Nature-Based Learning

"Blossoming Connections: Exploring the World of Pollinator Habitats"

Rhoma Geronimo-Pineda

NAU Teacher Leadership Shiłgozhóó Institute

2023

Author Note:

Rhoma Geronimo-Pineda is a Resource Teacher at Alchesay High School, in Whiteriver, Arizona. Correspondence concerning this curriculum unit should be addressed to Rhoma Geronimo-Pineda, Alchesay High School, PO Box 190, Whiteriver, Arizona 85941. Email: rgeronimo-pineda@wusd.us

Dedication:

This pollinator habitat curriculum is dedicated to the countless individuals who have tirelessly advocated for the protection and preservation of pollinator habitats. It is a testament to their unwavering commitment and passion for creating a sustainable future for pollinators and the ecosystems they support.

To the scientists, researchers, and conservationists who have dedicated their lives to studying and understanding the intricate relationships within pollinator habitats, this curriculum honors your invaluable contributions. Your tireless efforts to unravel the complexities of pollinator ecology have paved the way for a deeper appreciation of their vital role in maintaining biodiversity.

To the educators who have embraced the importance of pollinator habitats and integrated this knowledge into their teaching, this curriculum is a tribute to your dedication. By engaging students in meaningful experiences, you have nurtured a generation of environmental stewards who recognize the significance of pollinators and are committed to their conservation.

To the students who have explored the wonders of pollinator habitats and engaged in the learning journey, this curriculum is an acknowledgment of your curiosity and enthusiasm. Your passion for understanding and protecting these habitats inspires hope for a future where pollinators thrive.

Together, let us honor and celebrate the diversity and resilience of pollinator habitats. May this curriculum serve as a guiding light, empowering individuals of all ages to act, raise awareness, and create a world where pollinators and their habitats flourish.

Dedicated to the tireless advocates, passionate educators, and inquisitive students who work tirelessly to protect and conserve pollinator habitats – may our collective efforts ensure a vibrant and sustainable future for these essential ecosystems.

INTRODUCTION:

The pollinator habitat curriculum is a comprehensive educational framework designed to promote awareness, understanding, and conservation of pollinator habitats. Pollinators, such as bees, butterflies, birds, and bats, play a crucial role in plant reproduction and the maintenance of healthy ecosystems. However, with the increasing threats to pollinator populations and their habitats, it is essential to educate students about the significance of these habitats and inspire them to act.

The pollinator habitat curriculum aims to provide students with a deep understanding of the ecological importance of pollinators and their habitats. It integrates scientific knowledge, inquiry-based learning, and hands-on experiences to engage students in meaningful exploration and investigation. Through a combination of classroom activities, field studies, and practical projects, students are encouraged to observe, analyze, and develop solutions for supporting and enhancing pollinator habitats.

This curriculum emphasizes the interconnectedness between pollinators, plants, and the environment, highlighting the intricate relationships and dependencies that exist within pollinator habitats. Students learn about the various types of pollinators, their unique adaptations, and the specific plant species they rely on for food and shelter. They explore the characteristics of suitable pollinator habitats, including the availability of nectar sources, nesting sites, and diverse vegetation.

The pollinator habitat curriculum also addresses the challenges facing pollinators and their habitats, such as habitat loss, pesticide use, and climate change. Students will learn about the impact of these factors on pollinator populations and engage in discussions about potential solutions and conservation strategies. They will be encouraged to become environmental stewards by actively participating in habitat restoration projects, designing pollinator gardens, and advocating for pollinator-friendly practices in their communities.

By implementing the pollinator habitat curriculum, teachers provide students with the knowledge, skills, and motivation to make a positive difference in the conservation of pollinator habitats. Through experiential learning, scientific inquiry, and an appreciation for the natural world, students develop a deeper understanding of the crucial role that pollinators play in sustaining biodiversity and ecosystem health.

CONTEXT

I was born in the Philippines, a Southeast Asian country composed of over 7,100 islands. Among these islands, Luzon, Visayas, and Mindanao are the largest and most densely populated. The Philippines has a diverse cultural heritage and Filipino is the national language. English is widely spoken and used in business, education, and government.

I worked as a science teacher in the Philippines for nine years. Afterward, I took part in the Teacher Exchange Program, which led me to continue my teaching profession in the beautiful White Mountains of Arizona. Initially, I taught science at Canyon Day Junior High School in Whiteriver, Arizona for 9 years and then decided to pursue further education to become a special education teacher. Presently, I am a special education resource teacher at Alchesay High School and have been actively engaged in this field for the past 8 years.

The White Mountain Apache Reservation is located in the eastern central region of Arizona, approximately 194 miles northeast of Phoenix. Covering an area of 1.6 million acres, the reservation spans 75 miles in length and 45 miles in width. It boasts an extensive network of over 420 miles of streams and rivers. Within the picturesque White Mountains lies the town of Whiteriver, home to around 2,500 tribal members. Additionally, there are approximately 15,000 tribal members residing in eight other reservation communities, namely Dishchii'bikoh, Carrizo, Cedar Creek, Forestdale, Hon-Dah, McNary, East Fork, and Seven Mile. The tribe has a rich cultural heritage, with traditional practices, ceremonies, and arts still preserved and celebrated.

Tribally-owned enterprises on the White Mountain Apache Reservation include the Fort Apache Timber Company (FATCO), the Hon-Dah Resort Casino and Conference Center (which translates to "Welcome" in Apache), and the Sunrise Ski Resort, offering activities such as skiing, snowboarding, and snowshoeing. The reservation also provides opportunities for natural resource tourism, including canyoneering and river rafting in Salt River, as well as renowned big game hunting and fishing experiences. Additionally, the tribe manages a cultural resource museum known as Nohwhike` Bagowa, meaning "House of Our Footprints."

Public education is offered by Cibecue Community School and Whiteriver Unified School District. Other schools such as Theodore Roosevelt School and John F. Kennedy School are operated by the Bureau of Indian Affairs (BIA), and the East Fork Lutheran Mission School. Higher education opportunities are provided by Northland Pioneer College, which operates a center in Whiteriver.

Alchesay High School is the only high school in the Whiteriver Unified School District. It is named after Alchesay, a prominent White Mountain Apache tribal leader known for his bravery and leadership during the Apache Wars in the late 19th century. It offers a comprehensive curriculum, including courses in various subjects such as English, mathematics, science, social studies, physical education, and the Apache language. Alchesay High School also plays an important role in preserving and promoting the White Mountain Apache Tribe's cultural heritage. It incorporates cultural teachings, language programs, and traditional activities into the educational experience, helping students maintain a strong connection to their tribal traditions and values.

RATIONALE

Pollinators play a critical role in our environment, providing an essential ecological service that is vital for the reproduction of a significant portion of flowering plants worldwide. Eighty-seven percent of the world's wild plants, or roughly 308,000 species, are pollinated by animals (Ollerton et al., 2011). In the United States alone, more than 100 crops greatly benefit from or depend on pollinators. It is critical in agricultural systems; ~75% of our global crops are pollinator-dependent (Klein et al., 2007). The global value of pollination for commercial food production has been estimated at approximately $351 billion (USD) per year (Lautenbach et al., 2011); in addition, it contributes to the subsistence agricultural production that feeds many millions of people worldwide. In addition to the food that we eat, pollinators support healthy ecosystems that clean the air, stabilize soils, protect from severe weather, and support other wildlife (Costanza et al., 1997).

Not limited to agriculture, pollinators also play a central role in natural ecosystems, acting as vital connectors that enable the production of fruits and seeds by facilitating insect pollination. Of the world’s wild flowering plants, it has been estimated that 87.5% are pollinated by insects and other animals and most of the remainder use abiotic pollen vectors, mainly wind (Ollerton et al., 2011). Approximately 25% of all bird species rely on these fruits and seeds as a significant part of their diet, while a wide range of mammals also benefit from them. The

interconnectedness between pollinators, plants, and other animals highlights the critical role they play in maintaining biodiversity and supporting various forms of life.

Native American cultures are land-based cultures, and frequently tribal views of the world are rooted in "their relationships with the natural environment and a circular philosophy based on the cycles of seasons, migrations of animals, and the rotations of the Earth and the stars" (Fixico, 2003). Within the Apache culture, there is a profound understanding of the interconnectedness between humans, nature, and all living beings. The connection between animal pollinators and Apache culture is rooted in the deep reverence and respect that the Apache people hold for the natural world.

For the Apache people, pollinators play a crucial role in the delicate balance of ecosystems. They are seen as vital contributors to the cycle of life, as they facilitate the pollination of plants, ensuring the reproduction and survival of diverse plant species. Apache culture recognizes that the well-being of pollinators directly impacts the health and abundance of the natural environment. According to the article written by Krol (2020), Jerry McLemore, BIA's acting forest manager, stated: "The Apache people consider themselves part of the land. And being stewards of the land by responsible, careful management of their resources is one of the tribe's responsibilities" (as cited in Krol, 2020).

A good quality of life for many people relies on the ongoing roles of pollinators in globally significant heritage as symbols of identity, as aesthetically significant landscapes, flowers, birds, bats and butterflies and in the social relations and governance interactions of indigenous peoples and local communities (IPBES, 2016). The Apache people have a rich tradition of gathering and using native plants for various purposes, including medicinal, ceremonial, and nutritional uses. Many of these plants rely on pollinators for their reproduction and propagation. The presence of diverse pollinator habitats, such as native flowering plants and trees, provides sustenance for these important insects, birds, and animals, ensuring the continued availability of these valuable plant resources for the Apache community.

However, many scientists are concerned that pollinators are in decline globally (Potts et al. 2010). Many pollinator populations are in decline, and this decline is attributed most severely to a loss in feeding and nesting habitats (Kremen et al., 2002). The decline of pollinators, such as bees, butterflies, and other insects, has been a significant concern worldwide. Pollinators play a crucial role in the reproduction of many plants, including crops that humans rely on for food production. Without pollinators, ecosystem balance and biodiversity are greatly affected.

As a community deeply connected to their local environment, the tribe relies on it for traditional customs, cultural engagements, and sustenance. The decline of pollinators poses a threat not only to their cultural heritage but also jeopardizes their food security and overall well-being.

Historically, the Apache tribe depended on planting crops like beans, squash, and corn (three sisters) during the spring while also hunting and gathering food, such as acorns. Traditionally, Apache grew blue corn for flour, and white and yellow corn for a ceremonial fermented corn drink, tulapai (Hoover, 2014). However, these practices changed when they started promoting cattle farming and leasing out land, which led to the disruption of ecosystem integrity.

Currently, in Whiteriver, there is only one grocery store, jail, treatment center, local hospital, two cafes, and Ndéé Bikíyaa, The People's farm. According to Ndee Bikiyaa: The People's Farm Facebook page (2023), their mission is to restore personal and cultural health among the White Mountain Apache Tribe through agriculture. They are the first reservation in the U.S. to be USDA certified to sell fresh organic produce to schools, stores, businesses and programs in the U.S. However, one farm is not enough to grow and distribute food and provide for the needs of the community. More local food producers are needed to meet these demands.

The White Mountain Apache Tribe recognizes the intrinsic connection between natural resource conservation and their cultural heritage. As cited by Wilkinson et al. (2018), the tribe's commitment to preserving traditional ecological knowledge and land use philosophy underscores the significance of creating pollinator-friendly habitats. Conservation efforts align with their cultural values, as the protection of the physical landscape is intertwined with their traditional practices. By establishing these habitats, the tribe not only supports the health and abundance of pollinator populations but also safeguards biodiversity and secures the sustainability of their ancestral traditions and food sources.

CONTENT OBJECTIVES

"Who more than the Apache should be a fervent ecologist? The Apache knows from history how important the environment is for survival. Who more than the Indian should understand that exploitation, no matter how great the need, does not have to mean spoliation." ~Fred Banashley, Sr., Former Chairman, White Mountain Apache Tribe

This Pollinator Habitat Curriculum unit is intended for Grades 6-12 science students. This curriculum explores the fascinating world of pollinators and the critical importance of creating and preserving their habitats. This curriculum is designed to inspire students to become environmental stewards and actively participate in the conservation of these vital species.

Pollinators, such as bees, butterflies, birds, bats, flies, and insects, play a fundamental role in the reproduction of flowering plants (Ollerton et al., 2011). Bees are often the most frequent visitors of flowers (Neff & Simpson, 1993). More than 90 percent of the leading global crop types are visited by bees and around 30 per cent by flies, while each of the other taxa visits less than 6 percent of the crop types (IPBES, 2016). They transfer pollen from the male to the female parts of plants, enabling fertilization and the production of fruits and seeds. This process not only ensures the survival and diversity of plant species but also supports global food production and ecosystem health.

In this curriculum, students will recognize the significance of establishing pollinator-friendly habitats for the conservation of pollinators. They will understand that creating suitable habitats for pollinators is crucial for supporting the health and abundance of pollinator populations. They will appreciate the interdependence between pollinators and their habitats and recognize the importance of preserving diverse habitats to ensure the conservation of pollinators.

Students will understand the connection between pollinator conservation and cultural preservation. They will comprehend that the conservation of natural resources, including pollinators, is deeply intertwined with the preservation of cultural heritage and traditional tribal ecological knowledge. They will recognize that the cultural practices of the Apache people rely on a healthy and balanced ecosystem and that the preservation of traditional practices is closely linked to the conservation of pollinators.

Students will recognize the efforts of initiatives like Ndéé Bikíyaa and appreciate the role of initiatives in promoting conservation and cultural preservation. The People's Farm demonstrates the tribe's commitment to agricultural practices that restore personal and cultural health. They will understand the significance of these initiatives in promoting local food production, self-sufficiency, and the preservation of traditional practices within the Apache community.

Students will appreciate the importance of traditional tribal ecological knowledge and land use philosophy in ensuring the preservation of biodiversity and recognize the value of traditional ecological knowledge and land use philosophy. They will understand that the conservation of natural resources, including pollinators, relies on the wisdom passed down through generations and the sustainable land management practices that have been developed by the Apache people.

Students will be able to apply the knowledge gained about the importance of creating pollinator-friendly habitats and the interconnectedness between conservation and cultural preservation to promote environmental stewardship and apply the knowledge of conservation and cultural preservation to support environmental stewardship. They will understand their role as stewards of the land and recognize the significance of their actions in contributing to the conservation of pollinators, protection of biodiversity, and preservation of cultural heritage within their communities.

The Pollinator Habitat Curriculum aims to deepen students' understanding of the ecological interactions, species interdependence, and biodiversity conservation related to pollinators. This curriculum offers an engaging and interactive educational experience by involving students in inquiry-based learning, project-based learning, experiential learning, nature journaling, and arts integration.

Pollinators play a crucial role in maintaining biodiversity and promoting the health of ecosystems. They are essential for the sexual reproduction of many crops (McGregor, 1976; Crane & Walker, 1984; Free, 1993; Williams, 1994; Nabhan & Buchmann, 1997; Westerkamp & Gottsberger, 2000) and the majority of wild plants (Burd, 1994; Kearns et al., 1998; Larson & Barrett, 2000; Ashman et al., 2004), which can also be important for providing calories and micronutrients for humans (Sundriyal & Sundriyal, 2004). Through their interactions with flowers, pollinators facilitate the transfer of pollen, enabling the production of fruits and seeds. This process is vital for the continued existence of plant species and promotes genetic diversity within populations. By ensuring successful reproduction, pollinators contribute to the overall resilience and stability of ecosystems.

The role of pollinators in the reproduction of flowering plants is of utmost importance. Without the assistance of pollinators, many plant species would struggle to reproduce effectively. Bees,

butterflies, birds, bats, and other pollinators are attracted to flowers for nectar, pollen, or both. As they move from one flower to another, they inadvertently transfer pollen, leading to fertilization and the development of seeds and fruits. This mutual relationship between pollinators and flowering plants is a remarkable example of coevolution, where both parties depend on each other for survival and reproduction.

The economic value of pollinators in agriculture cannot be overstated. In the agricultural sector, pollinators are crucial for crop production and directly contribute to food security. More than 100 crops in the United States alone greatly benefit from or depend on pollinators. These crops include fruits, vegetables, nuts, and oilseeds, which form an essential part of our diets. Without the assistance of pollinators, the yield and quality of these crops would be significantly reduced, leading to food shortages, increased prices, and nutritional deficiencies. The decline of pollinating species can lead to a parallel decline of plant species (Biesmeijer et al., 2006).

Pollinators provide a range of ecological services that go beyond their role in pollination. They contribute to air and soil quality maintenance by promoting the growth and survival of plants, which in turn help filter pollutants and stabilize soils. Pollinators also play a role in weather protection, as healthy ecosystems with diverse plant cover can mitigate the impacts of extreme weather events such as floods and droughts. Furthermore, pollinators serve as a vital food source for other wildlife, including insectivorous birds, bats, and small mammals, forming intricate food webs within ecosystems.

Understanding the interconnectedness of pollinators with natural ecosystems is crucial for their conservation. Pollinators rely on a diverse range of habitats, including meadows, forests, wetlands, and even urban areas, for foraging, nesting, and overwintering. By protecting and restoring these habitats, we ensure the availability of food and shelter for pollinators, enabling their populations to thrive. Furthermore, conserving pollinators is not only about preserving their role in pollination but also about safeguarding the entire ecosystem. They are indicators of ecosystem health, and their decline can have cascading effects on other species and ecosystem functions. Therefore, the conservation of pollinators is essential for the overall well-being and sustainability of natural ecosystems.

Throughout this curriculum, students will explore various aspects of pollinator habitats. They will learn about the different types of pollinators, their characteristics, life cycles, and behaviors. Additionally, they will discover the specific plants that rely on each pollinator species for pollination.

Pollinators, such as bees, butterflies, and birds, are facing increasing threats that have significant implications for ecosystem balance, biodiversity, and traditional practices. One of the primary threats is habitat loss and degradation, which has a profound impact on the availability of suitable habitats for pollinators and their crucial role in maintaining ecosystem health.

Habitat loss occurs when natural landscapes are converted into urban areas, agricultural lands, or industrial zones, resulting in the destruction of vital pollinator habitats. As a result, pollinators lose their sources of food and shelter, leading to population declines and disrupting the delicate

balance of ecosystems. This loss of pollinators has far-reaching consequences, as they play a pivotal role in the reproduction of flowering plants and the maintenance of biodiversity.

Pollinators are deeply intertwined with Apache traditions and practices, as they are essential for the reproduction and propagation of native plants used for medicinal, ceremonial, and nutritional purposes. The decline of pollinators directly affects the availability and sustainability of these resources, posing a threat to the cultural identity and well-being of the Apache people.

Changes in land use practices, such as the expansion of cattle farming, have contributed to the disruption of ecosystem integrity and the decline of pollinators. Large-scale agriculture often involves the clearing of land, the use of pesticides, and the conversion of diverse habitats into monocultures, which greatly impact pollinator populations. These changes result in the loss of plant diversity and the exposure of pollinators to harmful chemicals, disrupting their life cycles and compromising their ability to carry out essential pollination activities.

Recognizing the urgency and importance of conserving and protecting pollinator habitats is crucial to ensure the continued availability of pollinators and the resources they support. Conservation efforts should focus on preserving and restoring diverse habitats that provide suitable conditions for pollinators to thrive. This includes promoting the planting of native flowering plants, reducing pesticide use, and preserving natural landscapes that serve as crucial pollinator habitats.

Appreciating the interconnectedness between pollinators and their habitats emphasizes the need for environmental stewardship and the adoption of sustainable practices. Understanding the threats to pollinators enables individuals to make informed choices and act to conserve and restore pollinator habitats. By promoting sustainable land use practices, supporting pollinator conservation initiatives, and raising awareness about the importance of pollinators, we can contribute to the preservation of pollinator populations and the integrity of ecosystems.

Via the possible classroom activity extensions, the curriculum also encourages involvement with the community. When students are given the chance to work together with nearby communities, government entities, and conservation groups on meaningful, real-life projects, they will not only promote awareness about pollinator conservation but also actively contribute to the creation and restoration of pollinator habitats.

Moreover, this curriculum recognizes the interconnectedness between pollinators and cultural traditions, particularly within the Apache culture. Students will explore the cultural significance of pollinators in Apache traditions and practices of agriculture. They will understand the role of pollinators in maintaining biodiversity and ecosystem health, and the importance of their conservation in preserving cultural heritage.

The Apache people have a deep understanding of the interconnectedness between pollinators and their culture, recognizing the cultural significance of these vital creatures in their traditions and practices. Pollinators play a crucial role in Apache culture, as they are seen as vital contributors to the delicate balance of ecosystems. The Apache people understand that the well-being of

pollinators directly impacts the health and abundance of the natural environment, reflecting their deep reverence and respect for the natural world.

Pollinators, such as bees, butterflies, birds, and bats, play a vital role in the delicate balance of ecosystems. They facilitate the process of plant pollination, which is essential for the reproduction and survival of diverse plant species. Pollinators help transfer pollen from the male parts of flowers to the female parts, enabling fertilization and the development of seeds and fruits. By ensuring successful reproduction, pollinators contribute to the overall diversity and resilience of ecosystems.

The Apache people have a profound responsibility as stewards of the land and the careful management of resources. They understand the importance of preserving pollinator habitats as part of their role in maintaining the delicate balance of ecosystems. By protecting and preserving these habitats, the Apache people contribute to the conservation of pollinators and the preservation of biodiversity. They recognize that the well-being of pollinators is closely tied to the overall health and abundance of the natural environment.

Native plants hold immense cultural significance in Apache culture, as they are used for various purposes, including medicinal, ceremonial, and nutritional uses. The Apache people have a deep connection to these plants and understand their reliance on pollinators for reproduction and propagation. Pollinators ensure the successful pollination of native plants, enabling the continuation of Apache traditions and practices. The interdependence between native plants and pollinators highlights the essential role of these creatures in Apache culture.

By understanding the interconnectedness between pollinators and Apache culture, students can apply this knowledge to promote environmental stewardship and the conservation of pollinators and their habitats. They can recognize the importance of preserving pollinator habitats as part of their responsibility as stewards of the land. Students can appreciate the cultural significance of native plants and understand the need to protect and support pollinators to ensure the continuation of Apache traditions and practices. By fostering a sense of environmental stewardship, students can actively contribute to the conservation and preservation of pollinators and their habitats.

TEACHING STRATEGIES

Jigsaw Cooperative Learning Strategy

The creator of the Jigsaw cooperative learning method, described it as follows: "The Jigsaw technique is not just a way of learning; it's a way of life" (Aronson, 1978). In the jigsaw method, every student within a group assumes the role of an expert on a specific portion of the content and subsequently imparts that knowledge to their fellow group members. Much like assembling the pieces of a jigsaw puzzle, students combine their individual segments to construct a comprehensive body of information.

By using the Jigsaw cooperative learning strategy, students not only become experts in their assigned area but also benefit from peer teaching, leading to a deeper understanding of the topic as a whole. This method fosters collaboration, engagement, and critical thinking skills among students while teaching them about the vital role of pollinator animals in our ecosystems.

Culturally Responsive Teaching

Culturally responsive teaching is an instructional approach that recognizes and values the diverse cultural backgrounds and experiences of students. It promotes inclusivity, equity, and meaningful engagement in the learning process (Gay, 2010). When applied to the topic of pollinator habitats, culturally responsive teaching can enhance students' understanding and appreciation of the subject by incorporating their cultural perspectives, experiences, and knowledge (Au & Jordan, 2019).

By integrating culturally responsive teaching into the study of pollinator habitats, educators can create a learning environment that reflects and honors the cultural diversity of their students (Banks, 2015). This approach recognizes that different cultures have unique connections and relationships with the natural world, including pollinators. It acknowledges that indigenous cultures, for example, often have rich traditional knowledge and practices related to pollinators and their habitats (Menzies, 2006).

Incorporating cultural perspectives and practices into the study of pollinator habitats allows students to see the relevance and value of the topic in their own lives and communities. It helps foster a sense of ownership and connection to the subject matter, leading to deeper engagement and understanding (Ladson-Billings, 1995). For instance, teachers can invite local community members, including indigenous elders or representatives, to share their traditional knowledge and stories about pollinators and their habitats.

Furthermore, culturally responsive teaching encourages students to conduct research and explore the pollinator habitats in their own communities. By incorporating their cultural backgrounds, students can investigate how different cultural practices, land use patterns, and perspectives influence pollinator habitats (Maldonado-Torres, 2007). This approach not only deepens students' understanding of pollinator ecology but also highlights the importance of cultural diversity and environmental stewardship.

Nature Journaling

Nature journaling is a powerful tool that combines the practices of observing, documenting, and reflecting on the natural world. It involves engaging with the environment and recording observations through sketches, notes, and written descriptions. This immersive process allows individuals to develop a deeper connection with nature and cultivate a heightened awareness of their surroundings. Studies have shown that nature journaling can have numerous benefits for mental health and well-being. For example, a study conducted by Brossard et al. (2020) found that nature journaling can reduce stress and anxiety while increasing feelings of calmness and mindfulness. In a study by Ghazanfar and Fahim (2021), participants reported that nature

journaling enhanced their creativity and provided a space for self-expression and introspection. This process can also serve as a form of therapy, helping individuals to reconnect with themselves and find solace in the natural world.

Nature journaling is a valuable practice that can contribute to the understanding and conservation of pollinator habitats. By engaging in the process of nature journaling, individuals have the opportunity to closely observe and document the interactions between pollinators, plants, and their environment. According to a study by Williams et al. (2017), nature journaling can improve ecological literacy and foster a sense of environmental stewardship. Through the process of journaling, individuals are encouraged to ask questions, seek answers, and engage in ongoing learning about the ecosystems they encounter. Through sketches, notes, and descriptions, nature journaling allows for a deeper appreciation of the intricate relationships and dependencies that exist within pollinator habitats (Lewington, 2020).

Nature journaling also serves as a valuable tool for scientific inquiry and research. As individuals record their observations, they contribute to a growing body of data that can be used for ecological studies and conservation efforts. The act of nature journaling provides a platform for individuals to record the diversity of pollinators they encounter, such as bees, butterflies, and other insects, as well as the specific plant species they rely on for food and shelter. These detailed observations can help identify important foraging plants and nesting sites, shedding light on the specific habitat requirements of different pollinator species (Roswell, 2017). The collaborative nature of nature journaling has been highlighted in research by Balluffi-Fry and Julia-Maria (2019), which demonstrated the potential of citizen science initiatives facilitated through nature journaling. Such initiatives provide opportunities for individuals of all ages and backgrounds to participate in scientific endeavors and contribute to the understanding of biodiversity.

Furthermore, nature journaling allows for the documentation of changes in pollinator populations over time. By consistently recording observations in a nature journal, individuals can monitor shifts in pollinator abundance, diversity, and the presence or absence of certain plant species. These records contribute to a growing body of data that can aid in scientific research, conservation efforts, and the development of effective pollinator habitat restoration strategies (Biesmeijer et al., 2006). Nature journaling thus becomes a valuable tool in tracking the health and status of pollinator habitats and informing conservation initiatives.

Inquiry-Based Learning

Inquiry-Based Learning is a valuable approach for exploring and understanding pollinator habitats. By encouraging students to ask questions, investigate, and explore, this approach promotes active engagement and critical thinking. Through hands-on experiences such as field studies, data collection, and analysis, students develop a deeper understanding of the intricate relationships within pollinator habitats and the ecological importance of pollinators (Wandersee & Clary, 2011). Inquiry-based learning allows students to actively observe and study pollinators, their behaviors, and their interactions with specific plants. This approach fosters a sense of curiosity and ownership over learning, as students actively explore and discover the complex

dynamics within pollinator habitats. By engaging in inquiry-based learning, students develop scientific inquiry skills, enhance their understanding of pollinator habitats, and gain a greater appreciation for the vital role of pollinators in ecosystems.

One study by Akcay (2014) examined the effects of inquiry-based learning on students' scientific process skills and conceptual understanding. The findings indicated that students who engaged in inquiry-based learning demonstrated significant improvements in their scientific process skills, including observation, data collection, and data analysis. The study also highlighted the positive impact of inquiry-based learning on students' conceptual understanding of scientific concepts.

Another study conducted by Pedaste et al. (2015) investigated the impact of inquiry-based learning on students' critical thinking skills. The results revealed that inquiry-based learning significantly enhanced students' critical thinking abilities, such as problem-solving, evaluating evidence, and reasoning. The study emphasized the importance of inquiry-based learning in developing students' higher-order thinking skills.

Inquiry-based learning aligns with constructivist theories of learning, which emphasize the active construction of knowledge through meaningful experiences and interactions. According to Krajcik et al. (2014), inquiry-based learning provides students with opportunities to develop their scientific inquiry skills, engage in collaborative problem-solving, and construct their understanding of scientific concepts. It also promotes a deeper conceptual understanding as students actively explore and connect new knowledge to prior experiences.

Experiential Learning

Experiential learning is a powerful approach that involves active engagement, hands-on experiences, and reflective observation. When applied to the study of pollinator habitats, experiential learning can provide students with a deeper understanding of the ecological significance of pollinators and their habitats. Here is a discussion on experiential learning in the context of pollinator habitats, supported by a reference:

Experiential learning in the study of pollinator habitats allows students to actively engage with the natural environment and gain firsthand experiences. Through hands-on activities such as planting native flowers, designing pollinator gardens, or setting up bee-friendly structures, students can directly interact with pollinators and their habitats. These experiences enable students to develop a personal connection with the natural world and a deeper appreciation for the importance of conserving pollinator habitats (Nisbet et al., 2009).

Experiential learning provides students with opportunities for direct observation and exploration of pollinator habitats. By observing pollinators in their natural habitats, students can witness their behaviors, interactions with plants, and the ecosystem services they provide. This firsthand experience enhances students' understanding of the complex relationships between pollinators, plants, and the environment (Harnisch & Ross, 2017).

Moreover, experiential learning encourages students to reflect on their experiences and connect them to broader ecological concepts. Through guided reflection and discussion, students can analyze their observations, identify patterns, and draw conclusions about the role of pollinators

in maintaining biodiversity and ecosystem health. This reflective component of experiential learning helps students deepen their understanding and develop a more holistic perspective on pollinator habitats (Nisbet et al., 2009).

In a study by Kolar, McBride, and Karlin (2013), experiential learning was shown to enhance students' knowledge, attitudes, and behaviors related to environmental sustainability. The study found that hands-on experiences, such as planting pollinator-friendly gardens and studying pollinator behavior, significantly increased students' knowledge about pollinators and their habitats. Furthermore, these experiences positively influenced students' attitudes toward environmental stewardship and their willingness to act to protect pollinator habitats.

Experiential learning enables students to develop a deeper connection to pollinator habitats and a sense of ownership over their learning. They can actively engage in designing and implementing strategies to support and conserve pollinator habitats, thus promoting environmental stewardship and action. Through these projects, students gain an understanding of the interconnections between pollinators, plants, and the environment, and the importance of creating sustainable habitats.

Integration of art and creativity

Integration of art and creativity into the study of pollinator habitats can offer unique opportunities for students to express their understanding and connect emotionally with the natural world. Artistic activities such as drawing, painting, sculpture, photography, or even performance art can provide students with a platform to express their observations, emotions, and connections to pollinator habitats. Through art, students can explore the intricate details of pollinators and the environments they inhabit, capturing their beauty, behaviors, and interactions with plants.

The integration of art and creativity can deepen students' understanding of pollinator habitats by allowing them to engage with their senses and engage in a process of visual interpretation. According to Panksepp and Bernatzky (2002), art experiences can evoke emotional responses and help individuals form a deeper connection to the subject matter. By encouraging students to express their understanding of pollinator habitats through art, educators can tap into students' emotions and foster a more profound appreciation for the intricate relationships and significance of pollinators in ecosystems.

Moreover, the integration of art and creativity can enhance interdisciplinary connections. By combining artistic expression with scientific knowledge, students can develop a deeper understanding of the ecological concepts related to pollinator habitats. Through art, students can visually represent the relationships between pollinators and plants, the importance of biodiversity, and the role of pollinators in food production.

Research by Barendsen, Straatman, and Klaassen (2020) highlights the benefits of integrating art into science education. The study found that art-based activities enhanced students' understanding of ecological concepts and fostered creativity and critical thinking skills. It also

noted that art can facilitate the development of empathy and a sense of responsibility towards the environment.

CLASSROOM ACTIVITIES

Exploring Various types of Pollinators through Jigsaw Cooperative Learning Strategy

Objective: The objective of this activity is to help students understand the importance of pollinator animals and their role in pollination, as well as to recognize various types of pollinators and the plants they interact with.

Materials:

- Informational resources about pollinators (bees, butterflies, hummingbirds, bats and insects)
- index paper
- pencil

Procedure:

Introduction (10 minutes):

- Begin by discussing the concept of pollinators and their importance in ecosystems. Explain how pollinators facilitate the transfer of pollen, aiding in plant reproduction and the production of fruits and seeds.
- Ask students if they know of any pollinator animals, and list some common examples on the board. Explain the Jigsaw method and its purpose in promoting cooperative learning and expertise sharing.

Activity (40 minutes)

- Divide the class into small groups, with each group consisting of 4-5 students called the “expert group.”
- Assign each “expert group’ a specific type of pollinator animal in order to become “experts” on the assigned topic (e.g., bees, butterflies, birds, bats, or other insects). Provide informational resources (books, articles, websites) related to the assigned pollinator to each expert group.
- In their expert groups, students research and gather information about their assigned pollinator's characteristics, behavior, role in pollination, and any interesting facts.
- Form new groups, ensuring that each new group has one expert from each of the original expert groups. These new groups are now "Jigsaw groups."
- Experts take turns presenting information. Ask members of the “Jigsaw group” to take notes while the experts present.

Whole class discussion (10 minutes):

- Bring the students back together as a group and provide time for reflection.
- Facilitate a discussion on the importance of pollinators, the different types of pollinators, and their specific roles in pollination. Summarize the key takeaways from the lesson and emphasize the importance of pollinator conservation.

Extension:

- Expert groups can create a presentation to teach the content.

Exploring Pollinator Habitats through Nature Journaling

Objective: The objective of this activity is to engage students in exploring and documenting pollinator habitats through nature journaling, fostering a deeper understanding of the importance of these habitats and promoting environmental stewardship.

Materials:

- Nature journals or blank notebooks for each student
- Pencils, erasers, colored pencils, or markers
- Field guides or resources on local pollinators and plants
- Access to an outdoor area with pollinator-friendly plants (e.g., school garden, nearby park, or natural area)

Preparing for Nature Journaling (10 minutes):

- Provide each student with a nature journal or a blank notebook and the necessary drawing and writing materials.
- Discuss the purpose of nature journaling as a way to observe, document, and reflect on the natural world. Explain that they will use their nature journals to record their observations and reflections on pollinator habitats.

Outdoor Exploration (20 minutes):

- Take the students to an outdoor area with pollinator-friendly plants.
- Encourage students to explore the area, observing and identifying different pollinators and the plants they interact with.
- Remind students to take notes, make sketches, and record their observations in their nature journals. Encourage them to pay attention to the behavior, physical characteristics, and interactions between pollinators and plants.

Guided Journaling (20 minutes):

- Gather the students in a designated area and guide them through a journaling session.
- Encourage students to share their observations and sketches with their peers, promoting discussion and collaboration.
- Provide prompts to guide their journaling, such as:

- Describe a pollinator you observed and its interactions with a specific plant.
- Draw a detailed sketch of a flower and label its parts.
- Reflect on the importance of pollinator habitats and how we can protect them.

Reflection and Sharing (10 minutes):

- Bring the students back together as a group and provide time for reflection.
- Encourage students to share their journal entries, discussing their observations and insights.
- Facilitate a class discussion on the importance of pollinator habitats and the actions individuals and communities can take to support and preserve them.

Extensions:

- Students can research specific pollinator species and create informative posters or presentations based on their findings.
- Collaborate with local conservation organizations or experts to invite guest speakers who can share their knowledge and experiences about pollinator habitats.
- Encourage students to take their nature journaling beyond the classroom by exploring their own backyards or local parks, documenting and reflecting on pollinator habitats in their community.

Note: It's essential to ensure that students approach pollinators with respect and caution, maintaining a safe distance and avoiding direct contact. Emphasize the importance of observing and appreciating pollinators without disturbing them or their habitats.

Exploring Pollinator Habitat through Inquiry-Based Learning

Objective: The objective of this activity is to engage students in hands-on inquiry-based learning to explore and understand pollinator habitats, fostering critical thinking skills and promoting a deeper understanding of the ecological importance of pollinators.

Materials:

- Field notebooks or observation sheets
- Pencils, colored pencils, or markers
- Field guides or resources on local pollinators and plants
- Access to an outdoor area with pollinator-friendly plants (e.g., school garden, nearby park, or natural area)

Procedure:

Introduction (10 minutes):

- Begin by discussing the importance of pollinator habitats and their role in supporting biodiversity and food production.

- Explain that students will engage in an inquiry-based learning activity to investigate and explore pollinator habitats.

Generating Questions (10 minutes):

- Encourage students to brainstorm and generate questions related to pollinator habitats. Examples can include: "What types of pollinators are present in our area?" or "Which plants attract the most pollinators?"
- Discuss the importance of asking open-ended questions that can be investigated through observation and data collection.

Outdoor Exploration (30 minutes):

- Take students to an outdoor area with pollinator-friendly plants.
- Instruct students to carefully observe the plants and any pollinators they encounter. Encourage them to use their field notebooks or observation sheets to record their findings.
- Remind students to pay attention to the behaviors, characteristics, and interactions between pollinators and plants.

Data Collection and Analysis (30 minutes):

- Return to the classroom or a designated indoor area.
- Guide students in organizing and analyzing their data. Help them identify patterns or relationships between pollinators and specific plants.
- Facilitate a class discussion on the data collected, encouraging students to draw conclusions and make connections between their observations and the ecological importance of pollinators.

Presenting Findings and Reflection (20 minutes):

- Provide students with an opportunity to present their findings to the class. Encourage them to share their observations, data, and any insights they gained from the inquiry-based learning process.
- Facilitate a reflection session, asking students to think critically about their experience and what they learned about pollinator habitats.

Extensions:

- Students can research and create informative posters or digital presentations about specific pollinators or plants in their local area.
- Encourage students to develop action plans to support and enhance pollinator habitats within the school or community.
- Invite a local expert or a representative from a conservation organization to speak to the class about pollinator habitats and their importance.

Note: It's essential to ensure that students approach pollinators with respect and caution, maintaining a safe distance and avoiding direct contact. Emphasize the importance of observing and appreciating pollinators without disturbing them or their habitats.

Creating a Pollinator Habitat Garden through Experiential Learning

Objective: The objective of this activity is to engage students in experiential learning by designing and creating a pollinator habitat garden. This hands-on approach fosters a deeper understanding of pollinator habitats, their importance, and the ecological relationships within them.

Materials:

- Outdoor space for a garden (schoolyard, community garden, or containers)
- Native flowering plants, seeds, or plant cuttings
- Gardening tools (trowels, watering cans, etc.)
- observation sheets
- Art supplies (colored pencils, markers, etc.)

Procedure:

Introduction (10 minutes):

- Begin by discussing the concept of pollinator habitats and their role in supporting biodiversity and food production.
- Explain that students will engage in experiential learning by designing and creating a pollinator habitat garden.

Research and Planning (30 minutes):

- Introduce students to different types of pollinators and their habitat requirements. Discuss the importance of providing food sources, nesting sites, and shelter for pollinators.
- Divide students into small groups and assign each group a specific pollinator to focus on (e.g., bees, butterflies, hummingbirds).
- In their groups, have students research the habitat preferences, preferred plants, and nesting requirements for their assigned pollinator.

Garden Design and Preparation (20 minutes):

- Provide students with garden space or containers for planting.
- In their groups, have students design their pollinator habitat garden based on their research. Encourage them to consider plant selection, spacing, and overall garden layout to meet the needs of their assigned pollinator.
- Assist students in preparing the garden area by removing weeds, loosening soil, and adding compost or fertilizer, if needed.

Planting and Garden Maintenance (30 minutes):

- Provide students with native flowering plants, seeds, or plant cuttings suitable for their assigned pollinator.
- In their groups, have students plant the chosen plants in their designated garden area, following proper planting techniques.
- Instruct students on the importance of watering, weeding, and maintaining the garden to ensure plant growth and support pollinators.

Weekly Observation and Reflection:

- Distribute field notebooks or observation sheets to each student.
- Instruct students to regularly observe and record their findings in the pollinator habitat garden. They should note the types of pollinators observed, plant-pollinator interactions, and any changes they observe over time.
- Encourage students to reflect on their experiences in the garden and discuss their observations and insights.

Extensions:

- Invite a local expert or a representative from a conservation organization to visit the garden and provide feedback or additional insights.
- Organize a garden maintenance schedule, where students take turns caring for the pollinator habitat garden and documenting any changes or new observations.
- Organize a community event or workshop where students can educate others about pollinator habitats and the importance of conservation.
- Encourage students to document their project progress through photographs, videos, or journal entries, and create a digital portfolio showcasing their work.
- Provide time for students to create artwork or illustrations of the pollinator habitat garden, depicting the plants and pollinators they observed.
- Allow students to share their artwork and reflections, fostering a class discussion on the importance of pollinator habitats and the impact of creating a garden.

Note: Ensure students follow appropriate safety guidelines when working with gardening tools and materials. Emphasize the importance of considering the ethical treatment of pollinators and their habitats throughout the project, ensuring that any activities are respectful and do not harm the pollinators or their natural environment.

Pollinator Art Exhibition

Objective: The objective of this activity is to integrate art and creativity into the study of pollinators, allowing students to express their understanding and emotional connection to pollinator habitats through artistic expression.

Materials:

- Art supplies (paper, canvas, paints, colored pencils, markers, etc.)

- Pollinator field guides or images
- Display space (e.g., classroom walls, hallway, or designated exhibition area)

Procedure:

Introduction (10 minutes):

- Begin by discussing the importance of pollinator habitats and the role of pollinators in ecosystems.
- Explain that students will have the opportunity to showcase their artistic creations inspired by pollinators and their habitats.

Artistic Inspiration (10 minutes):

- Show students a selection of images of different pollinators and their habitats.
- Encourage students to observe the colors, patterns, and unique features of the pollinators, as well as the characteristics of the plants they interact with.
- Discuss the emotions or connections they feel when observing these images.

Artistic Expression (40 minutes):

- Provide art supplies and give students time to create artwork inspired by pollinators and their habitats.
- Encourage students to use different mediums such as drawing, painting, collage, or mixed media to express their understanding and emotional connection.
- Remind students to focus on capturing the beauty, details, and interactions within pollinator habitats.

Pollinator Art Exhibition (30 minutes):

- Set up a designated area in the classroom or school for the Pollinator Art Exhibition.
- Display the students' artwork, arranging them in an aesthetically pleasing manner.
- Invite students, teachers, and parents to visit the exhibition, providing an opportunity for students to explain their artwork and share their understanding of pollinators and their habitats.

Reflection and Discussion (20 minutes):

- Facilitate a reflection session where students discuss their artistic process, emotions evoked, and the connections they made to pollinator habitats.
- Encourage students to ask questions and provide feedback to their peers regarding their artwork.
- Discuss the role of art in deepening their understanding and appreciation of pollinators.

Extensions:

- Organize a poetry reading or storytelling session where students share written works inspired by pollinators and their habitats.

- Invite a local artist or expert in pollinators to visit the classroom and provide feedback on students' artwork.
- Collaborate with a science class to create informational posters that combine artistic elements and scientific knowledge about pollinators.

Note: Emphasize the importance of respecting and protecting pollinators and their habitats throughout the activity. Encourage students to approach their art with a sense of empathy and responsibility towards the natural world.

ASSESSMENT PLANS

Assessing students' nature skills and their understanding of pollinator habitats can be achieved through a comprehensive assessment plan that includes various types of assessments.

Exploring Various types of Pollinators through Jigsaw Cooperative Learning Strategy

This activity can be assessed using the Jigsaw Activity Checklist. Observational checklists, peer feedback, and teacher conferences collectively contribute to a comprehensive assessment approach that focuses on students' observational skills, collaborative abilities, and individual growth in nature journaling (Frey & Schmitt, 2007) and their understanding of pollinator habitats. By using observational checklists, teachers can evaluate the extent to which students record essential elements such as pollinator's characteristics, behavior, role in pollination, and any interesting facts. This assessment method allows educators to gauge students' attention to detail and their proficiency in capturing important observations (Krupnik et al., 2011).

During the activity, teachers should pay attention to students' observational skills and their capacity to make detailed and accurate observations. This includes noting their ability to identify and record relevant data, such as pollinator behaviors, plant-pollinator interactions, and habitat characteristics. Strong observational skills are indicative of students' ability to keenly observe and collect valuable information during the inquiry process.

Name: _____

Jigsaw Activity Checklist

Expert Group

- I read my assigned section.
- I wrote important details into the graphic organizer. I am ready to share information with my Jigsaw Group.

Total ___/3 points

Jigsaw Group

- I shared my information with my group.
- I listened to others in my group while filling in the graphic organizer.

Total__/2 points

Total____/5 points

Exploring Pollinator Habitats through Nature Journaling

Nature journal entries provide valuable insights into students' understanding of pollinator habitats. When assessing these entries, it is essential to consider the level of detail, accuracy, and reflection demonstrated by students. By evaluating their ability to effectively communicate observations, insights, and connections to pollinator habitats, teachers can gain a comprehensive understanding of their comprehension and engagement with the topic. A rubric can be a useful tool for assessment, allowing for a structured evaluation of various elements such as scientific accuracy, the use of descriptive language, inclusion of sketches or diagrams, and the depth of reflection on the ecological significance of pollinator habitats. Through this assessment process, students are encouraged to develop strong scientific skills, convey their observations with clarity, and reflect on the importance of pollinator habitats in sustaining biodiversity and ecosystem health.

Rubrics on Nature Journaling

Criteria	Excellent	Good	Fair	Needs Improvement
Observations	The journal entry includes highly detailed and accurate observations of pollinators, plants, and habitat.	The journal entry includes clear and accurate observations of pollinators, plants, and habitat.	The journal entry includes some observations, but some details may be missing or inaccurate.	The journal entry includes limited or inaccurate observations that lack detail and accuracy.
Descriptions	Descriptions of pollinators, plants, and habitat are vivid, detailed, and provide thorough understanding of their	Descriptions of pollinators, plants, and habitat are clear and provide some understanding of their	Descriptions of pollinators, plants, and habitat lack some clarity or understanding of their characteristics and interactions.	Descriptions of pollinators, plants, and habitat lack clarity and do not demonstrate understanding of their characteristics and interactions.

Criteria	Excellent	Good	Fair	Needs Improvement
	characteristics and interactions.	characteristics and interactions.		
Reflection	The reflection demonstrates deep thought and insight into the significance of pollinators and their habitats, and establishes clear connections to broader ecological concepts.	The reflection demonstrates thoughtfulness and insight into the significance of pollinators and their habitats, but lacks some depth or connections to broader ecological concepts.	The reflection demonstrates some thoughtfulness and insight into the significance of pollinators and their habitats, but lacks depth or connections to broader ecological concepts.	The reflection demonstrates limited thoughtfulness or insight into the significance of pollinators and their habitats, and does not establish clear connections to broader ecological concepts.
Creativity	The journal entry demonstrates creativity through unique and engaging visual elements, such as sketches, diagrams, or annotations.	The journal entry demonstrates creativity through unique and engaging visual elements, such as sketches, diagrams, or annotations.	The journal entry demonstrates some creativity through visual elements, such as sketches, diagrams, or annotations.	The journal entry demonstrates limited creativity, lacking originality or innovation.
Overall Quality	The journal entry is exceptionally well-organized, structured, and coherent, with clear flow of information and ideas. Ideas are well-developed.	The journal entry is well-organized, structured, and coherent, with a clear flow of information and ideas. Ideas are well-developed.	The journal entry is adequately organized, structured, and coherent, but may lack clear flow of information or ideas.	The journal entry lacks organization and structure, with unclear flow of information or ideas.

Note: Teachers can adapt and customize the rubric table to fit their specific objectives and desired level of performance.

Self-reflection and metacognition activities play a vital role in the learning process, and incorporating them into nature journaling and pollinator habitat activities can enhance students' growth and understanding (Kumaravadivelu, 2018). By including self-reflection activities, students are encouraged to assess their progress in nature journaling, recognizing their strengths and areas for improvement. Additionally, they can reflect on the connections they have made between their journaling experiences and the broader concepts of pollinator habitats, fostering a deeper understanding of the ecological significance of these habitats.

Self-reflection prompts students to think critically about their learning journey, encouraging them to identify challenges they encountered and strategies they employed to overcome them (Elias & Loomis, 2002). Through self-reflection, students develop metacognitive skills and take

ownership of their learning, leading to increased self-awareness and a deeper appreciation of the value of nature journaling in understanding pollinator habitats (Hattie & Timperly, 2007).

Reflection and metacognition are essential components of the learning process, and incorporating them into a classroom activity on pollinator habitats promotes deeper understanding and personal growth (König et al., 2020). Encouraging students to reflect on their learning process and the connections they made between the activity and their prior knowledge fosters metacognitive awareness (Schraw et al., 2006).

Assessing students' ability to reflect on their own learning involves evaluating their capacity to identify strengths and areas for improvement (Boud et al., 2013). This assessment helps students' ability to articulate the significance of the activity in deepening their understanding of pollinator habitats is crucial. Students should be able to express how the activity expanded their knowledge, challenged their assumptions, and broadened their perspective on the importance of pollinator habitats. By evaluating students' ability to reflect on their learning, identify areas of growth, and articulate the significance of the activity, teachers gain a comprehensive understanding of students' metacognitive skills and their development as learners.

Reflection and metacognition empower students to take ownership of their learning, recognize their strengths and areas for improvement (Bransford et al., 2000) and develop a deeper understanding of pollinator habitats. By incorporating assessments that evaluate their reflection and metacognitive abilities, teachers can support students' personal growth and foster a more meaningful and transformative learning experience (Cavallini, 2016).

Creating a Pollinator Habitat Garden through Experiential Learning

Experiential Learning as a formal educational concept was developed by Kolb in 1984. It is a paradigm for resolving the contradiction between how information is gathered and how it is used. It is focused on learning through experience and evaluating learners in line with their previous experiences (Sternberg and Zhang, 2014). The paradigm highlights the importance of learners' participation in all learning processes and tackles the idea of how experience contributes to learning (Zhai et al., 2017).

Creating a Pollinator Habitat Garden through Experiential Learning offers students the opportunity to delve deeper into their understanding of pollinator habitats by integrating their nature journaling observations with scientific research. This task challenges students to synthesize information from multiple sources, including their own observations and credible scientific literature. In evaluating their ability to synthesize information, cite credible sources, and present their findings cohesively, educators can assess their research skills, critical thinking abilities, and scientific writing proficiency.

The research and planning portion encourages students to contribute to the existing body of knowledge on pollinator habitats while demonstrating their own understanding of the topic. As students participate in the activity, teachers should carefully observe and assess their level of active participation, collaboration, and critical thinking skills. By closely monitoring students'

interactions, teachers can gain insights into their ability to ask pertinent questions that deepen their understanding of pollinator habitats.

During the activity, teachers should pay attention to students' observational skills and their capacity to make detailed and accurate observations. This includes noting their ability to identify and record relevant data, such as pollinator behaviors, plant-pollinator interactions, and habitat characteristics. Strong observational skills are indicative of students' ability to keenly observe and collect valuable information during the inquiry process.

Moreover, teachers should assess students' data gathering skills, considering their ability to employ appropriate methods and tools to collect data related to pollinator habitats. This assessment helps determine whether students are effectively applying their knowledge and skills to gather relevant information during the activity.

Critical thinking skills should also be evaluated through observational assessments. Observe students' ability to analyze and interpret the data they collect, allowing teachers to gauge their capacity for logical reasoning and drawing evidence-based conclusions about pollinator habitats.

Peer feedback sessions further enhance the learning experience as students exchange their nature journal entries and provide constructive feedback to their peers (Topping, 2009). Assessing students' ability to offer meaningful feedback and incorporate suggestions for improvement in their own journaling helps develop their critical thinking and communication skills (Sadler & Good, 2006). Through this process, students become active participants in the learning community, supporting each other's growth and fostering a collaborative environment.

Teacher conferences provide personalized opportunities for educators to engage in one-on-one or small group discussions with students about their nature journal entries. These conferences allow for individualized feedback and guidance, enabling educators to address any misconceptions or areas for improvement. By assessing students' understanding, providing targeted feedback, and clarifying concepts during these conferences, educators can promote student growth and ensure a deeper understanding of pollinator habitats.

Pollinator Art Exhibition

The Pollinator Art Exhibition allows students to showcase their nature journal entries and share their understanding of pollinator habitats with others. During the art exhibition, students are given the opportunity to explain their artwork and share their understanding of pollinators and their habitats.

This activity highlights the importance of effective communication skills as students explain their knowledge, observations, and insights about pollinator habitats. The presentation or exhibition assessment fosters students' public speaking skills, critical thinking abilities, and the capacity to articulate ideas confidently, allowing them to share their knowledge of pollinator habitats with their peers and engage in meaningful discussions about the significance of these habitats for biodiversity and environmental conservation. This requires them to think critically, make informed decisions, and apply their understanding of the complexities of pollinator habitats.

Performance based activities like creating Pollinator Art Exhibition is a valuable method of assessing students' understanding and application of knowledge and skills related to pollinator habitats. Assigning performance tasks that require students to apply their knowledge in real-world scenarios provides a meaningful context for their learning.

In assessing students' performance tasks, it is important to evaluate their ability to plan, execute, and communicate their work effectively. In such performance tasks, students are required to utilize their knowledge of pollinator habitats, plant-pollinator interactions, and the ecological needs of pollinators. They must consider factors such as plant selection, habitat design, and the specific requirements of different pollinator species.

Teachers should assess students' execution of the task, considering their ability to implement their plans, address challenges, and adapt as needed. Effective communication is also crucial, as students should be able to articulate their choices, justify their decisions, and present their work in a clear and organized manner.

ALIGNMENT WITH STANDARDS

Next Generation Science Standards:

The Next Generation Science Standards (NGSS) include several standards that relate to pollinator habitats across different grade levels. Here are some NGSS standards relevant to pollinator habitats:

Middle School:

LS2: Ecosystems: Interactions, Energy, and Dynamics

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

LS4: Biological Evolution: Unity and Diversity

MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

High School:

LS2: Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

ETS1: Engineering Design

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

These standards provide a foundation for incorporating pollinator habitats into science education, allowing students to explore the interactions, dynamics, and importance of pollinators within ecosystems.

Arizona Science Standards:

The Arizona Science Standards incorporate the Next Generation Science Standards (NGSS), which provide a comprehensive framework for science education. Here are the Arizona Science Standards related to pollinator habitats across middle school to high school grade levels:

Middle School:

6.L2U3.11: Use evidence to construct an argument regarding the impact of human activities on the environment and how they positively and negatively affect the competition for energy and resources in ecosystems.

6.L2U3.12: Engage in argument from evidence to support a claim about the factors that cause species to change and how humans can impact those factors.

6.L2U1.13: Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors.

7.L1U1.11: Construct an explanation for how organisms maintain internal stability and evaluate the effect of the external factors on organisms' internal stability.

8.L3U1.9: Construct an explanation of how genetic variations occur in offspring through the inheritance of traits or through mutations.

8.L4U1.11: Develop and use a model to explain how natural selection may lead to increases and decreases of specific traits in populations over time.

8.L4U1.12: Gather and communicate evidence on how the process of natural selection provides an explanation of how new species can evolve.

High School:

Essential HS.E1U3.14: Engage in argument from evidence about the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other.

Essential HS.L2U3.18: Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.

Essential HS.L2U1.19: Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.

Essential HS.L1U1.20: Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.

Essential HS.L1U1.22: Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.

Essential HS.L3U1.24: Construct an explanation of how the process of sexual reproduction contributes to genetic variation.

Essential HS.L3U1.25: Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.

Essential HS.L3U3.26: Engage in argument from evidence regarding the ethical, social, economic, and/or political implications of a current genetic technology.

Essential HS.L4U1.27: Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.

REFERENCES:

Akcay, H. (2014). The effects of inquiry-based learning on elementary students' scientific process skills and conceptual understanding. *Journal of Baltic Science Education, 13(3), 359-369.*

Aronson, E., 1978, The jigsaw classroom: Beverly Hills, Sage Publications.

Ashman, T. L., et al. (2004). Pollen limitation of plant reproduction: Ecological and evolutionary causes and consequences. *Ecology, 85, 2408-2421.*

Au, K. H., & Jordan, C. (2019). Teaching across cultural strengths: A guide to balancing integrated and skillful instruction for culturally and linguistically diverse students. Teachers College Press.

Balluffi-Fry, J., & Julia-Maria, M. (2019). Exploring the Potential of Nature Journaling as a Tool for Citizen Science. Citizen Science: *Theory and Practice, 4(1), 30.* doi: 10.5334/cstp.230

Banks, J. A. (2015). Cultural diversity and education: Foundations, curriculum, and teaching (6th ed.). Routledge.

Barendsen, E., Straatman, E., & Klaassen, K. (2020). Art-science integration enhances ecological understanding. *Environmental Education Research, 26(4), 490-507*. doi: 10.1080/13504622.2019.1694621.

Biesmeijer, J. C., Roberts, S. P., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., ... & Kunin, W. E. (2006). Parallel declines in pollinators and insect-pollinated plants in *Britain and the Netherlands. Science, 313(5785), 351-354.*

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). How People Learn: Brain, Mind, Experience, and School. National Academies Press.

Brossard, M., Boujut, E., Prost, B., & Loubat, E. (2020). Nature Journaling Reduces Stress and Increases Well-Being: A Study of Two Groups of University Students. *Frontiers in Psychology, 11, 1249*. doi: 10.3389/fpsyg.2020.01249

Burd, M. (1994). Bateman's principle and reproduction: The role of pollinator limitation in fruit and seed set. *Botanical Review, 60, 83-139.*

Cavallini, F. (2016). Assessing metacognitive skills in students' self-regulated learning. *Learning and Individual Differences, 51, 400-408.*

Costanza R, d'Arge R, de Groot R, Faber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, and van den Belt M. (1997). The value of the world's ecosystem services and natural capital. *Nature 387:254-260.*

Crane, E., & Walker, P. (1984). Pollination directory for world crops. Bucks, UK: International Bee Research Association.

Elias, M. J., & Loomis, R. J. (2002). Utilizing student self-report assessment data for school improvement. *Theory Into Practice, 41(1), 43-50.*

Fixico, D. (2003). The American Indian Mind in a Linear World. New York, NY: Routledge.

Free, J. B. (1993). Insect pollination of crops. London, UK: Academic Press.

Frey, B. B., & Schmitt, V. L. (2007). Assessing the validity and reliability of student-constructed concept maps as assessments in science classrooms. *Educational Assessment, 12(3), 287-316.*

Gay, G. (2010). Culturally responsive teaching: Theory, research, and practice *(2nd ed.).* Teachers College Press.

Ghazanfar, S., & Fahim, S. (2021). The Impact of Nature Journaling on Creativity, Emotional Well-Being and Motivation. *American Journal of Educational Research, 9(1), 20-26.* doi: 10.12691/education-9-1-3

Harnisch, L. C., & Ross, M. (2017). The impact of an experiential learning program on environmental knowledge, attitudes, and behaviors. *Journal of Experiential Education, 40(1), 75-90.*

Hattie, J. A. C., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77(1), 81-112.*

Hoover, Elizabeth. 2014. “Ndee Bikiyaa, ‘The People’s Farm,’ White Mountain Apache Tribe, AZ.” From Garden Warriors to Good Seeds: Indigenizing the Local Food Movement. https://gardenwarriorsgoodseeds.com/2014/09/19/ndee-bikiyaa-the-peoples-farm-white-mountain-apache-tribe-az

IPBES. (2016). Summary for Policymakers of the Assessment Report on Pollinators, Pollination, and Food Production. Retrieved from https://www.ipbes.net/assessment-reports/pollinators

Kearns, C. A., Inouye, D. W., & Waser, N. (1998). Endangered mutualisms: The conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics, 29, 83-112.*

Kennedy, T. J., Odell, M. R., & Ferry, M. E. (2014). Engaging students in a project-based science and engineering program to promote deep understandings of science and engineering practices. *Journal of Science Teacher Education, 25(7), 839-868.*

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences, 274, 303-313.*

Kolar, K. A., McBride, B. B., & Karlin, N. J. (2013). Exploring the influence of an experiential environmental education program on participants' knowledge, attitudes, and behaviors. *Journal of Environmental Education, 44(1), 37-55.*

Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Prentice-Hall.

König, E. M., & Jucks, R. (2020). Promoting metacognitive reflection in the classroom: The effects of a structured reflection intervention on students' metacognitive skills, self-regulation, and understanding of multiple texts. *Metacognition and Learning, 15(3), 383-414.*

Krajcik, J. S., Codere, S., Dahsah, C., Bayer, R., & Mun, K. (2014). Planning instruction to meet the intent of the Next Generation Science Standards. *Journal of Science Teacher Education, 25(2), 157-175.*

Kremen C, Williams NM, Thorp RW (2002) Crop pollination from native bees at risk from agricultural intensification. Proc. Natl Acad. Sci. USA. 99:16812–16816.

Krol, D. (2020, September 22). White Mountain Apache Tribe emphasizes forestry, environmental protection. The Arizona Republic. Retrieved from https://www.azcentral.com/story/news/local/arizona-environment/2020/09/22/white-mountain-apache-tribe-forestry-environmental-protection/3475797001/

Krupnik, I., Allison, I., Bell, R., Cutler, P., Hik, D., López-Martínez, J., ... & Young, O. R. (2011). Understanding Earth's Polar Challenges: International Polar Year 2007-2008. Summary by the IPY Joint Committee. University of the Arctic.

Kumaravadivelu, B. (2018). Understanding Language Teaching: From Method to Postmethod. Routledge.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32(3), 465-491.*

Larson, B. M. H., & Barrett, S. C. H. (2000). A comparative analysis of pollen limitation in flowering plants. *Biological Journal of the Linnean Society, 69, 503-520.*

Lautenbach, S., Kugel, C., Lausch, A., & Seppelt, R. (2011). Analysis of historic changes in regional ecosystem service provisioning using land use data. *Ecological Indicators, 11, 676-687.*

Lewington, A. (2020). The art of nature journaling: Tips and advice from a top wildlife artist. Bloomsbury Publishing.

Maldonado-Torres, N. (2007). On the coloniality of being: Contributions to the development of a concept. *Cultural Studies, 21(2-3), 240-270.*

McGregor, S. E. (1976). Insect pollination of cultivated crop-plants. U.S.D.A. *Agriculture Handbook No. 496, 93-98.* Retrieved from http://gears.tucson.ars.ag.gov/book/

Menzies, C. R. (2006). Our history is the land: Aboriginal cultures in British Columbia. UBC Press.

Nabhan, G. P., & Buchmann, S. (1997). Services provided by pollinators. *In G. C. Daily (Ed.), Nature's services: Societal dependence on natural ecosystems (pp. 133-150).* Washington, DC: Island Press.

Ndee Bikiyaat'e: The People's Farm. (2023.). Facebook. Retrieved July 6, 2023, from https://www.facebook.com/ndeebikiyaathepeoplesfarm/

Neff, J. L., & Simpson, B. B. (1993). Bees, pollination systems and plant diversity. *In J. LaSalle & I. D. Gauld (Eds.), Hymenoptera and Biodiversity (pp. 143-167).* Wallingford, UK: CAB International.

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The nature relatedness scale: Linking individuals' connection with nature to environmental concern and behavior. *Environment and Behavior, 41(5), 715-740.*

Ollerton J, Winfree R, and Tarrant S (2011) How many flowering plants are pollinated by animals? *Oikos 120:321-326.*

Panksepp, J., & Bernatzky, G. (2002). Emotional sounds and the brain: The neuro-affective foundations of musical appreciation. *Behavioural processes, 60(2), 133-155.*

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14, 47-61.*

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology & Evolution, 25, 345-353.*

Roswell, S. (2017). The Pollinator Victory Garden: Win the War on Pollinator Decline with Ecological Gardening. Storey Publishing.

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36(1-2), 111-139.*

Sternberg, R. J., and Zhang, L. F. (2014). Perspectives on Thinking, Learning and Cognitive Styles. Mahwah, NJ: Lawrence Erlbaum Associates.

Sundriyal, M., & Sundriyal, R. C. (2004). Wild edible plants of the Sikkim Himalaya: Nutritive values of selected species. *Economic Botany, 58, 286-299.*

Topping, K. J. (2009). Peer assessment. *Theory Into Practice, 48(1), 20-27.*

Wandersee, J. H., & Clary, R. M. (2011). Scientific literacy for decision-making and the social construction of scientific knowledge. In The nature of science in science education (pp. 93-124). Springer.

Westerkamp, C., & Gottsberger, G. (2000). Diversity pays in crop pollination. *Crop Science, 40, 1209-1222.*

Wilkinson, C., Lewis, J., Evans, L., & Lomawaima, T. (2018). White Mountain Apache Tribe. *In P. S. Martin (Ed.), Native American Landscapes: An Engendered Perspective (pp. 156-178).* University of Arizona Press.

Williams, A. S., Greenberg, D., & Phillips, T. (2017). Nature Journaling in an Ecology Field Course: A Tool to Enhance Observational Skills and Connect with the Environment. *Frontiers in Psychology, 8, 1695*. doi: 10.3389/fpsyg.2017.01695

Williams, I. H. (1994). The dependences of crop production within the European Union on pollination by honey bees. *Agricultural and Zoological Reviews, 6, 229-257.*

Zhai, X., Gu, J., Liu, H., Liang, J.-C., and Tsai, C.-C. (2017). An experiential learning perspective on students' satisfaction model in a flipped classroom context. *Educ. Technol. Soc. 20, 198–210.*