seattle can be thought of as distinct sets of conditions.

Deletion

A question that tasked students with drawing a map of the path Seattle municipal water takes from mountain to tap was removed. The information required to answer this question was discussed during the pre-lab lecture, so students were able to construct a map without utilizing holistic systems thinking skills. Thus, it was deemed unnecessary to include after revisions.

Post Lab 2 Reflection

Insertion 1

Students were asked about the relationship between seasons and water availability. Living in Washington, the students should be able to predict this accurately based on their personal experience and observations of the water cycle.

Given a graph depicting the seasonal alkalinity variation (Figure 1), students were asked to describe the alkalinity trend in relation to season, where Quarter 1 data points are taken in March and Quarter 3 data points are taken in September.

Students are informed that the water supplied to Seattle University passes through the Cedar Falls Dam, a porous rock dam, before alkalinity measurements are taken. Students are then asked to hypothesize how the dam would affect the water sample's alkalinity. Having previously investigated an aquifer diagram (described above), students should be able to reasonably predict the dam's effect on the water sample.

To continue investigating the system, students are asked the main source of the water in the SPU measurement besides the water that passes through the dam. By this point, students have been provided with sufficient background information about the water cycle and maps of the local water system to deduce the other surface water sources.

Finally, students are asked to synthesize the information explored in this series of questions into a concise explanation of the observed seasonal variation of alkalinity. Over the course of these guiding questions, students must recognize that during drier months, a larger proportion of water in the SPU water sample has passed through the dam, therefore increasing alkalinity. In the wetter months, the SPU water sample is diluted by surface water sources, decreasing alkalinity measurements. Many systems thinking skills must be demonstrated along the way to arrive at this conclusion, in which students finally "explain the causes of cyclic behaviors within a system" (York & Orgill, 2020).

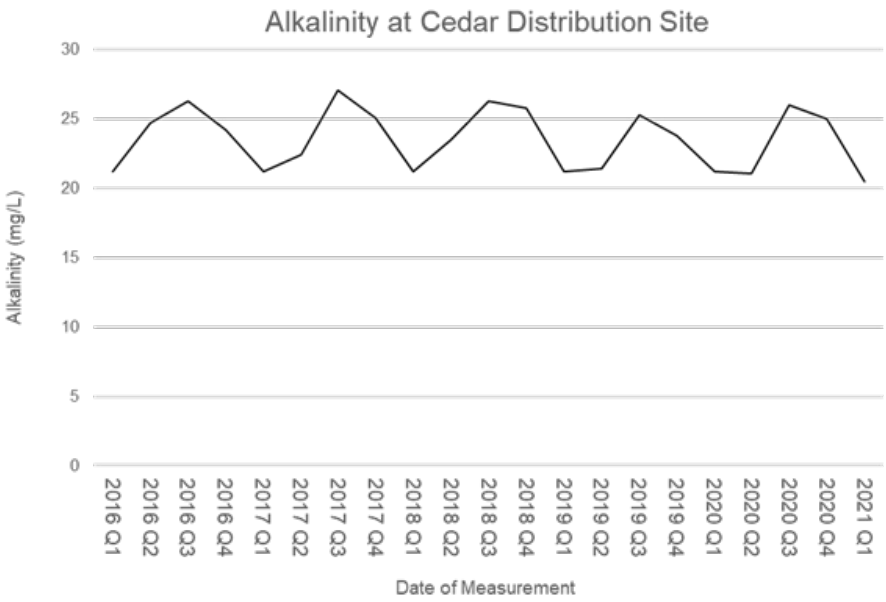

Figure B1 Cyclic variation of alkalinity of water collected at Cedar Distribution cite based on SPU public data (City of Seattle, 2022).

Appendix C
Systems Thinking Exploration

Why?

A system is a group of parts that can have a variety of interactions that contribute to a conducive whole. The topics often explored in introductory chemistry and biology courses are investigated as isolated topics, even though they are influenced by the complex systems in which they occur. This activity investigates "systems thinking," which is a tool for enhancing critical thinking and analyzing systems effectively.

Learning Objectives

- Explore systems thinking
- Begin applying a systems thinking lens to the Drinking Water Lab

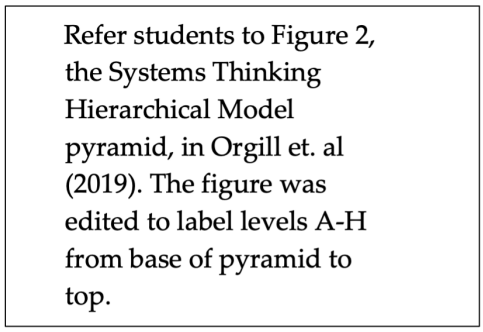

Figure C1 Systems Thinking Hierarchical Model pyramid (Orgill et al., 2019).

Key Questions

1. What do the different colored regions of the pyramid represent?
2. How do the analysis, synthesis, and implementation regions relate to each other?
3. Looking at the orange region of the pyramid, what skills are described there?
4. Now, look at the skills in the green region. How does the green region differ from the orange?
5. Finally, look at the purple region. Why is it at the top of the pyramid?
6. With the knowledge that systems thinking emphasizes the importance of the upper levels (A, B, C, etc.) of the pyramid, can you deduce the definition of systems thinking?
7. As you explored in Question 2, the systems thinking model is depicted as a pyramid because each level is contingent on the skills below. In an introductory course like general chemistry, what part of the pyramid would you expect to focus on?

8. Why is systems thinking an especially important skill for chemists and biologists?
9. What is an example of a topic from class that required you to understand the cyclic nature of systems?
10. In your experience, what do you need to know about a system to make a prediction about its future behavior?

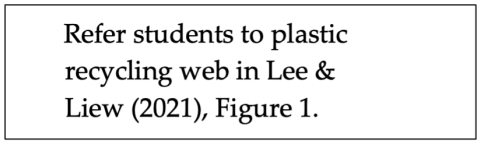

Figure C2 Process for plastic recycling (Lee & Liew, 2021).

Information Exercise

For each question below, please give the level letter and description.

1. If you and your friend had drawn this figure, what level (A, B, C, etc.) of the pyramid were you demonstrating?
2. You correctly induce that inhibition at the "extraction and processing" and the "pyrolysis" steps would result in decreased fuel and oil production. What level of thinking skill from the pyramid have you demonstrated?
3. Your friend hypothesizes that increasing the effectiveness of mechanical recycling would increase demand for molding and processing, lessen the demand for virgin polymer, and lessen materials available for tertiary or quaternary recycling. What level of thinking skill from the pyramid have they demonstrated?
4. Upon observation of the system, changes in international tariffs influence consumer application and the extent to which plastic waste is generated or can be reused. On the pyramid, how would you classify tariffs and their influence?

Wrap Up

1. How might systems thinking help you understand the chemistry concepts at play in the water quality lab?

Appendix D
Systems Thinking Exploration Facilitation Guide

Systems Thinking

Systems thinking is the lens that encourages students to not simply engage with parts of the system, but examine complex or emergent behaviors, trends, cyclic natures, and the boundaries of systems. Recognizing the system as an integrated whole is dually a learning outcome and a higher-order thinking skill required for the next generation of engaged scientists. The working definition of systems thinking is provided:

> Systems thinking is a holistic approach for examining complex, real-world systems, in which the focus is not on the individual components of the system but on the dynamic interrelationships between the components and on the patterns and behaviors that emerge from those interrelationships (York et al., 2019, p. 2742).

Science education has previously been dominated by reductionist methods aiming to reduce complex systems into digestible parts (Orgill et al. 2019). Although the reduction of complex problems into small pieces is extremely useful for furthering science and standardized testing, it limits pliability of student thinking. Systems thinking is not designed to replace reductionist methods of teaching and learning, but should instead supplement them (Orgill, et al. 2019). Many challenges facing current day students and scientists—global warming, materials recycling, water sanitation, gene editing—require extensive skills for reasoning within the context of a system.

Systems thinking has been widely acknowledged as the next step for science education because of its ability to enhance students' critical thinking and problem solving while increasing topic engagement. Strengthening systems thinking skills can look like building models, designing concept maps, predicting behavior, or analyzing boundaries of knowledge while incorporating environmental, social, and economic influence (Jegstad & Sinnes, 2015).

Facilitation Notes

Through beta testing, students have been observed to have trouble understanding the purpose of systems thinking and its applicability to the Water Quality Analysis lab. To help facilitate these connections, here are some facilitation tips we recommend:

- Before class, think of an example from your research in which you have used systems thinking skills and share with the class at the beginning of the activity.
- Give a time limit for the activity and inform students you will be having a report-out component.

- During the report-out portion, focus on questions 6 and 8-10, being sure to give the

literature definition after the discussion of question 6.

- Feel free to inform students that this is not a novel idea, but it puts language to a learning process they are possibly familiar with.

Systems Thinking Hierarchical Pyramid (Orgill et al., 2019)

This pyramid is a tool for visualizing systems thinking skills and recognizing how they build upon each other. It has been included in the systems thinking activity as the main model for exploration of the topic.

ChEMIST Table (York & Orgill, 2020)

Refer to Figure 2, the Systems Thinking Hierarchical Model pyramid, in Orgill et. al (2019).

Figure D1 Systems Thinking Hierarchical Model pyramid (Orgill et al., 2019).

The following table has been used to evaluate current activities and guide our revisions to the updated Water Quality Analysis lab. The leftmost column describes desired learning outcomes while the other three columns include student behaviors on the spectrum from "more analytical" to "more holistic" that demonstrate the specified learning outcome. The "analytical" column aims to familiarize students with the parts of the system, while the "holistic" column gets students to practice skills critical to systems thinking. Examining this column can help us understand what systems thinking skills look like when applied.

This is an additional resource that neither you nor the students will be using actively during the activity, but it provides a helpful breakdown of the skills critical to systems thinking.

Table D1 Reprinted (adapted) with permission from York, S., & Orgill, M. (2020). ChEMIST table: A tool for designing or modifying instruction for a systems thinking approach in chemistry education. *Journal of Chemical Education, 97*(8), 2114-2129. https://doi.org/10.1021/acs.jchemed.0c00382. Copyright 2020 American Chemical Society.

Refer to the ChEMIST Table in York et al. (2020).

Adipose-Derived Stem Cells (ADSCs): A Promising Future for Breast Reconstruction

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Abstract

Breast cancer diagnoses may necessitate a bilateral or unilateral mastectomy; this involves the removal of breast tissue and affected surrounding area. Breast reconstruction to restore pre-surgical appearance has become commonplace as the rate of breast cancer incidence has increased. Shortcomings and frequent complications with these treatments have resulted in the proposition that established treatment methods be supplemented with adipose-derived stem cells (ADSCs) collected from the patient. ADSCs may be isolated from adult adipose tissue and are widely applicable in stem cell therapeutics due to their unique characteristics such as pluripotency and widely observed paracrine effects. Although concerns have been voiced over safety and efficacy due to ADSCs' purported role in oncological processes when employing in vitro or non-human models, a vast majority of experiments have suggested that this is a promising treatment method and may help moderate postoperative complications. Further studies are necessary to review clinical benefits and establish standard results and practices.

Introduction

Cancer is a common biological disease caused by the unregulated proliferation of cells which eventually results in body tissue destruction and patient health degradation. Clinically, cancer is defined by the body part in which cell abnormalities originate; breast cancer is among the most common forms. A secondary analysis of globally documented cancer occurrences found that as of 2020, breast cancer surpassed lung cancer as the most prevalently diagnosed form of cancer worldwide (Cao et al. 2021). It is also cited as one of the five leading diagnoses in cancer-related death.

The American Joint Committee on Cancer has produced eight editions of the TNM Staging System, a standardized staging system that determines cancer prognosis using tumor size (T), spread to lymph nodes (N), and the presence or lack of metastasis (M) (Koh and Kim 2019). As identified by Maughan et al. 2010, the stages of cancer are as follows: Stage 0 refers to the presence of abnormal tissue growth contained within a portion of the breast and no observed invasion of abnormality to surrounding tissue. Stages I and II are considered early-stage invasive breast cancer. Stage I is designated by either the presence of a primary tumor less than or equal to two cm in size without axillary nodal involvement or axillary micometastases, clusters of tumor cells between 0.2 mm and two mm in size, with or without a primary tumor less than or equal to two cm in size. Stage II is designated by larger tumors or increased lymph node involvement in comparison to Stage I. Stage III is known as locally advanced breast cancer, as the primary tumor has exceeded five cm in size, has become inoperable without distant metastases, or abnormalities have spread to the chest wall or underlying skin. At Stage IV, the cancer has become metastatic and spread beyond local regions, such as to the bones, liver, or lungs.

For stages I to III of breast cancer, a partial removal of only the affected breast tissue (lumpectomy) or mastectomy combined with chemotherapeutic drugs is the common form of treatment. A mastectomy consists of the surgical removal of affected breast tissue, including the nipple and tissues covering the chest musculature (Bianchini et al. 2016). The complete removal of this organ may cause patients to feel mutilated, less attractive, and depreciated; post-mastectomy patients with low physical self-esteem display significant linear correlations to low amounts of hope and depreciation in mental wellbeing (Heidari and Ghodusi 2015). As a result, some patients may elect to undergo reconstructive surgeries of the chest to restore a semblance of preoperative appearance. Individuals that pursue reconstructive surgery display a lower incidence of symptoms related to depression or anxiety (Bredicean et al. 2020). Hence, the outcomes of these surgeries play a pivotal role in not only the confidence, but also the general well-being of the patient.

Various techniques are employed for breast reconstruction involving synthetic implants, patient-derived lipotransfer, or both. Although these methods are standard, postoperative success has been riddled with sequelae since their conception. Silicone and saline prosthetics are the modern forms of breast implants. Silicone models used today are typically derived from silicone gel, but more than 200 separate models have been proposed since their introduction to the United States in 1962 (Powell et al. 2021). Evolved manufacturing provided later versions with more natural breast contour, and new implant anchoring designs have improved stability, yet there are still frequent complications observed such as contracture of the implantation pocket (narrowing of implant pocket due to build-up of scar tissue), infection, and high incidences of rupture as the implants age (Powell et al. 2021). Hedén et al. (2006) observed that in a total of 106 women with at least one Inamed-brand silicone breast implant postoperative rupture incidences occurred after 10.9 years. Increasing public concern over the incidence of implant-related risks led the Food and Drug Administration to temporarily restrict the usage of these prosthetics, only approving updated models for reintroduction to the market as of 2012 and 2013 (Kaoutzanis et al. 2019). Original saline implants were first used in France in 1965 and were initially favored because a smaller incision was necessary for insertion in comparison to silicone models. Early designs were extremely prone to rupture; however, this issue became relatively resolved when the implant model was reworked. Despite this, the new design proved to be similarly problematic as palpation of these prosthetics offered a comparable feel to that of water rather than viscous breast tissue and yielded an unnatural inflexibility if overfilled. They are now primarily used in patients with thick tissue as they are prone to provide a more synthetic feel without proper tissue padding. Currently, patients and surgeons alike still experience a variety of postoperative difficulties when using either type of synthetic implant, including capsular contracture of the implant pocket, hematoma (accumulation of blood), seroma (accumulation of plasma or lymphatic fluid), infection, postoperative separation of incision, implant migration, rupture, and patient dissatisfaction with results (Siggelkow et al. 2004).

Lipotransfer, also commonly referred to as fat grafting or fat transfer, is another method used to reestablish breast volume. Fat grafts are taken from the patient and redistributed to the breast to supplement the implant and provide natural volume restoration. In general, modern liposuction involves the transplantation of undesired subcutaneous deposits to newly identified locations (Van Milligen et al. 2006). Autologous collection decreases the risk of tissue transfer rejection and allows for more optimal volume enhancement. Common donor sites are the abdomen, hip, and thigh. Predicating liposuction's conception in the 1970s, the use of sharp carving instruments for subcutaneous sculpting of excess hereditary adipose-tissue deposits or significant incisions for simultaneous resection of fat and skin were standard practice (Coleman 1999, Venkataram 2008). However, both methods provided varied, less

than desirable results; unnatural deformities caused by reaccumulated fat around the incision, frequent hematomas and seromas, and further complications yielded low patient satisfaction. As a result, Italian surgeons Arpad and Giorgio Fischer designed a hollow, blunt cannula attached to a suction source for crisscrossed adipose collection from multiple sites; this was the prototype for the modern liposuction instrument (Fischer and Fischer 1976). "Wet liposuction", where a solution of saline and hyaluronidase is injected pre-procedure, became the popular method of collection due to the vasoconstriction offered by this approach (Illouz 1983). Current practices have taken this methodology and expanded upon its approach to develop a procedure termed "cell-assisted lipotransfer", or CAL.

Adipose-derived stem cell assisted lipotransfer (ADS-CAL) involves conjunctive use of adipose-derived stem cells and autologous fat transplants as a solution for typical lipotransfer's unpredictable outcomes and frequency of graft necrosis (Yoshimura et al. 2008). Stem cells are self-renewing cells found in most multicellular organisms that are uniquely capable of producing terminally differentiated cells of various germlines while maintaining their undifferentiated state (Zakrzewski et al. 2019; Hima Bindu and Srilatha 2011). Cell differentiation is the highly regulated process in which non-specialized cells develop unique characteristics, such as cell shape or extracellular signal responsiveness, to become mature cells of unique function. The broad category of stem cells may be further classified by several increasingly specified characteristics, such as the number of different cell lineages they can produce (potency) and specific cell-surface antigens (clusters of differentiation or CDs) (Zakrzewski et al. 2019). Adipose-derived stem cells are tissue specific stem cells present in adult adipose tissue that are capable of meso-, ecto-, and endodermal cell differentiation (Bunnell et al. 2008). They are ideal for use in regenerative medicine due to the ease with which they can be harvested and transplanted, large population size, and reproducible differentiation patterns (Bunnell et al. 2008; Naderi et al. 2017).

As a direct result of ADSC attributes, ADS-CAL procedures may provide the recipient with enhancements in graft retention by inducing angiogenesis and ideal wound repair factors, leading to an improvement in patient-desired aesthetics. Others have proposed that this treatment could pose a threat to patient safety due to their poorly understood, but suggested, role in tumorigenesis or metastasis. This is of relevance to those undergoing reconstructive breast surgeries as they are typically women with a history of cancer. Promotion of favorable tumor conditions may put them at high risk of metastasis or redevelopment during their remission. The primary aim of this review is to characterize adipose-derived stem cells in consideration of their efficacy and patient safety to discern whether ADS-CAL should be considered a highly regarded method for breast reconstruction.

Adipose-Derived Stem Cells: Systematic Definition, Nomenclature, and Historical Observations

Stem cells may be categorized by the degree to which they are able to differentiate, developmental stage presence, tissue location, and expressed cell-surface receptors (CDs). All these characters lend themselves to capabilities that foster observed post stem cell treatment effects.

Potency

Potency refers to the degree of mature cell type differentiation a stem cell is capable of (Hima Bindu and Srilatha 2011). Unipotent cells are the most limited, only capable of producing a singular cell type, but they still exhibit self-regenerative mechanisms; they are highly regarded for therapeutic applications due to their narrow maturation trajectory (Argentati et al. 2018). Oligopotent classes can differentiate into a limited number of mature cell types (Hima Bindu and Srilatha 2011); a common example are myeloid stem cells which are capable of white blood cell, but not red blood cell, differentiation (Zakrzewski et al. 2019). Multipotent stem cells are those that can differentiate to a greater degree, but only to cells of closely related family groups. For example, human hematopoietic stem cells may differentiate into several blood cell types (Argentati et al. 2018). Pluripotent stem cells are those that can differentiate into cells of the three germ layers to produce any mature cells of the adult organism, only restricted by their inability to differentiate into embryological structures like the placenta. They are largely represented by embryonic stem cells derived from embryos during development. Totipotent cells may differentiate into all cell types, including extraembryonic structures, and are only observed during the first 4 days of development following spermatic fertilization of the ova. The large population sizes of pluripotent and totipotent cells arise from their asymmetric method of self-replication; pluri-/toti- potent cell division produces two daughter cells, one that retains the parental stem cell phenotype and one that exhibits mature cell characteristics (Argentati et al. 2018).

It should be noted that while adipose-derived stem cell potency is often designated multipotent due to their mesenchymal origins, they have displayed maturation into non-familial cell groups such as myogenic differentiation when treated with promyogenic conditions (Mizuno et al. 2002; Dominici et al. 2006). As they have shown their ability to differentiate into non-familial germlines, the pluripotent label supplied by Zuk et al. (2002) is corroborated (Savoia et al. 2017; Simonacci et al. 2019; Ong et al. 2021). Their unique degree of potency may be responsible for the notable postoperative effects discussed later in this review.

Developmental Stage

Stem cells are further categorized by their presence during certain stages of development. Totipotent cells are only observed after blastocyst formation during early embryonic development. While these cells are desirable for their unrestricted differentiation potential, they are only present and collectable for short periods of time; their safety due to the lack of restriction and morality of collection requirements prevents any in vivo applications (Zakrzewski et al. 2019; Hima Bindu and Srilatha 2011). Fetal stem cells (FSCs) are pluripotent cells residing in fetal organs that may be collected from fetal blood, tissue, or bone marrow. As with the previous stem cell group, their usage is complicated and riddled with moral dilemmas. In 2001, President Bush fully prohibited federal National Institute of Health funding for research involving derivatization or use of any FSCs (Lo and Parham 2009). Research for their medical application is minimal as a result. Adult mesenchymal stem cells (Adult MSCs), or tissue stem cells, persist within the niche of developed organs and tissues of adult organisms (Argentati et al. 2018). Adult MSCs were first reported following the observation of cells with the capacity for osteogenic differentiation (Friedenstein et al. 1968, 1974). Due to advancements in collection methods, Zuk and co-authors were able to positively identify the presence of adipose-derived stem cells by collecting human-adipose tissue via liposuction, and subsequently isolating what was described as a population of "fibroblast-like cells" (Zuk et al. 2001). Initially labeled as processed lipoaspirate (PLA) cells, their behavior suggested they were a newly discovered population of pluripotent, multi-germline potentiated cells, closely related to MSCs. This was later confirmed after extensive biochemical and molecular characterization identified similarities between the following: CD surface antigens, induced product differentiations, and lineage-specific metabolic activities (Zuk et al. 2002). However, further testing began to distinguish PLA cells from MSCs by their unique capacity for chondrogenic and myogenic differentiation, expression of group-specific CD antigens (CD49d+, CD106-), possible variations in genomic expression, and ability to be characterized independently of sera screening (Zuk et al. 2001). Adipose-derived stem cells of adult adipose tissue origin may be largely collected without major ethical or political controversies as the adult donors are able to provide informed consent.

Tissue-Sites

Tissue-sites, where cells are collected, lend themselves to the nomenclature of stem cells but do not give rise to the cells themselves. The tissue location of stem cells also contributes to their medical relevance. Mesenchymal stem cell (MSC) is the hypernym for all adult stem cells that arise from mesenchymal tissues with adipogenic, osteogenic, or chondrogenic differentiation capabilities (Argentati et al. 2018). Adult MSCs can be found in almost all postnatal organs and tissues, most notably bone marrow and white adipose tissue (Ong et

al. 2021). Adipose-derived stem cells are considered MSCs specifically derived from adipose tissue (Dominici et al. 2006), but are notably populous in subcutaneous fat deposits. As a result, there is an additional benefit for usage when considering the anatomical region ADSCs are derived from. Non-ADSC MSCs are most often procured from bone marrow (BM) through the introduction of a biopsy needle to the collection site; standard methods yield aspirated samples from consecutive heterosite needle insertions (Sivasubramaniyan et al. 2018). Procurement of BM is a highly invasive and painful procedure that necessitates a substantial application of anesthesia (Berebichez-Fridman and Montero-Olvera 2018). In contrast, the lateral location of adipose tissue allows for relatively painless harvesting with minimal invasiveness, increased safety, and avoidance of donor morbidity (Coleman 2001, Nordburg and Loboa 2015).

Surface Antigens

To standardize characterization and provide a uniform nomenclature for cross-referencing, The Mesenchymal and Tissue Stem Cell Committee of the International Society for Cellular Therapy put forth a minimal set of criteria for human MSCs that has been adopted by those in relevant fields of study. Cells designated as MSCs must (1) adhere to plastic in standard culture conditions, (2) be CD44+, CD105+, CD73+ and CD90+, (3) be CD45-, CD34-, CD14- or CD11b-, CD79α- or CD19- and HLA-DR-, all of which are positive indicators for hematopoietic stem cells, and (4) show osteogenic, chondrogenic, and adipogenic differentiation in vitro (Dominici et al. 2006). Specificity beyond this is limited by inadequate knowledge of stem cell "heterogeneity", a term used to describe the differences in morphology and phenotypes of cells regarding factors such as cell-specific antigens, the predilection for certain mature cell types, and genetic expressions (Mabuchi et al. 2021). Currently, CD90+, CD44+, CD29+, CD105+, CD13+, CD34+, CD73+, CD166+, CD10+, CD49c+, CD59+, and CD31 are all frequently characterized in ADSC results. The presence of CD31, more commonly known as PECAM-1, is particularly of note for therapeutic usage of ADSCs due to its modulating effects on endothelial junction activity in inflammatory or thrombotic conditions (Lertkiatmongkol et al. 2016). Additionally, the unique expression of cell-surface antigens allow ADSCs to induce a variety of other ideal paracrine effects on surrounding cells due in part to their secreted paracrine factors (Sikora et al. 2021, Argentati et al. 2018). The "paracrine effect" is a mechanism by which donor cells signal surrounding cells to repair diseased tissue without the signaling donor cells directly contributing to the new tissue. However, the positive presence of other antigens such as CD90 and CD44 provide support for arguments against widespread usage as these are two identified cancer stem cell (CSC) markers (Ong et al. 2021; Su et al. 2011).

Cell-Assisted Lipotransfer: An Adaptation of the Body's Natural Repair System

There has been a notable increase in the usage of ADSCs as test subjects in stem cell research for therapeutic application. Collected samples yield a high number of cells per tissue volume, proliferation rates are more pronounced than other MSCs, and ADSC products or surface receptors have been shown to induce regulatory effects on paracrine activity, inflammation, angiogenesis, apoptosis, and immune response (Sikora et al. 2021; Naderi et al. 2017; Merrick et al. 2019; Iyyanki et al. 2015; Tsekouras et al. 2017b; Cheng et al. 2021; Ong et al. 2021). Stem cells occur naturally within the body and have inherent roles within the body's mechanisms. ADSCs serve as an ideal repair source for breast tissue, as their adipose-tissue location predisposes their differentiation to preadipocytes and produces favorable aesthetic enhancement (Ong et al. 2021). As liposuction already involves the procurement of these adipose tissues, methods for aspirate enrichment with ADSCs have been developed through a natural progression. Coleman first reported what was eventually adapted as standard practice for adipose-tissue harvesting via liposuction: (1) The patient is administered a localized anesthetic, or general anesthetic upon request, to induce vasoconstriction and the harvesting site is sterilized, (2) a stab incision is made by a blunt, two-hole syringe attached to a cannula with a large entry portal, (3) collection of fat deposits proceeds, (4) collection syringe is centrifuged and 3 layers result, (5) the top layer of oil byproduct is poured off and the bottom aqueous layer of lidocaine, erythrocytes, and blood plasma is drained, (6) a 17 gauge syringe is attached to a Coleman Infiltration Cannula (Coleman 2001). Subsequent placement of adipose tissue into the breast occurs by numerous small passes using gentle pressure to deposit isolated fat in extremely small quantities of ideally only 0.2-0.5 mL within any one pass.

The procedure for cell-assisted lipotransfer (CAL) requires an additional step following the collection of aspirated samples using modified Fischer cannulas. The stromal vascular fraction (SVF) of aspirate adipose tissue is isolated during centrifugation and used to enrich progenitor cells in the graft before placement occurs (Yoshimura et al. 2010). In the initial trial of CAL, noticeable augmentation was observed, and postoperative atrophy of the fat grafts was minimal (Yoshimura et al. 2008). Follow-up measurements of postoperative results after 12 months found that the surviving transplant volume was 155 +/- 50 mL on average in the right breast and 143 +/- 80 mL in the left after an initial CAL of 264 mL (Yoshimura et al. 2010). Following this trial, the usage of ADS-CAL was highly recommended for further evaluation.

Evidenced Merits for Liposculpture with ADSC Assistance

Though implants and fat grafts are considered a relatively effective way to aesthetically augment breasts, they have a plethora of undesirable secondary effects that may arise. Loss of implant integrity and minimal retention of grafts can confound surgical outcomes, necessitating remedial surgeries or the removal of the implant altogether (Siggelkow et al. 2004). In a study of implant-related complications, 53 women, some of whom underwent cosmetic implantation and others who required implants for reconstructive purposes, were observed for post-operative sequela; 28 patients had a total of 35 complications, 21 patients had one, five patients had two, and two patients had three (Siggelkow et al. 2004). Siggelkow et al. 2004 additionally found there were also notably higher occurrences of complications in patients undergoing surgery for reconstructive purposes ($P < 0.02$). Graft retention following placement displays undesirable and common hindrances as well: they may quickly degrade due to ischemic cell damage, be encapsulated after incorrect implantation, or become calcified if transplant volume is sizable (Savoia et. al 2017). The introduction of ADSCs to lipoaspirate has shown an ability to minimize many of these issues.

Aesthetics

As breast reconstruction is an elective cosmetic surgery, one of the necessary outcomes is improvement in the chest's aesthetic. ADSCs have been shown to aid in a more ideal implant outcome by supporting correction of breast defects and overall asymmetries. In one clinical trial involving two female patients that had received reconstructive surgery, ADSC-rich autologous fat transplants were administered, and, in both cases, patients exhibited significant contour improvement with no further complications (Tsekouras et al. 2017a). Another clinical trial performed by Ito et al. (2017) treated 10 females with ADSC-enhanced fat grafts to observe the long-term aesthetic benefits of ADS-CAL. After 7.8 ± 1.5 years, six of the nine available patients reported "more than or equal to average" satisfaction with the appearance of their postoperative breasts, and five of nine reported "more than or equal to average" overall satisfaction. A metanalysis on studies comparing the aesthetic outcomes of ADS-CAL versus standard lipotransfer found that of the 17 weighted preclinical trials, 15 of them favored CAL for improvement of weight and volume; six of the seven clinical trials favored CAL (Toyserkani et al. 2016). Reconstructive surgeries partially seek to replace the lost tissue volume, so evidenced improvements in volume retention post-treatment suggest ADS-CAL is effective in achieving aesthetic improvements.

Regulation of Inflammatory Factors Promotes Implant Retention

Capsular contraction wherein scar tissue tightens around an implant is a high incidence complication that leads to implant displacement (Sood et al. 2017). This is suspected of arising from implant site fibrosis induced by complex inflammatory responses. Several methods, such as massaging the tissue postoperatively, have been postulated to have preventative benefits, but the efficacy of these techniques is unsubstantiated. In contrast, secreted factors from ADSCs perform a documented regulatory role in the inflammatory and immune response that may reduce the likelihood of capsular complications. Sikora et al. (2021) performed an in vitro experiment on human limbal epithelial stem cells treated with a derived ADSC-conditioned medium to observe effects on the genetic expression of pro- and anti- inflammatory factors relative to cytokine secretion. Levels of cell viability, cytotoxicity, apoptosis, and cellular proliferation were recorded in induced inflammatory and standard conditions; results suggested that ADSC paracrine activity played a role in the regulation of factor expressions associated with autoimmune function in response to outstanding infection. ADSCs secrete IL-6, an interleukin directly responsible for the regulation of cell viability, cytotoxicity, apoptosis, and cellular proliferation levels which contribute to epithelial cell maintenance during wound healing.

Similarly, ADSC effects on levels of cytokines promoting inflammation and bone morphogenic proteins induced by inflammation were observed during an in vivo experiment where ADSCs were applied to murine specimens with surgically induced osteoarthritis (Cheng et al. 2021). ADSCs displayed regulatory effects on pro-inflammatory factors by reducing IL1-β (pro-inflammatory cytokine) expression and lowering apoptotic rates. They additionally upregulated the expression of crucial structural components in the cartilage. To observe these effects in a breast implant setting, a separate in vivo study was conducted on rabbits to see if adipose-derived stem cells affected the outcomes of implant reconstruction after engraftment to the acellular dermal matrix (Jin et al. 2017). Silicone implants were inserted into 16 rabbits randomly assigned to control or experimental treatments, and histological analysis was collected at the one and three-month marks. Data comparison showed that there was an increase in gene expression related to angiogenesis and inflammation, suggesting that ADSCs aid with the early incorporation of donor tissue. With the regulation of postoperative inflammation, the likelihood of fibrosis and thereby contracture of the capsule would be reduced, resulting in a decreased frequency of implant migration. Furthermore, ADSCs have been shown to lessen the amount of time required for complete wound healing due to their ability to differentiate into new epithelial cells and promote the formation of granulated tissue (Gawronska-Kozak et al. 2018), which would reduce probability of infection at the incision and diminish recovery time for patients following implant placement.

Regulation of Angiogenesis and Degree of Potency Increases Graft Retention

Following adipose-tissue transplantation, three zones become distinct: (1) the superficial surviving zone where old adipocytes and stem cells remain, (2) the regenerating zone in which only ADSCs survive, and (3) the necrotic zone where both adipocytes and ADSCs die due to the ischemic conditions (Caldeira et al. 2018). After 12-weeks post-operative in human patients, the measurable adipogenesis within the graft reaches completion, but the regenerating zone continues to stabilize with the assistance of resident ADSCs (Kato et al. 2014). Non-enriched fat grafts without supplemented populations of ADSCs in human recipients have displayed 45.1% retention during four-month postoperative evaluations, while those with supplementation have displayed retention of 80.2% of graft volume on average (Kølle et al. 2020). In a preclinical trial using porcine models, a 41% enhanced retention rate was observed in all enriched grafts with no noted difference in morphology when compared to non-enriched controls (Rasmussen et al. 2019). These observations may be a result of ADSCs' ability to promote angiogenesis, thereby increasing fat graft retention by reducing ischemic adipocyte apoptosis. ADSCs' ability to regenerate endothelial cells can counteract ischemic complications by increasing the perfusion of blood and promoting proper vascular reformation, thus minimizing the size of the necrotic zone. One study utilized the acellular dermal matrix (ADM) of mice combined with human ADSCs in an in vivo murine model to investigate regenerative capabilities on full-thickness cutaneous wounds (Huang et al. 2012). Subjects treated with ADM ADSCs had improved granulation (tissue growth as part of the healing process), an increased rate of re-epithelialization, and a greater blood vessel density.

Similarly, ADSCs have shown efficient production of cell sheets by increasing paracrine secretions in the extracellular matrix with or without collagen sheets, meaning their reconstructive properties are not dependent on assistance of additional tissue engineering (Mazini et al. 2020). Their degree of potency also allows them to mature into keratinocytes, fibroblasts, and endothelial cells, the last being of note for graft retention due to their role in refractory wound repair (Li and Guo 2018). Damage to cellular junctions yields hyperpermeable endothelial barriers that lack vascular homeostasis, which in turn cause tissue impairment and reduced angiogenesis (Park-Windhol and D'Amore 2016). ADSCs are CD31+, an antigen now commonly referred to as "platelet/endothelial cell adhesion molecule-1" (PECAM-1) and can therefore directly regulate vascular permeability and integrity, and molecular trafficking (Lerkiatmongkol et al. 2017). ADSCs play an important role in modulating the inflammatory, immune, and angiogenesis responses, particularly when the body is under stress by inducing signal cascades. Thus, incorporation of ADSCs into transplant tissue show markedly improved results by ensuring the graft receives proper oxygenation via promotion of angiogenesis and by encouraging ideal environments for wound repair.

Treatment for Lymphedema

Breast-cancer-related lymphedema (BCRL) is another common sequela of reconstructive surgery that lacks a reliable method of treatment. In a pilot study conducted on 20 human patients, the efficacy of ADSCs was observed as a postoperative treatment method to fluid build-up in the brachium (Maldonado et al. 2011). Twenty women exhibiting postoperative lymphedema were randomly assigned to either the control group, those given the typical decongestive treatment method (a compression sleeve), or the experimental group, those injected with ADSC in the affected arm. Results were reported by patients after treatments were allowed to proceed over a 12-week period. The study concluded that while both treatments provided improvement of lymphedema volume, the experimental group treated with ADSCs continued to show an overall reduction in the fluid build-up after treatment, while the control group experienced a recurrence of the complication after the sleeve was removed.

A separate study attempted to assess whether these results were applicable long-term. A group of ten post-operative patients elected to undergo ADSC injections for treatment of their BCRL, and follow-ups were conducted at the 1, 3, 6, 12, and 48 month marks (Jørgensen et al. 2021). While there was no overall fluid reduction, patients reported the following: all expressed increased mobility in the extremity's function, six of the ten patients had reduced conservative treatments, and five of ten felt as though there was some reduction of the lymphedema. It should be noted that this more recent study was not constructed as a blind, randomized control study, so further tests are necessary to accurately evaluate its clinical applicability. Although the two studies do not corroborate a reduction in volume, both show that patients feel an overall improvement in their condition. Quality of life is important to consider when assessing the efficacy of treatment, and ADSCs have been shown to improve lymphedema symptoms, again displaying the benefits of ADS-CAL.

Safety Concerns and Evidence to the Contrary: ADSCs and Cancer

Upon review of the frequency with which efficacy of the procedure is reported, ADS-CAL is shown to largely provide beneficial effects during clinical application. Purported harms have been reported by studies conducted in vitro or in non-human models, suggesting that these results require further testing before they can be used to negate therapeutic observations. No issues regarding tissue site collection were noted in any studies referencing potential issues with adipose derived stem cell applications, and none reported instances where ADSCs differentiated into CSCs, as this is not a predisposition they have displayed in any setting,

clinical or otherwise. Most oncologic issues arise from extra membranous markers and secreted paracrine factors, though results directly contrary to some of these effects have been reported as well. However, a holistic consideration of ADS-CAL should still be taken as patient safety is of the utmost importance for any clinical procedure, therefore, in vitro model results must be considered.

Cancer Cell Immunomarkers

ADSCs express the cell surface protein CD44 (Dominici et al. 2006). Positive expression of CD44 is linked with cells observed to express biological CSC characteristics due to comparable proliferation rates, differentiation inclinations, and related radiosensitivity and chemosensitivity levels (Su et al. 2011). Adhesion properties of CD44 mediate activation, aggregation, and migration of cells which may then undergo splicing events, resulting in variants (vCD44) with larger exons that encourage further vCD44 proliferation (Senbanjo and Chellaiah 2017). This variant interacts with ligands to produce CD44-ICD, which induces metastatic gene transcription in the nucleus.

Despite CD44 being linked to cancer, this potential involvement cannot be simplistically resolved. In a study conducted with ADSCs to investigate potential oncological risk and patient-specific responses to ADSCs, breast tissue samples were collected from five healthy female patients that had received breast reduction surgery, and one female patient with Stage III breast cancer (Kengelbach-Weigand et al. 2019). Previously known cell lines for normal mammary epithelial cells, ADSCs, and Stage III breast cancer cells were cultured in ADSC-conditioned medium alongside patient-derived samples. Normal mammary cell (NORMA1-5 MEC) migration and invasion was found to increase upon introduction to cultures treated with ADSC-conditioned mediums. The ADSC-conditioned medium was also shown to increase normal cell gene expression and proliferation to varying degrees reliant upon donor characteristics when comparing between patient-derived samples and the known cell lines. However, this study also showed ADSCs to have a similar effect on cancerous mammary cells (IFDUC1-5 MEC) which directly illustrates the outstanding lack of mechanistic understanding concerning ADSC signal transduction. Several studies have alluded that this deficit in knowledge disallows conclusions regarding expressed ADSC immunomarkers and their role in oncologic promotion (Ong et al. 2021; González-Cruz et al. 2012; Brielle et al. 2021). ADSCs have not been observed as tumerogenic in in vivo settings since they cannot prompt the oncologic transition of normal mammary cells, but may amplify pre-existing tumor activity through HGF/c-MET pathway activity (Eterno et al. 2014). Therefore, screening with c-MET can be used to predict the probability of tumorigenesis following ADS-CAL graft placement, which would assist in monitoring patient risk.

Acquired Drug Resistance

Particularly aggressive forms of breast cancer, such as triple-negative breast cancer, necessitate chemotherapeutic drugs for systemic treatment (Bianchini et al. 2016). As patients undergo chemotherapy, initial success can slowly diminish and many tumors can become unresponsive to original treatment methods, developing resistances that result in metastasis or death (O'Reilly et al. 2015). ADSCs have the potential to contribute to chemoresistance by increasing the expression of ABCG2, also known as breast cancer resistance protein, on surrounding cells in an in vitro model , which results in the efflux of doxorubicin (Yeh et al. 2017). Additionally, the ADSC medium also increased cell viability and reduced doxorubicin's ability to induce apoptosis as a result of the ABCG2 upregulation.

In contrast, ADSCs have also been shown to inhibit ovarian cancer growth in chemoresistant cells by shuttling paclitaxel (PTX) into the cells following PTX priming (Borghese et al. 2020). PTX-treated ADSC cell medium was even found to be more active than non-treated PTX, able to counteract resistance in all drug-resistant cell lines with notable efficacy. Since ADSCs can also be used to counteract displayed chemoresistance in cells, this should not be labeled as an inherent safety risk and instead be considered for therapeutic contextualization.

Supposed Promotion of Ideal Metastatic Environment

The greatest concern is that ADSCs might induce the recurrence of cancer in postmastectomy patients due to their proximity to the mammary gland upon deposition and propounded ability to increase the rate of metastasis in in vitro models. To discern if adipose-derived stem cells gave effect within tumor environments, ADSCs were isolated from human adipose tissue and transplanted alongside tumor cells in an in vitro model; results indicated that cohabitation with H460 or U87MG murine cells promoted tumor growth in test subjects (Yu et al. 2008). Results of another study found that after the administration of ADSCs from the abdominal tissue of two of the three human female subjects, multiple mouse organs administered with these xenografts exhibited breast cancer cell migration and metastasis (Rowan et al. 2014). The ADSCs of the third female subject yielded an expression of MMP-9, an enzyme common to cancer pathology as it is known to aid in metastasis and cell invasion. Other studies have also further speculated about the effect that ADSCs have on cancer growth due to their unknown, but considerable, effect on tumor behavior (Freese et al. 2015). Gebremeskel et al. (2019) observed that in a murine model, mice treated with an ADSC medium had increased proliferation of cancer cells ($p = 0.03$), migration ($p < 0.01$), tumor growth ($p < 0.05$), and other transcription factors related to metastasis.

However, a long-term study on ten female recipients of ADSCs-enriched adipose grafts over a period of 7.8 ± 1.5 years found no recurrence or metastatic disease (Ito et al.

2017). When treated with medium containing ADSC secretomes, mammary epithelial cells upregulated the proliferation of normal ADSCs collected from urologic neoplasms, exhibited non-tumorigenic differentiation upon introduction to xeno-free growth conditions, and no genomic abnormalities were observed within their molecular karyotype (García-Contreras et al. 2014). They were still able to produce exosomes with unaltered miRNA, which are proposed contributors to the traditional paracrine benefits displayed by healthy preadipocytes from xeno-free samples. This suggests that, so long as ADSCs are expanded in xeno-free culture conditions before therapeutic administration, they should not pose a threat to patient welfare regardless of their health. Previous studies that asserted ADSC encouragement of tumorigenesis employed co-injection with tumor cells (Yu et al. 2008), unaltered expansion conditions predicating collection (Rowan et al. 2014), or untreated ADSC medium applied to pre-existing tumorigenic-favorable environments (Gebremeskel et al. 2019). Despite this, careful consideration for ADSC usage on patients of oncologic concern is still advised and further studies should be conducted for further confirmation as patient safety should be the crux of stem cell research.

Final Considerations: Applicability and Limitations

Oncological concerns are not unjustified but may be due to inadequate stem cell standardization or lack of established methodology. Additionally, studies that support concerns over ADSCs' role in cancer solely employ in vitro models. Stem cell populations are heterogeneic, which confounds current identification methods; functional criteria and nomenclature do not take into account ADSC-specification, cells from common donor sites are not adequately categorized, variation of patient attributes (such as body mass index, age, sex) can result in variations in preadipocyte maturation, in vitro models may not accurately represent in vivo interactions, and non-standardized experimental instruments further complicate comparison of reported data (Ong et al. 2021). To resolve this issue and truly establish ADSCs as a safe method of treatment, a labeling system that no longer uses CD positive or negative designations to identify could be implemented instead. González-Cruz et al. (2012) found that mechanical properties of ADSCs could be related to lineage differentiation potential and used for subpopulation groupings which were corroborated with high statistical significance. More recent studies have found that single-cell RNA sequencing, performed during multiple stages of differentiation, allowed for notably complex understandings of the biomechanical roles of stem cells in vivo (Brielle et al. 2021). Since ADSCs have shown beneficial effects long-term with metastatic concerns being solely reported within in vitro models, further studies on their oncologic roles should be conducted with techniques that more accurately consider ADSC behavior in an in vivo setting. Additionally, the results of

ADSCs can be variable and do not work with the same amount of efficacy among harvesting techniques. Techniques applied during the preparatory phase of the procedure can have profound effects as well. Iyyanki et al. (2015) conducted adipose tissue harvesting in human patients by four methods, mechanical liposuction, direct fat excision and deposit, and Coleman's technique with or without centrifugation, and found that there was significant variation in the level of SVF and ADSCs obtained. Of the techniques employed, direct excision yielded the largest number of ADSCs ($P = 0.007$), while Coleman's technique yielded more SVF cells ($P < 0.005$), but not an observable amount of ADSCs. Another study sought to quantify differences between solely mechanic (MC) (involving the primary use of centrifugation) versus mechanic plus enzymatic (ME) (requiring an additional treatment with a collagenase digestion solution) isolation techniques (Raposio et al. 2017). ME was observed to isolate a greater number of ADSCs from the human donor tissue.

Donor sites also have significant implications for ADSC harvesting, with some suggesting that outer thighs are more ideal harvesting locations due to significantly higher viable stem cell count following isolation ($p<0.05$) (Tsekouras et al. 2017b). Others report that the abdomen should be more highly regarded for yield (Iyyanki et al. 2015). In contrast to all of this, Oedayrajsingh-Varma et al. (2006) purported that harvesting procedures and donor sites affected the characteristics of ADSCs but did not affect the isolation number of viable cells; their data suggested that changes in yield were merely due to a decreased ability to proliferate depending on collection method. Further studies must be conducted to positively identify the quintessential site for collection, harvesting method, and isolation technique, though this may be confounded by patient-composition variations. A proposed study could be one designed for comparison of ADSC yield of outer thigh or abdomen donor sites by mechanical liposuction, direct excision, or Coleman's technique with or without centrifugation. Additionally, tissue obtained from these two sites could be isolated by either ME or MC means. This may assist in determining ideal procedural methods for the synthesis of an industry paradigm, eventually allowing for the standardization of reported data and better comparability of observed results.

A task force formed by the American Society of Plastic Surgeons evaluated autologous fat grafts and found that, upon review of documented case studies, they were confirmed as a safe and effective procedure in clinical settings up to 12 months following use on human recipients (Gutowski et al. 2009). Villani et al. (2010) later verified these findings by employing fat grafts for scar remodeling in 250 patients and observing only beneficial aesthetic outcomes, normal histological data, and patient reported satisfaction.

However, the most recent and compelling evidence for the viability of ADS-CAL comes from the meta-analysis of Li and Chen (2021), which found that the CAL results showed statistically significant improvements in fat graft retention rates compared to control groups (Standard mean difference = 1.79). Additionally, no abnormal or significant complications

were reported within ADS-CAL treatment groups. As with the previous meta-analysis, these results prompted Dominic et al. (2021) to write a letter to the editor of the Aesthetic Plastic Surgery journal that emphasized the conclusions of Li and Chen's (2021) review and implied the necessity of further meta-analyses to rectify controversies found in literature. The efficacy of ADS-CAL was undisputed. Yoshimura (2020) submitted that within the years following his initial implementation of ADSC-assisted lipotransfer, its usage has provided patient grafts with extensive rejuvenation, regeneration, and therapeutic resolve.

There is even the potential for ADS-CAL to replace previous methods altogether, an ideal progression for patient satisfaction since autologous deposits provide natural breast pliancy upon palpation. Within the study conducted by Kølle et al (2020), additional results found that there was an average enlargement of 2.6 times that original volume, and no further surgeries were necessary to achieve the desired effect. This level of graft retention suggests that with increased uniformity and development of methods, ADS-CAL may be able to render synthetic implants obsolete. So, while more studies should be conducted and techniques should be standardized, ADS-CAL can be considered an effective and tentatively safe treatment method for breast reconstruction purposes based upon reported treatment outcomes.

Summation of Considered Efficacy and Safety

With the assistance of ADSCs, it has been shown that angiogenesis is promoted, inflammation is moderated, and wound healing is idealized through influence on the endothelial barrier. Increased proliferation and vascularization yield a higher degree of graft retention, frequency of fibrosis may be reduced to negate capsular contracture, and other secondary effects such as lymphedema may be minimized as well. All these effects provide ameliorated aesthetic outcomes which lead to improved patient satisfaction and a predicted boost in mental wellbeing. However, their antigens and secreted paracrine factors have still been shown to induce various carcinogenic effects in experimental in-vitro or non-human models.

As such, it is concluded that ADS-CAL has impressive efficacy for improved aesthetic outcomes of breast reconstructive surgeries and can regulate undesirable secondary effects but should be implemented with reasonable caution until oncologic results are better understood. Ideal harvesting techniques, donor sites, and other methodological factors are still under review, but must be standardized to provide equitable data for comparison.

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Contributor Biographies

Student Authors

Maddie Chaplain is a third-year Nursing student at Seattle University. Upon graduating, she aspires to enter the nursing field and gain clinical experience with at-risk and underserved populations in Seattle before pursuing a doctorate. She resonates deeply with the stories of others and feels passionate about social justice in the context of mental healthcare. When she embraces free time, Maddie enjoys creating art, visiting with her family and animals, and eating delicious food.

McKenna Kelly graduated from Seattle University in 2022 with a BS in Biology. She is currently applying to graduate schools to obtain an MS in Medicinal Sciences before moving on to medical school. These steps will bring her closer to her childhood dream of becoming a surgeon, specifically working in reconstructive edenjoys hiking with her three dogs, painting, and tending to a copious number of houseplants.

Piper Klinger graduated from Seattle University with a BS in Environmental Science and a minor in Environmental Engineering. She is currently pursuing her MS in Civil and Environmental Engineering at the University of Washington and will graduate this upcoming June. She has a passion for water quality management and natural systems, fueled in part by her research on the paper "Arsenic Removal from Drinking Water Using Enhanced Biochar." Piper aims to build a career in water management and watershed restoration.

Breann Kniffen is a graduating Cell & Molecular Biology major and Chemistry minor student at Seattle University. While her career ambitions involve earning a doctorate focused on biomedical research, her passion for preventing and stopping climate change led her to work with the Center for Environmental Justice and Sustainability and write the "Urban Campus Native Bee Conservation Guide." This paper reflects her enthusiasm for making projects accessible in a way that encourages engagement and community involvement. Breann would like to express her gratitude to her mentor, Dr. Heather Brown, for their guidance and support in completing this project. She would also like to extend her gratitude to Seattle University's Grounds and Landscaping Manager, Shannon Britton; Lead Carpenter for Seattle University Facilities, Mark Murray; Assistant Director of Sustainable Facilities Operations, Rick Moyer; all 2021 bee monitoring volunteers, and others who have generously helped with guidance and influence. Thank you to each and every person who helped contribute to this project.

Alyssa Konopaski graduated in Spring 2022 with a BS in Chemistry from Seattle University. She was deeply integrated in the Chemistry department and the College of Science and Engineering where she participated in two research projects, served as a Student Advisory Council member, acted as Chemistry Club president, and worked as an organic chemistry tutor and study group facilitator. She was even recognized as a Bannan Scholar and awarded Outstanding Senior Chemist for her service work. Alyssa got her start in educational research at Highline College Writing Center, where she and a team of writing consultants investigated the ability of their Writing Center to connect non-native English speakers to the campus community. After transferring to Seattle University, she sought further educational research opportunities where she got involved in curricular improvements of General Chemistry to include more systems thinking themes, inspiring her paper "Curricular Innovations to Promote Systems Thinking in a General Chemistry Laboratory Course." Her ORCID is: https://orcid.org/0000-0002-3138-2342.

Janice Lee is a fourth-year student at Seattle University majoring in Civil Engineering, graduating in June 2023. With a passion for design and creativity since childhood, she hopes to be able to take part in designing something bigger than herself and to advocate for environmental sustainability throughout her structural career. Although her specialization isn't in environmental science, she was drawn to Dr. Thomson's experiments to make eco-friendly reusable water filters for lower income demographics and jumped at the opportunity to help as a research assistant over the summer of 2021.

Mikey Redding is a fourth-year student from Issaquah, Washington, graduating with a double degree in International Studies and Public Affairs. They plan on contributing to local and state policymaking through the application of their studies, while planning to earn their graduate degree abroad through Fulbright programs. They are excited to continue expanding on the foundations set at Seattle University, and work to apply tangible change in the world with mounting threats against human rights from the local to the global scale. Their policy analysis is reflective of their motivation to present alternatives within a flawed system for a more equitable future in local, state, and national governance to protect queer children from overwhelming discriminatory legislation in the United States.

Cady Seavey graduated from Seattle University with a BS in Kinesiology with Departmental Honors and a minor in Chinese. Her paper "Associations Between Decreased Attentional Resources and Hand Function in Young Adults" was inspired by her personal experiences with older adults, fascination with human movement, and appreciation for science. She has since expanded this research to the older adult population and presented findings at the Society for Neuroscience Annual Meeting in 2022. Cady intends to pursue graduate studies in kinesiology and aims to promote successful aging through research in motor control and learning.

Susannah Sherwood graduated from Seattle University in 2022 with a BS in Chemistry and a minor in Mathematics. She is currently a graduate student at the University of Oregon's Knight Campus Graduate Internship Program for her MS in Chemistry with a focus in Semiconductors and Photovoltaics, and she is working at an R&D startup in Austin, Texas to complete her degree. When she isn't busy conducting research or reflecting on the nature of scientific knowledge, she enjoys reading fiction, writing book reviews, exploring the city, baking, and hanging out with her cat.

Brandon Teola is a second-year student from Los Angeles, California, majoring in English Literature with a minor in Communication and Media. He conducted the research for his paper in Dr. Allison Meyer's course, "Renaissance and Reformation Literature," which he participated in as a student in the University Honors Program (Intellectual Traditions Track) during the spring of 2022. He hopes that his paper will spotlight the Ottoman literary tradition as a significant and valuable subject of literary studies that is underexamined in the field. Outside of academics, he works at the Writing Center and serves as the Student Executive Council representative of the English department. He is also the Vice President of Circle K International, a service club on campus that participates in local community service projects. Once he graduates from Seattle University, he plans to go to graduate school to continue pursuing literary studies. He believes in the power of storytelling, both when telling one's own and listening to others'.

Student Editors

Nicole Beauvais is a fourth-year student in the English and Communications Studies departments and was the editor for two papers: "Curricular Innovations to Promote Systems Thinking in a General Chemistry Laboratory Course" by Alyssa Konopaski and "Don't Say Gay: An Examination of Florida's Restrictive Education Policies and Potential Alternatives" by Mikey Redding. Outside of *SUURJ*, Nicole is the Communications Assistant for the Office of Strategic Initiatives and a Blog Editor for KXSU. Nicole is grateful to work with the *SUURJ* team as their first student intern, and hopes readers enjoy Volume 7 of the journal.

Masami Carpenter is a third-year Creative Writing major anticipating graduating in March of 2024. She helped to edit the essay titled "Adipose-Derived Stem Cells (ADSCs): A Promising Future for Breast Reconstruction" by McKenna Kelly. Editing this work reignited her passion for writing and editing publications. She is very grateful to have worked on this volume of *SUURJ* and will continue to carry the skills that she acquired in her career following graduation. She is hoping to work in the publishing field.

Tripp Ceyssens is a third-year Communications Studies major at Seattle University. He edited the paper "Arsenic Removal from Drinking Water Using Enhanced Biochar" by Piper Klinger and Janice Lee and is currently studying online communities and cultures with a view of going into the video game industry. In the future, he hopes to be able to organize creative communities in producing fascinating cultures.

Riley Flanagan is a fourth-year English Creative Writing major with a Film Studies minor at Seattle University. She served as the editor for Breann Kniffen's paper, "Urban Campus Native Bee Conservation Guide." Working for *SUURJ* has created an interest in copyediting and copywriting and a new appreciation for our little pollinator friends. Outside of academia, Riley enjoys writing poetry, watching movies, and hanging out with her cat.

Katrina Manacio is a third-year English Literature major with a minor in Political Science. She served as the student editor for Madeline Chaplain's paper, "Inefficacy of the Crisis Intervention Team Model" and as the secondary student editor for Mikey Redding's paper, "Don't Say Gay: An Examination of Florida's Restrictive Education Policies and Potential Alternatives." Katrina hopes that the skills and experience she has gained through her work on this volume of *SUURJ* will benefit her pursuit of a career in law. Aside from *SUURJ*, she also works as the administrative office assistant for Seattle University's English department.

Olivia Merrick is a second-year Criminal Justice major with a specialization in Criminology and Criminal Justice Theory and is also minoring in Writing Studies. She had the pleasure of working as the copyeditor on Brandon Teola's paper, "The Value of the Nazîre: Comparing the Poems of Nejâtî and Bâkî in the Tradition of Ottoman Lyric Poetry." Outside of her work for *SUURJ*, Olivia works as a writing consultant at Seattle University's Writing Center. After graduating, Olivia plans to attend law school and work as a criminal defense attorney.

Olivia Moretta is a fourth-year English Creative Writing major and Writing Studies minor from Dallas, TX. She edited "A Spectrum of Scientific Rigor: Reconsidering the Demarcation Problem from a Quinean Lens" by Susannah Sherwood and co-edited "Adipose-Dervied Stem Cells (ADSCs): A Promising Future for Breast Reconstruction" by McKenna Kelly. When Olivia isn't writing, editing, or reading, she can be found at her hardware store job or spending time with her cat. After graduation, she plans to pursue both writing and editing.

Emelia Vonada is a second-year Journalism major and Creative Writing minor from Beaverton, Oregon. She would like to thank every person in *SUURJ* for their kindness and collaboration throughout the year. She had the utmost privilege of editing Cady Seavey's paper, "Associations Between Decreased Attentional Resources and Hand Function in Young Adults." She would like to thank Cady, Dr. Heintz Walters, and Dr. Rauff for their efforts in putting together the first kinesiology paper in *SUURJ*. She hopes she can use her gained experiences in the future, as she plans to pursue a career in the publishing world.

Faculty Content Editors

Heather Brown, PhD, is an Associate Teaching Professor in the Biology Department. She started at Seattle University in 2010 after earning a PhD in Molecular and Cellular Biology at the University of Washington and following a postdoc at Fred Hutchinson Cancer Research Institute. She teaches multiple courses within Biology and the Core, including Developmental Biology, General Biology I and II, and Cancer in the 21st Century.

Katherine Frato, PhD, is an Associate Professor of Chemistry and has been at Seattle University since 2013. Her areas of focus are biophysical chemistry and bioinorganic chemistry.

Brooke Gialopsos, PhD, is an Assistant Professor in the Department of Criminal Justice, Criminology, and Forensics. Her current research interests involve the prevention and harm mitigation of school shootings, civilian active assailant protocols, psychological impacts of safety protocols, fear of crime and risk perceptions, sexual victimization, and school-based victimization. Her works have appeared in *Crime and Delinquency, Journal of Criminal Justice, Journal of School Violence, Journal of Contemporary Criminal Justice, Criminal Justice Review, Teaching of Psychology,* and the *Encyclopedia of Criminological Theory.* She also co-authored a chapter in *The Oxford Handbook of Criminological Theory.* In addition, Dr. Gialopsos is a certified ALICE (Alert, Lockdown, Inform, Counter, Evacuate) instructor and educates members of the community on how to survive active shooter situations, in general, and school shootings, in particular. She is also an LGBTQ+ Ally and a Safe Zone educator.

Lyn Gualtieri, PhD, is the Director of the Environmental Science Program. She teaches courses in geology, arctic environments, natural hazards, and field methods. She has published research papers on the glacial and sea level history of the Bering Strait region as well as the extent of glaciation in arctic and alpine areas. She served as faculty content editor for Piper Klinger and Janice Lee's research paper.

Brett Kaiser, PhD, is an Associate Professor of Biology and has been at Seattle University since 2012. He earned a BS in Biochemistry from UC Davis, his PhD in Cancer Biology from Stanford University, and trained as a post-doc at the Fred Hutchinson Cancer Center in Seattle. He uses biochemical and biophysical approaches to address protein function. His current research aims to understand the molecular mechanisms by which bacteria fend off viruses (phages).

Allison Machlis Meyer, PhD, is an Associate Professor in the English department, where she specializes in early modern literature. She teaches courses on early modern drama, including Shakespeare, as well as Honors seminars on early modern, medieval, and classical literature. Her research areas include gender, politics, and queenship in historical narratives and history plays, contemporary all-female and nonbinary performances of Shakespeare, and the construction of religious difference in early modern textual compilations. She is the author of *Telltale Women: Chronicling Gender in Early Modern Historiography* (University of Nebraska Press, 2021). She served as the faculty content editor for Brandon Teola's paper.

Janice Moskalik, PhD, is an Associate Teaching Professor in the Philosophy Department and also teaches for Interdisciplinary Liberal Studies and for Albers School of Business and Economics. She teaches courses on issues in education, ethics (including ethics in health care and business ethics), and courses that explore philosophical questions about personhood and recognition. Dr. Moskalik's research interests include responsibility practices and moral emotions, philosophy of law, and philosophy in education. She is currently the faculty advisor for Seattle University's Undergraduate Philosophy Club and served as a faculty content editor for *SUURJ*.

Erica Rauff, PhD, is an Assistant Professor of Kinesiology, where she specializes in Sport & Exercise Psychology. Her current research involves examining physical activity, psychological well-being, and other health behaviors (i.e., diet, sleep) in first year university students and how the transition to university influences health behaviors. The goal of her research is to develop theoretically-based physical activity programs in first year university students to improve their health, psychological well-being, and provide these young adults with the behavioral skills and strategies they need to engage in positive health behaviors across their lifespan.

Kevin Ward, PhD, is Associate Professor in the Institute of Public Service at Seattle University where he teaches graduate and undergraduate public policy and capstone courses. He is also Director of the Bachelor of Public Affairs program. His research interests include national service programs such as AmeriCorps, nonprofit lobbying and advocacy, motivations of public and nonprofit employees, and inter-organizational collaboration. He holds a PhD and MPA from the School of Public Affairs at the University of Colorado, Denver and a BA in Economics from the University of Illinois. He also served two years in the national service program AmeriCorps National Civilian Community Corps. His essays and op-eds on national service have appeared in the *Seattle Times* and *Huffington Post.*

Faculty Advisory Board

Brenda Bourns, PhD, is an Associate Teaching Professor in the Biology Department. She completed her Bachelor of Science in Biology at the University of North Carolina where her thesis work centered on mammalian Cell Biology, specifically microtubule dynamics during cell division. She moved to researching the chromosome structure of telomeres in budding yeast at the Fred Hutchinson Cancer Research Center and Princeton University before receiving her PhD in molecular biology from the University of Washington Pathology Department in 1997. Her post-doctoral studies focused on mammalian cell communication during cell division in the Surgery Department at the University of Washington. At Seattle University, she specializes in teaching Biology to non-Biology majors as part of the Core curriculum as well as teaching Cell and Molecular Biology to majors. She is particularly interested in experiential learning. She has developed field courses in the dynamic ecosystems of the San Juan Islands and Olympic Rain Forest of the Pacific Northwest. She is currently pursuing a new program of Community-Engaged teaching by developing a partnership with the Black Farmers Collective of Seattle to design and construct a new urban farm for displaced community members near the campus of Seattle University.

June Johnson Bube, PhD, is an associate professor in the English Department and Director of Writing Studies. She holds a BA in English and an MA in Education from Stanford University, an MA in English from Mills College, and a PhD in mid-nineteenth century American literature from the University of Washington. In her Americanist field, she has published articles on women's alternative fictions about the West. In Writing Studies, she has authored Global Issues, Local Arguments, an argument rhetoric and reader focused on civic literacy and a cross-curricular introduction to global problems. She has co-authored (with John C. Bean) two other writing textbooks: *Thinking Rhetorically: A Guide to College Writing*, a writing-across- the-curriculum rhetoric, and *Writing Arguments*, a leading argument text. Her recent scholarship has appeared in *College English, the Journal of Teaching Writing*, and a forthcoming book on empathy studies and teaching writing. Her current focus includes global studies, argumentation, collaborative rhetoric, listening studies, and climate change rhetoric. She serves on the *SUURJ* Faculty Advisory Board.

Marc A. Cohen, PhD, is a professor with a shared appointment in the Department of Management and the Department of Philosophy. He earned a doctorate in philosophy from the University of Pennsylvania and, prior to joining Seattle University, worked in the banking and management consulting industries. His research concerns trust, moral psychology, management theory, and questions in social and political philosophy about what makes society more than an accidental crowd.

Nova Robinson, PhD, is an Associate Professor of History and International Studies at Seattle University. She is currently preparing her book manuscript *Truly Sisters: Arab Women and International Women's Rights* for publication. She is also co-editor with Bonnie G. Smith of the *Routledge Global History of Feminism.*

Michael Spinetta, PhD, is an associate professor of Psychology with a doctorate in Behavioral Neuroscience. He is particularly interested in learning, memory, and psychopharmacology, with an emphasis on the consolidation and reconsolidation of emotionally salient events and the effects that drugs of abuse and therapeutic drugs have on the learning process, including the formation, storage, and retrieval of memories.

Chief Faculty Editors

Tara Roth, MA, is an Associate Teaching Professor in English. Her background is in rhetoric and composition, and she teaches a number of academic writing and creative writing courses in the Core. Outside of academia, she has written and published a variety of musical projects, is a former Jack Straw writer, and co-authored the memoir *Throw it in the Sea*. She served as a chief faculty editor for *SUURJ* Volume 4 and Volume 6 and is excited to return for Volume 7 with this amazing team of student authors and editors.

Hannah Tracy, PhD, is an Associate Teaching Professor in English. She teaches literature and composition courses, specializing in nineteenth- and twentieth-century British and American literatures, political rhetoric, and news media analysis. She feels grateful to be working on *SUURJ* again this year with her friend and co-editor Tara Roth, outstanding faculty colleagues from across the university, and a brilliant and hardworking team of student editors to produce an exciting and inspiring new volume of *SUURJ*.

Journal Design

Caleb Hou graduated from Seattle University in 2014 with a BA in Digital Design and has been designing for *SUURJ* since 2018. He currently works as a Senior Designer for Disney. His work focuses on the digital app experiences for Disney Cruise Lines, Disneyland, Disney World, and the Aulani resort in Oahu, Hawaii. In his spare time Caleb enjoys freelancing for local businesses, designing and making costumes, and collaborating on art projects with his wife and former *SUURJ* editor, Jane Kidder.

Administrative Support

Shawn Bell, English department administrative assistant, is from Spokane, Washington and has served as professional staff in several capacities at Seattle University for ten years. His roles at Seattle University have ranged from supporting student researchers to doing the back-office work of grants administration to working in his present multi-faceted role. He studied business software at Bellevue College and in previous endeavors has been a coffee shop manager; a freelance photographer in Syria, Lebanon, and Egypt; and has held supervisory roles in the corporate world. Working at the University of Washington, the Seattle University Bookstore, and serving on the University of Washington North of 45th Committee, he developed a strong commitment to supporting students that ultimately lead to staff work at Seattle University.

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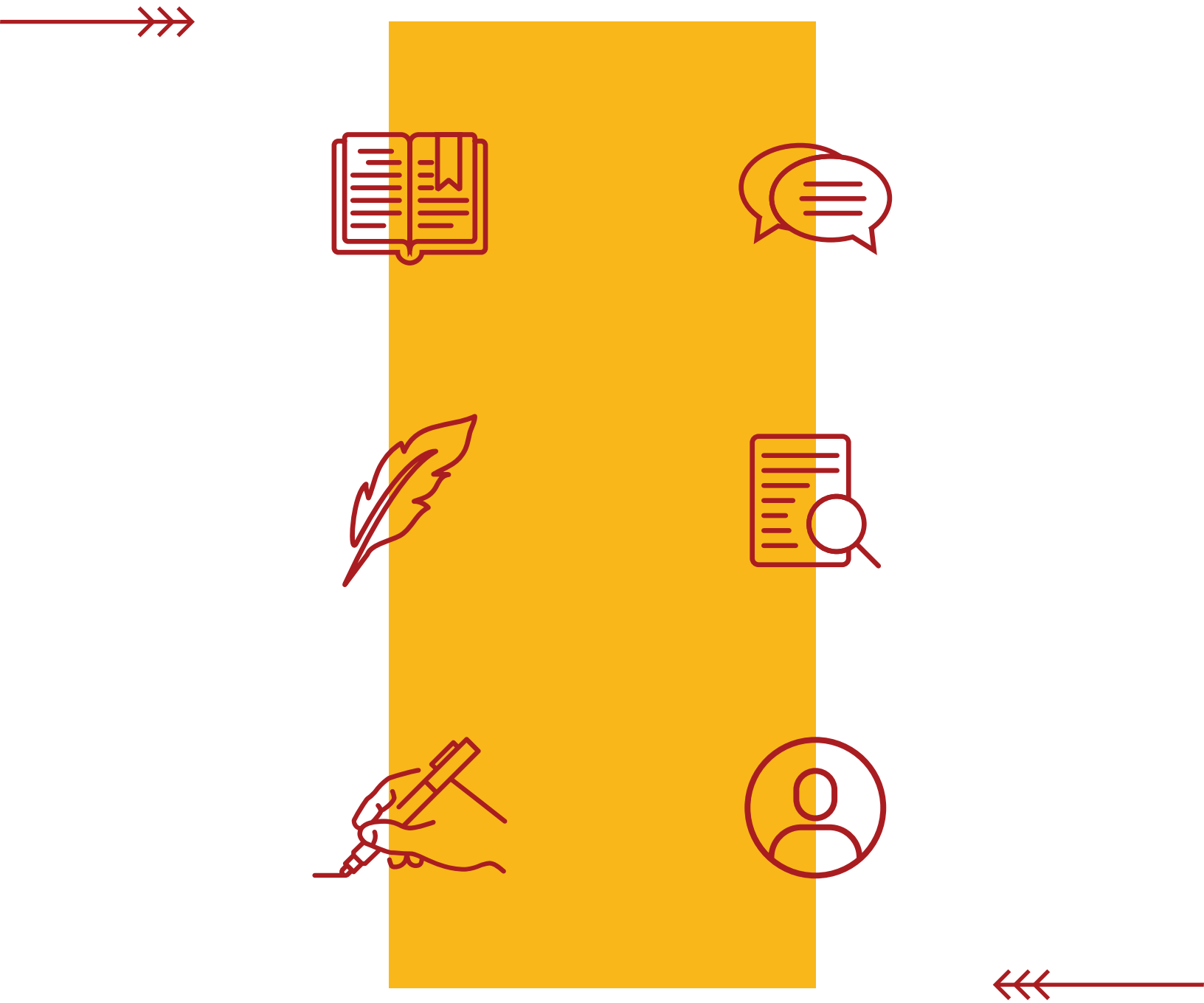

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