Improving Guided School Programs at the Sarah P. Duke Gardens

By

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Abstract

The Sarah P. Duke Gardens (SPDG) requested new curriculum, pre- and post- lesson plans for curriculum, and general perceptions of teachers as to the effectiveness of their guided school programs. This master’s project aimed to address all three of these needs. This work is predicated on the view that environmental education in a nonformal setting, such as a field trip, can enhance student learning by allowing students to connect concepts through experiential learning. However, insufficient evaluation exists on the effectiveness of nonformal educational settings within a botanical garden. In this exploratory study, a qualitative data analysis approach was used to 1) develop and evaluate a variety of programmatic educational activities, and 2) evaluate local teachers’ general perceptions of the guided school programs for the Education Program at SPDG. Recommendations from the evaluations included that the Education Program should continue to (1) develop pre- and post-lesson plans, (2) consistently evaluate the guided school programs in the future, (3) disseminate logistical information to classroom teachers prior to the visit, (4) continue to encourage teachers to bring students to SPDG on multiple occasions to reduce the novelty effect, and (5) incorporate evaluations into docent training. The exploratory study conducted here sets a framework to further analyze the effects of nonformal education on student learning within a botanical garden.
1. Introduction

School-sponsored field trips to museums, zoos, and public gardens provide students with opportunities to interact with potentially new concepts, ideas, people and even a new environment. Significant research exists on the effectiveness of nonformal educational settings, such as museums and zoos, in the ability to enhance student learning. Yet, the effectiveness of botanical garden education has not been quantitatively assessed (Williams et al., 2015). Although many botanical gardens find importance in education, these programs were not sufficiently evaluated in their effectiveness in enhancing visitors’ knowledge and altering peoples’ attitudes and behaviors (Yang & Chen, 2015). Through this project, I explore effective ways to teach elementary and middle school students within a nonformal environmental educational setting, more specifically, in a botanical garden during a field trip (or school program).

I conducted two activities on behalf of the guided school programs implemented by the Children’s Education Program (Education Program) at the Sarah P. Duke Gardens (Duke Gardens or The Gardens). The first aimed at two specific curricula, and the second applied more generally to the guided school programs at The Gardens. I provided evidence-based observations and formative evaluation of the importance and effectiveness of nonformal education at The Gardens. Several Duke Gardens Education staff provided oversight and support for this work, including Kavanah Anderson, the Education Program Coordinator; Kati Henderson, Education Program Assistant; BJ Boyarsky, a part-time Education Program staff member; and Education Program docents1.

First, I developed and evaluated a variety of activities for the guided school programs. Education staff provided two specific curricula for me to develop and/or evaluate: Go With the Docent: Duke Gardens trains volunteers to lead (lead docent) or assist (assistant docent) guided school programs. The number of docents is based on docent availability and based on the school program occurring.

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1 Docent: Duke Gardens trains volunteers to lead (lead docent) or assist (assistant docent) guided school programs. The number of docents is based on docent availability and based on the school program occurring.
Flow and Bug's Life. Table 1 summarizes which activities I developed and which activities I evaluated for this study.

Currently, out of the twenty school programs available, the Education Program only has two school programs specifically for middle school students. The Education Program also does not have a school program related to the hydrosphere or the watershed of Duke Gardens. The content covered in this school program is within the NCSCS curriculum for eighth grade science. By creating curriculum on the watershed of Duke Gardens, the Education Program hopes to bring in more students from middle schools.

Additionally, pre- and post-lesson plans for pre-existing school program lesson plans are currently not available for the teachers who sign up for a school program at The Gardens. This led to the development of pre- and post-lesson plans for the Go With the Flow and Bug’s Life school programs.

Table 1 The specific programs developed and evaluated for this project including two on-site guided school programs with associated pre- and post-lesson plans.

<table>
<thead>
<tr>
<th>Guided School Program</th>
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<th>Evaluated</th>
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<tr>
<td>Go With the Flow: On-Site</td>
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<td>Go With the Flow: Pre- Lesson Plan</td>
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<td>Go With the Flow: Post- Lesson Plan</td>
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<td>Bug’s Life: Post- Lesson Plan</td>
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Second, I interviewed local teachers to obtain their perceptions of the guided school programs in general, not tied to any specific curricula, at The Gardens. The interviews were used to evaluate guided school programs and provide the Education staff with positive and constructive feedback relating to general curricula of the guided school programs.

I have been personally working at Sarah P. Duke Gardens for two years as an Education Program intern. My experience in nonformal education at Duke Gardens and prior experiences in settings such as a nature preserve and a local recreation center, launched my interest in specifically helping Sarah P. Duke Gardens to improve their educational programming.

2. Background

2.1 Environmental Education (EE)

Early exposure to environmental concepts can help children to develop positive attitudes and a solid knowledge base, especially when using sensory and hands-on activities (Kahtz, 1995). Children have a unique, direct and experiential way of knowing the natural world (Malone, 2004). The affinity with nature is not solely on aesthetics, but through the interaction with nature as a tangible and ever-changing phenomenon (Malone, 2004). Children can see and be among the environment especially when outside. A child can attain environmental learning through two types of experiences with nature: direct and indirect (Malone, 2004). Experiencing nature directly involves observations, sensory stimulation, and movement in space, while indirect experiences involve education, interpersonal communication, and popular media. However, education can also be included under a direct experience within certain spaces.

As learners become actively engaged in deciding for themselves what is right and wrong, educators can use environmental problems to help learners explore their own responsibilities and ethics (Simmons et al., 2010). Simmons et al. (2010) state, “Environmental Education is rooted
in the belief that humans can live compatibly with nature and act equitably toward each other; […] people can make informed decisions that consider future generations; […] and it] aims for a democratic society in which effective, environmentally literate citizens participate with creativity and responsibility.”

Based on the values and goals of organizations who conduct environmental education, the definitions of environmental education itself will vary. According to the United States Environmental Protection Agency ([EPA], 2017), “Environmental Education is a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions.”

Whereas the North American Association for Environmental Education (NAAEE) states, “Environmental education (EE) is a process that helps individuals, communities, and organizations learn more about the environment, and develop skills and understanding about how to address global challenges. It has the power to transform lives and society. It informs and inspires. It influences attitudes. It motivates action. EE is a key tool in expanding the constituency for the environmental movement and creating healthier and more civically-engaged communities” (“About EE and Why it Matters”, n.d.).

Lastly, specifically for North Carolina, the Office of Environmental Education and Public Affairs writes (“North Carolina Department of Environmental Quality [NC DEQ], n.d.), “Environmental Education is a resource that transcends the classroom—both in character and scope. Regardless of where, how or to whom it’s provided, the end goal is the same: environmental literacy. […] People require knowledge, tools and sensitivity to successfully
address and solve environmental problems in their daily lives. [...] Environmental education is a lifelong process for the learner.”

Nationally, EE is defined as a process, but in North Carolina the NC DEQ mentions that EE is a resource. An important distinction however, is that the NAAEE mentions that EE is a process for individuals, communities and organizations. On the other hand, the EPA’s definition mentions only individuals. Moreover, gaining skills and tools as a citizen were highlighted throughout all definitions. The varying depths and goals of the EE definitions shows the numerous extents, scopes and outcomes of EE.

Kassas suggests three approaches to EE (1) education in the environment, (2) education about the environment, and (3) education for the environment (Kassas, 2002). People can be educated about the environment by physically being within the environment. While learning about the environment can occur within a classroom, from a form of entertainment, or from another person. Lastly, education for the environment is closely related to advocacy for the environment.

EE aims to develop an environmental literate world population, which has the knowledge, motivation and commitment to solve current problems (Kassas, 2002). EE also aims to (1) instill in learners a positive perception of environmental worldview and (2) cultivate in the society, through educational institutions, a broader worldview (Kassas, 2002). Environmental citizenship is another imperative purpose of environmental education (Kassas, 2002).

Environmental educators are faced with some difficulties, because the field is broad. EE is a highly varied subject, with multiple disciplines, audiences, issues, geographies, and dimensions. Environmental issues can be perceived, spatially, on multiple levels (i.e. a room, a city, a rural area, a country, an ecoregion, continent or even globally) (Kassas, 2002). These
issues can also relate to ecology, societal pressures, and scientific constraints (Kassas, 2002). Additionally, environmental issues are multi-dimensional, because they relate to interactions in the biosphere, the sociosphere, and the technosphere (Kassas, 2002). EE can integrate across multiple subject areas. Education and learning processes are interdisciplinary efforts that involve knowledge related to psychology, ecology, and pedagogy (Yang & Chen, 2015). The multitude of audiences changes the methodology and instruments used in EE programs (Kassas, 2002). Kassas (2002) states, “A pedagogical approach to environmental education befits school curricula. If the audience is within the university level, for example, education needs to combine the objectives of training and human development (Kassas, 2002).

Overall, the varying definitions, goals, and fields of environmental education make this an interdisciplinary subject. Moreover, educators can harness to help students become more environmentally aware and environmentally literate citizens.

2.1.1 History of Environmental Education

EE has a long history both internationally and nationally. EE originated in the 1970s, with two founding documents that defined environmental education: the Belgrade Charter and the Tbilisi Declaration. The Belgrade Charter presents the goal of EE:

“To develop a world population that is aware of, and concerned about the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions to current problems, and the prevention of new ones.” (UNESCO-UNEP, 1975).

Two years later, the Tbilisi Declaration created three goals based off the Belgrade Charter. These goals are fostering an awareness about the interdependence of society, economy, policy and ecology in urban and rural areas; providing all people opportunities to acquire knowledge,
values, attitudes, and skills to protect and improve the environment; and creating new behavior patterns of individuals, groups and society towards the environment (UNESCO-UNEP, 1977).

History of the United States also plays a role in awareness of environmental issues. In 1990, the United States enacted the National Environmental Education Act (NEEA) to develop and implement educational programs and offices to promote environmental stewardship (20 USC 5501). Through the NEEA, the Office of Environmental Education within the EPA was established (20 USC 5503). The office was charged with developing and supporting programs to improve the understanding of the relationship between humans and their environment (20 USC 5503). Additionally, during the late half of the 20th century, environmental groups of concerned citizens and advances in ecology and environmental science created a world where humans felt it was their duty to protect the environment (Kassas, 2002). During this time, EE became a tool for nurturing environmental ethics, and instilling a prudent attitude towards nature, its health and its resources (Kassas, 2002).

The legacy of EE truly began through the international community in the mid-1970s. Over the course of various other international documents, national and state-level policies, EE can continue to involve citizens in countries across the world.

2.2 Educational Settings

Environmental Education can take place in four educational settings, formal, nonformal, informal, and self-directed. Although this project specifically involves a nonformal environmental education setting, the students who attended the Guided School Programs, were from primary and secondary schools, which is considered a formal educational setting. Understanding the objectives of the various educational settings, will give further background
information on the incorporation of formal, informal, and self-directed learning in nonformal settings.

2.2.1 Formal Education

Formal education is closely associated with primary and secondary education. This form of learning usually takes place at a school. It is structured and teacher-led where learning is evaluated and usually prearranged (Eshach, 2007). In formal learning, learners have no control over the objectives or means of their learning (Mocker & Spear, 1982). La Belle (1982) states the definition of formal learning as the institutionalized, chronologically graded and hierarchically structured educational system that spans from lower primary school through the upper reaches of the university. Mocker and Spear (1982) determined that the decisions regarding the objective and the means are made by someone other than the learner.

EE is being incorporated into formal education curriculum using offsite programs to connect to the curriculum being taught in the classroom. This is occurring both nationally and internationally.

Nationally, as a part of the No Child Left Inside Initiative (NCLI), states are asked to develop an Environmental Literacy Plan (ELP) (Braus et al., 2014). The ELP is meant to lay out a roadmap to achieving environmental literacy in each state. In 2012, the NAAEE launched an effort to gather data on the states’ progress in developing and implementing the ELPs (Braus et al., 2014). As of 2014, four states have not begun ELP development, eighteen states are in the drafting stage, twelve are completed but not adopted, four are adopted but not implemented, and thirteen are adopted and implemented (Braus et al., 2014).

Internationally, some countries, such as Taiwan, are integrated environmental education into their national school system. In 2018, environmental education will become one of the
priority educational issues along with human rights, gender equality, and ocean education (Chang, 2016). The 2018 revision will include addressing five EE themes, environmental ethics, sustainable development, climate change, disaster preparedness and sustainable use of resources and energy (Chang, 2016). The process of including environmental literacy into formal school curriculum shows how environmental education can fit into a formal educational setting.

2.2.2 Nonformal Education

Nonformal environmental education occurs in places such as zoos, museums, botanical gardens. Nonformal education is structured, usually not evaluated and can be led by the teacher or another educator (Eshach, 2007). Nonformal learning can draw to a range of intelligences. This potentially can promote a higher likelihood of engagement by people with different strengths and preferences for learning (Eshach, 2007).

The Nonformal Environmental Education Program: Guidelines for Excellence, lays out six key characteristics of nonformal environmental education programs (Simmons et al., 2009).

- Characteristic #1 relates to the needs assessment, which is designed to address identified environmental, educational, and community needs and to produce responsive, responsible benefits that address those identified needs.

- Characteristic #2 is the organizational needs and capacities. This means that the materials support and complement the parent organization’s mission, purpose, and goals.

- Characteristic #3 is the program scope and structure that is designed with well-articulated goals and objectives that state how the program will contribute to the development of environmental literacy.
Characteristic #4, program delivery resources, requires careful planning to ensure that well-trained staff, facilities, and support materials are available to accomplish program goals and objectives.

Characteristic #5, program quality and appropriateness, builds on the foundation of quality instructional materials and thorough planning.

Characteristic #6 relates to evaluation in which defined and measured results are used to improve current programs, ensure accountability and maximize the effects of future efforts.

Understanding the goals of EE generally, and the definition of nonformal EE specifically, will set the stage for the work of this project.

Field trips are a form of nonformal education. Nadelson and Jordan (2012) found that field trips are effective, because they can situate learning and facilitate knowledge transfer. They further state that this will in turn influence the students’ learning attitudes, interests and motivation. Fields trips can have a variety of objectives, from broadening a child’s experience to reinforcing classroom lessons, to even advancing cognitive abilities to promote social skills (Falk et al., 1978). Field trips have the potential to be educational and meaningful. In addition, can enhance student learning when these characteristics are considered.

Field trips take place in an open, flexible and democratic environment and has the potential to provide student-centered instructional techniques (Hofstein & Rosenfeld, 1996). The student-centered approach allows students to move around at their own pace, and to explore and experiment on their own (Hofstein & Rosenfeld, 1996). Field trips can offer hands-on and concrete experiences as students interact physically with objects (Hofstein & Rosenfeld, 1996).

However, barriers exist in how teachers use field trips to accomplish school, district, or county academics aims. Field trips are often seen as a day away from learning, costly,
logistically unfamiliar, and hard to implement. Studies find that teachers avoid outdoor activities because of a lack of curriculum material, for both the student and teacher that is relevant to the content (Hofstein & Rosenfeld, 1996).

2.2.3 Informal Education

Informal learning lies within the framework that learning can occur everywhere and is a life-long process. Learners control the means but not the objectives of learning (Mocker & Spear, 1982). This setting of learning displays characteristics such as unstructured, spontaneous, non-evaluated learning, motivation is mainly intrinsic, and usually learner-led (Eshach, 2007). Eshach (2007) argues that since informal learning occurs spontaneously, it is more likely to occur in places within the day-to-day routine. Places include homes, yards, parks, streets or even school. Hofstein and Rosenfeld (1996) provide similar characteristics of informal learning, in that, it can occur in formal learning environments (e.g. schools) and in informal learning environments (e.g. museums and zoos).

2.2.4 Self-Directed

Self-directed learning provides the learner with ultimate autonomy. Self-directed learning happens for the most part outside of the imposed structure and requirements of schools, universities, or workplaces (Falk & Dierking, 2002). “Self-directed learning is any study form in which individuals have primary responsibility for planning, implementing, and evaluating the effort” (Hiemstra, 1994).

The learner has control over and the major responsibility for choosing both the goals and the means of learning (Mocker & Spear, 1982). The learner decides what and how to learn through selecting, rejecting, adding or changing resources at will (Mocker & Spear, 1982). Hiemstra (1994) lists several characteristics of self-directed learning such as learners are
empowered to take more responsibility associated with their learning endeavor; self-direction does not mean all learning takes places in isolation from others; self-directed study can involve various activities and resources; and lastly, self-directed learners seem to be able to transfer learning from one situation to another. This type of learning involves a strong measure of choice; a choice over what, why, where, when and how we will learn (Falk & Dierking, 2002).

EE can help students become self-directed learners. A key strategy in environment-based education is learning through a problem- or project-based approach (National Environmental Education Foundation [NEEF], 2017). Through this approach, students will gain a better understanding of what they learn and take charge of their own learning (NEEF, 2017).

2.3 Learning in Novel Environments

When students are in placed into a new environment, this can affect their learning. Studies call this the novelty effect--the ability of students to conduct cognitive tasks depends on their familiarity with the setting (Hofstein & Rosenfeld, 1996). Environmental educators also must be able to understand the environmental novelty and change their methodology of the structured activity to allow the familiar and unfamiliar groups to have meaningful and beneficial experiences. Orion and Hofstein (1994) built upon the study done by Falk et al. (1978) about novelty environments. They established three factors of a novelty environment: the cognitive novelty, the geographical novelty, and the psychological novelty (Hofstein & Rosenfeld, 1996). Cognitive novelty depends on the concepts and skills that the students are asked to learn during the field trip; the geographical novelty reflects the familiarity a student has of the field trip area; and psychological novelty relates to the students’ previous experiences with the outdoors (Orion & Hofstein, 1994). Activities should be structured to better accommodate the explorative needs of students who are unfamiliar with the environment.
A sole exposure to a public garden creates an environmental novelty experience for children (Falk et al., 1978). Williams et al. (2015) found that one single visit to a botanic garden will not substantially affect visitors’ ecological knowledge (Williams et al., 2015). A single visit to a field trip area will not allow students to learn until they have passed the novelty effect. The study conducted by Falk et al. (1978) found that drop-in, one-shot field trip classes can be problematic due to the heterogeneity of the students in classes. When students gain further familiarity with a space, they can truly learn within and about the space they are in.

However, proper preparation prior to the field trip and the proper placement of the field trip in the science curriculum can help remedy the novelty factor (Orion & Hofstein, 1994). Although, novelty can be considered as a negative behavior for students, ‘real’ learning can still occur (Falk et al., 1978). The process of overcoming the novelty is a learning step itself. From these novel experiences, children’s curiosity has the potential to be sparked in positive ways, and in turn, begin to accomplish the goals of environmental education mentioned above. With better understanding of the details and nature of the cognitive and affective processes children go through during a field trip, improvements should be made to structured environmental education programs (Falk et al., 1978).

Field trips can be advantageous to learning, yet determining the best structure to accomplish learning can be difficult. Many field trips place children in a novel and stimulus-rich setting which can have a significant impact on the learner (Falk et al., 1978). Children who are not familiar with an environment can feel disoriented and uneasy when visiting a site for the first time (Falk et al., 1978). They can also react by being uncharacteristically active and excited and show a more explorative behavior. Falk et al. (1978) tested whether a child placed in a novel learning setting during a field trip would display certain distinctive behaviors that would
interfere with the demands of a structured learning activity. They found that the subjects in an unfamiliar environment failed to benefit directly from a structured educational activity and that exploration and setting-oriented learning took priority over task-oriented conceptual learning. Yet, the familiar group could do both setting and task-oriented conceptual learning simultaneously (Falk et al., 1978).

2.4 Botanical Gardens

Prior sections established background information about environmental education, nonformal education, and field trips as a tool for learning. This section aims to integrate all the sections above by providing information about nonformal environmental education programs occurring in botanical gardens.

The creation of environmentally rich and diverse green spaces will support environmental learning, and help children gain a sense of connection, ownership and knowledge about their environment (Malone, 2004). Botanical Gardens are an important site for providing diversity and choice in children’s environmental experience (Malone, 2004). Field trips to botanical gardens… have great teaching potential, because they emphasize participatory activities (Kahtz, 1995).

Children are usually exposed to a single garden visit during their primary education (Kahtz, 1995). “A student’s first exposure to public garden education often occurs when attending with their school group for a class or tour” (Kahtz, 1995).

Williams, Jones, Gibbons & Clubbe (2015) performed the first large-scale study to assess how botanical gardens influence ecological knowledge and environmental attitudes. Their results show a strong positive relationship between ecological knowledge and environmental attitude when visitors left the botanical gardens (Williams et al., 2015). Although they found a relationship between these two, they were not able to determine the causal direction between
ecological knowledge and environmental attitudes. Williams et al. (2015) was unsure if the ecological knowledge influenced the environmental attitude of the students or if their environmental attitude affected their ecological knowledge.

2.4.1 Education in Botanical Gardens

Environmental Education can take place in various places such as a classroom, playground, park, science museum, and botanical garden. Botanical gardens are museums without walls whose mission is to cultivate and to study the diversity of plants (Bagarinao, 1998). Over 2,500 botanical gardens around the world reach over 300 million visitors a year (Williams et al., 2015). The mission of these botanical gardens traditionally focuses on developing horticulture and plant biodiversity. However, conservation issues and education are now being addressed in botanical gardens (Williams et al., 2015).

2.4.2 Change in Purpose for Botanical Gardens

Education at botanical gardens is an important mission component in addition to cultivating and studying plants. Globally, education is becoming one of the most fundamental tasks for modern botanical gardens. The International Agenda, which includes the Convention of Biological Diversity and the Global Strategy for Plant Conservation, emphasizes the need for education within botanical gardens to increase understanding and awareness of the value of biodiversity and biodiversity conservation (He & Chen, 2012). This shows that the function of a modern botanical garden is moving beyond plant collection, and more towards public education, *ex-situ* conservation, and scientific research (He & Chen, 2012). Yang and Chen (2015) state that the Botanical Garden Conservation International (BGCI) indicates 107 out of 118 botanic gardens include education in their mission or vision, and 79 out of 117 have a specific budget for education work.
2.5 Project Client: Sarah P. Duke Gardens

Sarah P. Duke Gardens is a 55-acre botanical garden in Durham, NC, on Duke University’s campus (see Appendix 1). Duke Gardens is open to the public 365 days of the year from 8am to dusk. Duke Gardens is comprised of over five miles of allees\(^2\) and pathways and includes many water features, both to add beauty to the gardens and to help control flooding.

The history of Duke Gardens, with an emphasis on water movement and retention, set the stage for a large part of this project. During original construction, debris from the construction of the Duke University Medical Center and West Campus was dumped in the area that became The Gardens. The main water focus for the Duke Gardens was for flood control. The south lawn, which is in the Historic Gardens, is a large grassy area off Flowers Drive, Durham, NC. The south lawn is a bowl shape area in which water runoffs from the nearby parking lots and roads into the garden. Most of the flowers were originally planted here. However, heavy summer rains in 1934 washed away many of those flower beds. The Asiatic Pond was built in 1984, to alleviate drainage problems and improve aesthetics. This landscape is one of many areas in Duke Gardens in which water is important to the watershed of Duke Gardens.


\(^2\) An allee is an alley in a formal garden or park, bordered by trees or bushes. Source: Oxford Dictionary
For this project, my client was the Children’s Education Program (hereafter, Education Program) at Sarah P. Duke Gardens. The Education Program is a key piece to the mission and vision of Duke Gardens indicated by the word “learning” in their mission statement. The Education staff refers to Duke Gardens as a museum for plants and as an outdoor classroom.

The Education Program offers school programs that introduce students to the wonders and complexities of our natural world (“Sarah P. Duke Gardens”, n.d.). The Education Program provides programming for schools of all types (public, private, charter, Montessori, homeschool) to come to Duke Gardens for a guided school program which are led by docents. The lessons given during the guided school programs mostly align with the North Carolina Standard Course of Study (NCSCS). The teacher requests one lesson plan from the twenty lesson plans available, and which specific dates they want to come to the Duke Gardens, by submitting a request to Education staff.

Duke Gardens is a place where learning types are blended. When classroom educators bring children on-site to Duke Gardens for a field experience, they are blending formal and informal learning within a non-formal setting. Hofstein & Rosenfeld (1996) believe formal and informal education are most beneficial when blended together because this blending can help meet the challenge of ‘science for all.’ They seek for science education to be tailored to diverse and heterogeneous populations of future citizens (Hofstein & Rosenfeld, 1996). Interest in learning science varies among different populations, but the integration of informal learning experiences within the formal school curriculum can make an important contribution in dealing with this issue (Hofstein & Rosenfeld, 1996). Hofstein and Rosenfeld (1996) mentioned the lack

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3 NCSCS defines the appropriate content standards for each grade level and each high school course to provide a uniform set of learning standards for every public school in North Carolina. These standards define what students know and should be able to do (source: http://www.dpi.state.nc.us/curriculum/).
of research in effectively blending informal and formal learning experiences and evaluating if this blend enhances student learning in science. Twenty years later, Weinstein, Whitesell, and Schwartz (2014), provided first estimates of the impact of a formal and informal science program on academic achievement. Their study found the collaboration between formal and informal education institutions could be an effective way to improve science education, especially in urban schools (Weinstein et al., 2014).

3. Methods

The following sections will describe the methods of (a) material development, (b) material evaluation, (c) teacher perceptions data, and (e) data analysis. The on-site curriculum for Go With the Flow, pre- and post- lesson plan for Go With the Flow, and pre- and post- lesson plan for Bug’s Life, were developed for this project. The on-site curriculum of both Go With the Flow and Bug’s Life were evaluated. Data from teachers’ perceptions of general curriculum was collected. Lastly, all data were analyzed.

3.1 Material Development

Three primary resources guided development of the activities and information in the lesson plans. First, the NCSCS provided grade-level specific concepts and vocabulary words for each specific lesson plan topic; the Next Generation Science Standards (NGSS) provided information on ways to incorporate crosscutting concepts and practices among core ideas (“Appendix A” [NGSS], 2013). Second, specifically regarding effective environmental education, the NAAEE provided guidelines in creating effective EE curriculum. Third, my own direct experience as a docent in the Gardens, and information from Education staff from the Gardens supplied me with significant insight into possibilities and expectations in developing the
activities. In addition to several hydrology related courses at the Nicholas School for the Environment at Duke University.

3.1.1 On-Site Lesson Plan

All the school program lesson plans in the guided school programs include the materials, the objectives, the actual student activities during the program, and the background information related to the school program topic. Each docent is given a reusable bag that contains the materials. The materials are indicated by a list at the top of the page. These are of all supplies that each docent should have in their docent bag for either the docent or for the students to use during the program. The objectives are listed after the materials. These objectives are specific content-related goals that the students should be able to do by the conclusion of the school program. Depending on the school program lesson plan, the number and type of activities will vary. Also depending on the school program lesson plan, background information can be either be incorporated throughout or found at the end as appendices.

At the request of the Gardens Education staff, I created the Go With the Flow program for 8th-grade students visiting Duke Gardens. The curriculum teaches students about the local watersheds, topography, green infrastructure and experiments done by hydrologists. Components included the on-site lesson, and pre- and post- visit lesson plans.

The following NCSCS middle school curriculum is associated with information about watersheds: 8.E.1, 8.E.1.1, 8.E.1.3, 8.E.1.4 (see Appendix 2). Standard 8.E.1 states, “Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans” (NC Science Essential Standards, 2017). The Go With the Flow school program lesson
plan seeks for students to explain spatial water distribution in a local watershed\(^4\), examine how water is used in Duke Gardens, and describe how this relates to the hydrosphere through a multitude of field experiments.

Using the standards and the information provided regarding the water features of Duke Gardens, I developed *Go With the Flow*. A 90-minute lesson plan created specifically to be used at Duke Gardens during a guided school program visit (see Appendix 3). This lesson plan was consistent with the basic framework of existing guided school program lesson plans. However, *Go With the Flow*, contained additional discussion points for the docents to facilitate a further conversation with the students after each activity.

Before officially piloting *Go With the Flow* with students, an on-site initial walk-through was conducted in April 2017 with Education Program staff. They were provided with the lesson plan before the walk through. During this walk-through, the Education Program staff provided positive and constructive feedback on the lesson plan and field notebook. Based on the feedback, revisions were made to the lesson plan and to the format of field notebook. A final walkthrough occurred ten days later with the Education Program staff, where the school program was conducted as if it was meant to happen with students. The purpose of this was to give the Education Program staff an opportunity to do the three main experiments conducted in the lesson plan before completing the lesson with students. In April 2017, the pre- and post-lesson plan was sent to one 8\(^{th}\) grade teacher. Data on the use of pre-visit materials by selected teacher was not collected.

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\(^4\) A watershed is an area of land that drains all the streams and rainfall to a common outlet such as outflow of a reservoir, mouth of a bay, or any point along a stream channel (USGS Water Science School, 2016).
The Duke Gardens Education Program produces an associated quick reference guide of all the guided school program lesson plans as a quick reference for docents to use during the school program. Therefore, based on the full lesson plan, I created quick reference guide for Go With the Flow (see Appendix 4). The quick reference guide of this lesson plan is also consistent with previous existing quick reference guides for each lesson plan. This quick reference guide contains information about the activities for the lesson plan and leaves out most of the additional background information.

Additionally, the lesson plan includes an on-site field notebook given to every student during the guided school program (see Appendix 5). The field notebook includes a black, grey and white map of Duke Gardens, edited by Kati Henderson, for students to mark the flow of water in The Gardens. The light grey areas on the map are the planned water features in Duke Gardens. Whereas the black lines indicate the intentional paths throughout The Gardens. Each student was able to take the field notebook with them after the school program.

3.1.2 Pre- and Post- Lesson Plans

Based off the school program lesson plan, a pre-lesson plan and a post-lesson plan, to be used in the classroom, were developed. I researched effective formats and activities using NGSS, NAAEE, and the NCSCS. I used the curriculum design resource, UbD, to provide me with curriculum examples.

Pre-lesson plans provide the teachers and the students with initial background information and introduction to the content. Post-lesson plans help the teachers reinforce the information the students were taught during the school program and extend their learning. The pre- and post-lesson plans were to provide a basis of information that the students should know beforehand and extensions to add after they attend the field trip to Duke Gardens.
The pre- and post-lesson plans of *Go With the Flow* and *Bug’s Life* contain essential questions, key vocabulary words, three pre-activities, three post-activities, four independent practice activities, and five online activities (see Appendix 6 and Appendix 7, respectively). The pre- and post-lesson plans of both *Go With the Flow* and *Bug’s Life* were provided feedback and edits by Education staff. The feedback and edits were taken into consideration and used to improve the pre- and post-lesson plans.

### 3.1.2.1 *Go With the Flow*

The *Go With the Flow* pre- and post-lesson plan was based on the on-site lesson plan. Specifically, the objectives and the concepts of the school program.

The design of the pre- and post-lesson plan was based on the NCSCS, the NAAEE Guidelines for Learning (K-12), and the Understanding by Design (UbD) curriculum format. The NCSCS provided key vocabulary and concepts the state wants the students to know about the hydrosphere. The NAAEE Guidelines for Learning determined the types of activities that were included in the pre- and post-lesson plans. The pre- and post-lesson plan includes, Guideline 1: Questioning, analyzing, and interpreting skills and Guideline 2: Knowledge of Environmental Processes and Systems. Lastly, the UbD curriculum format provided the framework for important parts necessary for effective student learning. This included, the essential questions, the lesson objectives, the key vocabulary words, and the standards.

### 3.1.2.2 *Bug’s Life*

*Bug’s Life* is an existent school program lesson plan aimed at 2nd grade students that teaches students to name parts of insect anatomy, to describe life cycles, both in general and of insects, and to observe insects in the gardens (see Appendix 8). The following NCSCS elementary school curriculum standards are associated with information about life cycles of
insects: 2.L.1, 2.L.1.1, 2.L.1.2 (see Appendix 9). Standard 2.L.1 states, “Understand animal life cycles” (http://scnces.ncdpi.wikispaces.net). The Bug’s Life program objectives seeks for students to name parts of an insect’s anatomy, describe an insect life cycle, and look for insects in the garden.

The on-site lesson plan already exists in the Education Program’s school program curriculum. Education staff asked me to develop corollary, pre- and post- lesson plan materials to be used in the classroom of visiting teachers. The Bug’s Life pre- and post- lesson plan is based on the established curriculum objectives and on the NCSCS standards. The design of the pre- and post-lesson plan for Bug’s Life also used the NCSCS, the NAAEE, and the UbD curriculum framework as resources in the same ways mentioned above.

3.2 Material Evaluation
3.2.1 Go With the Flow

When evaluating the on-site curriculum for Go With the Flow, a school partnership, docent evaluations and direct observations were necessary. Although the teacher was provided pre- and post- and onsite materials, I only evaluated the on-site materials.

3.2.1.1 School

A school partnership was sought to help pilot the Go With the Flow both the pre- and post- lesson plan and the on-site lesson plan. Education staff identified a school in Durham, NC to pilot based on the time of year and flexible nature of the school. Within the school, the Education staff found an 8th grade science teacher who was willing to pilot the program with their students. Education staff spoke directly with the 8th grade science teacher to seek out interest and to schedule a date for the school program.
3.2.1.2 Docent

In May 2017, three docents led the program to 45 eighth graders. The students were split in groups between 11 and 15 among the three docents. All the docents completed a docent post-field trip reflection form after the school program (see Appendix 10). In addition, a verbal discussion occurred with all three docents after writing their post-field trip reflection form.

3.2.1.3 Observation

I accompanied one docent with their group of eleven students for the entire duration (90 minutes) of the program to collect more detailed and direct observations of the on-site visit. During this observation period, I asked some of the students various questions. Students also asked me questions related to the experiments or The Garden itself. Their responses and further comments were written during this observation period.

3.3.1 Bug’s Life

To evaluate this specific on-site curriculum, a school partnership, docent evaluations, and detailed observations were necessary. Although the participating teachers were provided pre- and post- and onsite materials, I only evaluated the on-site materials.

3.3.1.1 School

Based on the identified school program and the time of year, Education staff chose one Durham Public School to be a part of the evaluation of the on-site curriculum, Bug’s Life. Education staff notified participating teachers via email that their classes would be involved in the on-site evaluation of Bug’s Life.

3.3.1.2 Docent

In April 2017, eight docents led the Bug’s Life school program for 94 2nd grade students. The students were split in groups between 10 to 13 students. Docents were given pre-assessment questions before the students arrived (see Appendix 11). These questions were centered on the
pre-lesson activities of *Bug’s Life* mentioned above. During the beginning of the program, students were asked to stand in a circle with the docent (and assistant, if applicable). The docents went over the three guidelines and mentioned the topic of the program. The docents then asked the students the some or all of the four pre-assessment questions that they were provided. Student responses were written on the paper provided. All the docents completed a docent post-field trip reflection form after the school program. In addition, a verbal discussion occurred with all three docents after writing their post-field trip reflection form. The data mentioned are representative of the group of 2nd grade students from the Durham Public School that came to Duke Gardens for the *Bug’s Life* school program in April 2017.

5.3.1.3 *Observation*

I accompanied one docent who led a group of twelve students to collect detailed and direct observations of the on-site visit for the entire duration (90 minutes) of the school program. During the observation, I asked the students various questions. Their responses and further comments were written during this observation period.

3.3 *Teacher Perceptions Data*

The following section will provide information regarding how data about the general teacher perceptions of guided school programs at Duke Gardens were collected.

At the end of August 2017, an email request was sent to 15 teachers in Orange County, NC and Durham County, NC by Education staff (see Appendix 12). The teachers were requested to responded back via email within a three-week period, if interested. Of those emails, four total responses (three confirmed their participation, one sent regrets of their participation) were received. Two weeks later, requests were sent to an additional nine teachers in Durham County, NC. Of those emails, three responses (all confirmed their participation) were received. A week
later one respondent was no longer able to participate due to schedule conflicts and availability. In total, 24 teachers from varying school types were asked to participate: three teachers from charter schools, 11 teachers from independent schools, and seven teachers from public schools (Table 2).

Interviews were completed with all the teachers who confirmed their participation. The teachers who participated teach at charter schools (3) or independent schools (4). The one teacher who expressed their regret teaches at a public school. The other teacher who was no longer able to participate teaches at an independent school.

Each of the interviews were about forty minutes long. The interviews were conducted either in the teacher’s classroom (four interviews) or at Duke Gardens (one interview). Table 3 shows a profile of the teacher interviewees based on their school type, grade level, and number of years of teaching formal education.
Table 2 The 24 teachers that were contacted between Orange and Durham County, NC. The table sorts the teachers based on school type, showing the variety of school types and grade levels.

<table>
<thead>
<tr>
<th>Teacher Grade level</th>
<th>School Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Charter</td>
</tr>
<tr>
<td>3</td>
<td>Charter</td>
</tr>
<tr>
<td>8</td>
<td>Charter</td>
</tr>
<tr>
<td>Pre-K</td>
<td>Private</td>
</tr>
<tr>
<td>Pre-K</td>
<td>Private</td>
</tr>
<tr>
<td>Pre-K</td>
<td>Private</td>
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<tr>
<td>Pre-K</td>
<td>Private</td>
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<tr>
<td>Pre-K</td>
<td>Private</td>
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<tr>
<td>K</td>
<td>Private</td>
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<tr>
<td>1</td>
<td>Private</td>
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<td>2</td>
<td>Private</td>
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<tr>
<td>3</td>
<td>Private</td>
</tr>
<tr>
<td>K-8</td>
<td>Public</td>
</tr>
<tr>
<td>1</td>
<td>Public</td>
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<tr>
<td>1</td>
<td>Public</td>
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<td>3</td>
<td>Public</td>
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<tr>
<td>3</td>
<td>Public</td>
</tr>
</tbody>
</table>
Table 3 Five interviews occurred with seven total teachers who teach in Independent Schools in Durham, NC. The teachers have a range of years of teaching experience.

<table>
<thead>
<tr>
<th>Interview Number</th>
<th>Teacher 1</th>
<th>School Type</th>
<th>Grade</th>
<th># of years of teaching</th>
<th>School Program Attended at Duke Gardens</th>
<th>Attended multiple times?</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Durham County Charter School</td>
<td>3rd</td>
<td>13</td>
<td>Discovery Garden &amp; Plant Power</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td>Durham County Independent School</td>
<td>3rd</td>
<td>4 (general education) + 5 (art education)</td>
<td>Soil City</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td>Durham County Charter School</td>
<td>K</td>
<td>25</td>
<td>Dirt &amp; Worms</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Four</td>
<td>Durham County Independent School</td>
<td>Pre-K</td>
<td>4a: 25, 4b: 12</td>
<td>Dirt &amp; Worms</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Five</td>
<td>Durham County Independent School</td>
<td>Pre-K</td>
<td>5a: 12 + 3 (substitute teacher), 5b: 18</td>
<td>Farm &amp; Folktales</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Questions were developed to gain teacher’s perceptions about the guided school programs at Duke Gardens. Education staff were interested in knowing why teachers chose Duke Gardens for a field trip, how much time they had to prepare, whether the field trip met their expectations, and whether the Duke Gardens Education Program adequately covers topics the teachers need. Based on input from The Gardens Education Program staff and my project advisor, a 26-question interview guide was created (see Appendix 13).

Education staff selected and recruited the interviewees based on those who visited recently and based on the ease of communication and responsiveness with the teacher. I interviewed a total of seven teachers, who took their students to the Duke Gardens, about their general perception of Gardens programming, based on their participation in a scheduled school program visit within 2016-2017 school year. Three of the teachers interviewed were in solo interviews, and four of the teachers interviewed were in dual interviews.

Semi-structured interviews were conducted with every teacher using the same interview guide each time. The interviews took place over a one-month period (September 2017 – October 2017). Based on the teacher’s schedule, the date, time and location of the interview was set. A brief introduction of myself and this project was mentioned before starting each interview. All teachers interviewed provided permission for the interviews to be recorded. Written notes were additionally taken. In conducting the dual interviews, both teachers were requested to provide a response to the question and/or say that they agree or disagree with the response initially given.

3.4 Data Analysis

A qualitative data analysis through manual coding was performed for all aspect of this project. Themes based on the data were inductively and deductively obtained.
3.4.1 Coding

Manual coding was used to identify themes and the data that provides evidence for each theme. Some of the themes were identified deductively ahead of time. Other themes were produced inductively throughout the coding process. The various themes were differentiated using different colors. The themes that frequently appeared were color-coded to initially analyze the data. Then, the responses of every question were also color-coded based on the theme.

The raw data strictly from the responses were coded first. The responses were then copied and pasted under each theme using these raw data responses. The responses were further sorted under one or multiple themes. Lastly, this was used to find common threads, similarities, and differences among the responses. The results were compared to determine the frequency among and between themes.

3.4.1 Themes

The Go With the Flow analysis consisted of the docent post-reflection responses that were provided and obtained after the program. For each topic, similar words and phrases were combined. Overall experience responses were sorted based on positive, neutral or negative responses. The responses from the other four themes were sorted by general and specific. The specific student information known was additionally separated into known and less known/unknown.

The Bug’s Life analysis used pre-assessment responses to inform the students’ readiness, interest and preparation about insects. The sorted responses were then coded based on their validity: correct versus incorrect in general and correct versus incorrect specifically to the question. The Bug’s Life analysis also used docent post-reflection responses to inform about their experience. For each topic, similar words and phrases were pooled together. Overall experience
responses were sorted based on positive, neutral or negative responses. The other responses from the other four topics were sorted by general and specific. The specific student information known was additionally separated into known and less known/unknown. The responses for the pre-assessment questions and the docent post-field trip reflection were sorted based on student voice and docent voice, respectively.

After conducting the interviews with the seven teachers, recordings were analyzed and additional responses that were not reported during the interview were cataloged. The themes that frequently appeared were based on topical information of the question and the responses. The interview questions were initially used as the themes. Some interviewee responses were coded under multiple themes. Through the analysis and coding process, overarching themes that encompassed multiple questions were created. The themes were sorted chronologically based on the preparation of the field trip, the on-site field trip, and post reflection after the field trip.

4. Findings

4.1 Specific Curricula

Based on the data analysis of each school program, the following section presents the findings for Go With the Flow and Bug’s Life, respectively.

4.1.1 Go With the Flow

At the beginning of the observation of this school program, students were asked if they knew the definition of a watershed. The students specifically observed, did not know the definition. For this lesson, the definition of a watershed is an area of land where all the water that falls in it and drains off it goes to a common outlet. The docent leading the group asked the students if they studied about the water cycle in their curriculum. A student said they studied the hydrosphere in the first quarter of the school year. The docent mentioned another key vocabulary
word, topography, to explain the change in physical features of The Gardens. The teacher added more information about the topography for the students to obtain a better understanding by relating the concept to what the student previously learned. When the students conducted the evaporation experiment in the lesson plan, the subsequent discussion led to some students mentioning the lack of difficulty. Additionally, the experiment also did not work very well initially. The docent prompted the students to change their method of executing the experiment. The students showed fluency in the stream velocity experiment using the float-test method. Most of the students understood what velocity meant and how it would relate to streams. All groups knew how to conduct the experiment with little prompting from the docent, but varying degrees of help from the teacher. The teacher at times would walk one group through what their procedures would be, while providing positive reinforcement statements to other groups that conducted their first trial run. Lastly, the infiltration experiment was found to be a potentially quick activity. The students finished quicker than the time allotted for the experiment.

The post-reflection responses were coded under the following themes: Overall Experience, Student Information Known, Questions Asked, Correct Answers from Pre-assessment Questions, and Knowledgeable about Subject.

The overall experience for the docents led to a mix of positive responses and negative responses. Some positive responses included “enjoyed following the path of water”, “left with a new understanding of watersheds and how they connect”, and “well planned and organized”. A docent wrote, “[The students] came away with new understanding of watersheds and how they connect.” Whereas, some of the negative responses included, “some difficulties”, “trouble getting interested”, “did not engage with the hands-on experiments”, and “students went off the
A docent wrote, “Students were pretty quiet and unresponsive throughout the program.”

The docents were then asked to reflect on the amount of information the students knew. In general, the docents found that information known varied among the three groups. A docent wrote, “They knew a modest amount of information about most things.” Specifically, the students knew concepts such as runoff, onsite infiltration and the water cycle. But knew less about watersheds and watersheds as a connected system. The students did not think about how changes in one area could affect another, wrote a docent.

In general, the questions the students asked the docents were related to clarifying questions about the experiments or the students did not ask any questions at all. Specifically, the students asked five out of seven questions that were directly related to the lesson, based on the docent’s reflection. One docent found the students consistently asking purely identification questions, i.e. “What’s this?”

The next two questions used a scale of strongly agree to strongly disagree. The first question asked if the docent felt the students answered pre-assessment questions correctly. Two docents agreed, and one docent was neutral on if the students were able to answer the pre-assessment questions correctly. Based on their responses, generally, some students needed reminders, but they pretty much knew the information. Specifically, the docents said students “knew about the water cycle”, “could apply the information to the landscape”, and “knew a lot of vocabulary.” One docent stated that they introduced the concept and vocabulary word, watershed to the students. The students did not know the definition but made guesses to the word. This also occurred with other words such as infiltration and bio-swales.
Lastly, when the docents were asked to reflect on if the students seemed knowledgeable about the subject, two agreed and one was neutral. There were no common responses found, but in general the students did not know the specifics. Some of the students were able to make connections. Student behavior and attitude was a common thread throughout the various questions. Comments such as “sub-vocalizing”, “difficult to determine with accuracy how many knew what”, “uninterested”, and “pretty quiet” were a few negative responses the docents mentioned. However, for this question, a docent wrote “The teacher was pleased with the hands-on experiments and planned more follow-up back in the classroom.”

4.1.2 Bug’s Life

The pre-assessment responses were coded under the following questions: What is an insect? What are the characteristics of an insect? What are examples of an insect? and What is a life cycle? The responses were coded to be under two themes: Facts or Examples of Insects mentioned by students. The Facts theme contained nine subsections: insect anatomy, life cycle, food, seasonality, sounds, terminology, movement of insect, adaptations, and visual markers. Those responses were then coded under Facts or Examples of Insects and placed into a subsection, if applicable.

Question one asked, “What is an insect?” The correct definition, any small invertebrate animal, was not provided by any student among all eight groups. Eleven responses given, related to the insect’s anatomy. Five responses given, related to specific examples of insects. Additional responses included, two about an insect life cycle and one response given about insect related terminology.

Out of the 11 responses related to insect anatomy, two were incorrect and nine were correct. The following are examples of responses given related to insect anatomy: “8 legs, no
legs, have more or less legs, wings, abdomen, tiny creature, thorax, antenna and head.” In this case, “8 legs” and “no legs” were incorrect in general since insects have six legs.

Out of the five responses given about specific insect examples, two were incorrect, two were correct, and one was neither correct nor incorrect. “Arachnid” and “spider” were the two incorrect responses; “butterfly” and “bee” were the two correct responses; and “types of insects” was neither correct nor incorrect. The responses overall did not answer the question that was asked.

Question two asked, “What are characteristics of an insect?” The main characteristics of an insect are, three body parts (head, thorax, abdomen), six legs, antennae, compound eyes, and specialized mouth. Answers given included, 15 responses related to insect anatomy (examples: “6 legs,” “3 body parts,” “head,” and “antenna”), one related to insects as prey (“Birds eat bugs”), one related to seasonal changes (“not around in winter”), one related to sounds (“make noise”), two related to insect adaptations (“see at night” and “infrared vision”), and three related visual markers (“have spots,” “colorful,” and “like worm spots”).

All 15 responses related to insect anatomy for question two were correct and properly answered the question. The responses about insects as prey was coded as a correct response in general. The responses related to sound and insect adaptations were coded as correct responses for the concept in general, but coded incorrectly for the specific question. The three visual markers responses were coded as correct in general since these can be visual characteristics of insects, but incorrect for the question.

Question three asked, “What are examples of an insect?” Any response that followed the characteristics of an insect mentioned above was coded correctly. Students responded saying bee (7x), spider (2x), ant (3x), ladybug (4x), and dragonfly, cricket, fleas, daddy long legs, arachnid,
and grasshopper. All responses except, arachnid, spider, and daddy long legs, provide correct examples of insects, which also answered the question. Arachnid, spider and daddy long legs were coded as incorrect because they do not fit the characteristics of an insect.

Question four asked, “What is a life cycle?” The correct definition of a life cycle is a series of changes in the life of an organism, including reproduction. Responses varied for this question. Some responses were the “butterfly cycle → egg, caterpillar, cocoon, hatches, dry its wings, butterfly lays eggs.” While another response was “babies grow bigger.” There were four correct responses that were answers to the question, but the other 16 responses were aspects and parts of a life cycle, which did not answer the question.

Five additional responses to this question could not be coded as correct in general because of the word, “cocoon.” A cocoon was written as a part of the life cycle of a butterfly and a beetle. However, a butterfly grows out of a chrysalis, and a beetle out of a pupa. For this question, “cocoon” was mentioned five times, “butterfly” five times, “egg’ seven times, and “caterpillar” three times. A docent asked a secondary question, “What has a life cycle?” under this pre-assessment question. All three responses to the secondary question were correct in general and the student’s answered the question correctly.

Based on observations during the field trip, some of the students did not know the theme of the school program they attended. This was known based on some students’ responses when they were asked during the program if they knew what they were learning about today. During the pre-assessment questions, the docent asked a follow-up question, “What makes something an insect?” after the first question mentioned above. This led to an increase in responses of question #1, “What is an insect?” Throughout the program, she asked students to repeat after her when they explicitly covered vocabulary words that were significant in the NCSCS for 2nd grade. The
students asked questions for most of the program. They made keen observations, and wrote and
drew what they saw on their insect explorer sheet. Towards the end, the students lost focus and
wanted to run on the path instead of walk. Before the program concluded, a small group
interaction occurred with two students. They spotted a bug on the water fountain at the Mill
Stone Pond in the Blomquist Garden for Native Plants. One student immediately began to count.
They seemed to be counting the legs. The students were asked what another identifier of insects
was. They began to say the body parts. With some prompting, they were able to say each part
correctly.

The post-reflection responses from the docents were coded under the same themes as
mentioned previously. The overall experience for the docents led to half of the responses being
positive and half of the responses being negative. Some of the negative responses included, “not
as curious”, “tired of directed activities”, and “some distractions.” Whereas, some of the positive
responses included “great experience”, “[the students] explored everywhere and were engaged”,
and “enthusiastic kids.”

The docents were asked to reflect on the amount of information the students knew. In
general, the docents found that the information known varied among their group. This was the
case across all eight groups. Specifically, some students knew all three body parts, the life cycle
structure and additional physical characteristics. However, the students did not apply their
observation skills to find insect and they were mixing up terminology, such as larva, cocoon,
cicada, bug and insect. Some docents mentioned that some students did not know the body parts
or only partially and had little knowledge of the life cycle. The questions that the students asked
the docents in general were related to identification, or the students taught each other.
Specifically, a consistent topic was not found that stemmed from this aspect of the reflection.
The questions asked were all different and were based on the location of the group within The Gardens.

The next two questions used a scale of strongly agree to strongly disagree. The first question was based on the docent’s reflection on if the students answered the pre-assessment questions correctly. Seven docents agreed, and one docent disagreed, if the students were able to answer the pre-assessment questions correctly. Generally, some students had partially correct information, some had inaccurate information, and some had answers to every question. Specifically, the docents said students knew about the legs, antenna, head, and thorax of an insect, as well as partial aspects of their life cycle. But they knew less about the life cycle and the correct terminology used in different life cycles. A docent wrote, that a few of the students knew some terminology such as “entomologist”, “metamorphosis”, and “exoskeleton.”

Lastly, when the docents were asked to reflect on if the students seemed knowledgeable about the subject, five agreed, two were neutral, and one disagreed. Common responses from the docents were that individuals had specific knowledge and experiences with insects, but the knowledge truly varied from student to student, and seemingly from group to group. Although the students learned information during the program, they were not able to apply or remember the information. Similar patterns were seen in this case where some students knew more than others, while some had basic knowledge and others this was completely new information.

4.2 Teacher Perceptions

After combining all teacher interview responses, nine themes were identified from the entire data set. These themes were first arranged by determining the overall chronological order of the questions. Interviewee Demographic asked at the beginning of the interview to gather information about the teacher. Benefits of Field Trip and Preparations were themes related to
why the teachers planned an outdoor-based field trip and how the teacher and students prepared for that experience. Secondly, _Teacher Observations of Duke Gardens Experience_ and _Moments_ were themes related to the actual experience at Duke Gardens. Lastly, themes related to what occurred after the school program at Duke Gardens were determined to be _Expectations, Curriculum Ties/Standards, Evaluating Student Learning, and Suggested Improvements from Teachers_. The explanations of all themes can be found in Appendix 14.

In this section, findings for each theme are presented. For some of these, there are additional sub-themes related to the main theme. When speaking specifically about interviewee responses, the interviewee will be referenced as “Teacher # (Grade Level Taught)” Teacher 1 (3rd), is a specific example. The grade level for each teacher is listed in Table 3.

![Diagram of Nine Themes based on topical responses from the interviews](image)

*Figure 1* Nine Themes based on topical responses from the interviews
4.2.1 Themes

Interviewee Demographic

Table 3 shows the interviewee demographic breakdown and a list of the teacher number, their school type, the grade they taught during their Duke Gardens scheduled visit, the number of years taught, the school program they attended at Duke Gardens for this project, and if they attended Duke Gardens for other school programs.

Benefits of Field Trip

The responses relating to benefits of field trips were coded further under the following subsections: (a) general outdoor education and (b) Duke Gardens specifically. General outdoor education relates to the teacher taking their students outside, to learn or to play. When asking about Duke Gardens specifically, the responses were specifically related to being outside on a field trip at Duke Gardens.

General Outdoor Education

Overall, all the teachers interviewed agreed that outdoor education is beneficial to their students. These teachers purposefully sought to bridge the gap between formal learning and nonformal or informal learning through outdoor experiences and at Duke Gardens, specifically. When asked about the benefits of outdoor education, Teacher 1 (3rd) and Teacher 2 (3rd) both mentioned bringing a sense of real application and reality to their students. While, Teacher 3 (K), Teacher 4a (Pre-K) and Teacher 5b (Pre-K) mentioned that their students are spending less time outside, and want to simply give them exposure to being outside.

“It is so great to be able to take your kids to the great outdoors.”

– Teacher 5b (Pre-K)

Also, being outside, but in a different place was important to this group. Teacher 4b (Pre-K) mentioned even the car ride over is the best part of someone’s day. However, Teacher 2 (3rd)
took the exposure aspect to another level and spoke on the students gaining cultural exposure since they are meeting new people and learning from different educators. Two teachers, Teacher 1 (3rd) and Teacher 4a (Pre-K) chose to use the word “Field Work” instead of field trips with their students. Three teachers, Teacher 1 (3rd), 2 (3rd), and 4a (Pre-K), mentioned connecting to the world and the environment. Teacher 3 (K) found some of the students have a fear of nature and a “fear of the dirt.” Teacher 4b (Pre-K) mentioned that field experience is what makes learning meaningful for [their students]. Teacher 2 (3rd) and Teacher 5a (Pre-K) mentioned the negative effects of the field trip on their students. They expressed the students are used to a certain structure and procedure such as, driving in their own family’s car to and from school or when they have snack/lunch at school. However, the day of the field trip was a significant change for the students, which at first is a hard adjustment. Nevertheless, the teachers expressed that once they arrived and began the program, the students were engaged and had fun.

Duke Gardens Specifically

The teachers found Duke Gardens to be a magical and inspiring place for their students and themselves. Teacher 4a (Pre-K) and 4b (Pre-K) were the only teachers who did not return to the Gardens for the same school program or a different school program. However, they would come back again if any of the school programs offered tied into one of the classes’ project that year. These teachers explained that beginning a class project is an organic process with their students, and lies wherever the student’s interests are presently. This would then lead them to Duke Gardens, if a program is provided for their topic.

Community was mentioned by two teachers, but in different ways. The following are direct quotes from Teacher 2 (3rd) and Teacher 3 (K).
“[The field trip] builds community when having experiences outside of your
typical place.”
- Teacher 2 (3rd)

“[The students] get a sense of community by using the city bus, going onto a
university’s campus and walking off the bus into the gardens, oh they really
enjoyed that.”
- Teacher 3 (K)

Teacher 2 (3rd) found that the experience built a community within the classroom,
whereas Teacher 3 (K) felt that the students were able to understand the community
they live in by using the bus and walking into Duke Gardens.

Benefits that were mentioned at least three times were: hands-on, cost, proximity, and the
novelty factor. Teacher 2 (3rd) and 4a (Pre-K) used words such as experiential learning when
describing reasons why they brought their students to Duke Gardens. The school programs
Teacher 2 (3rd) and 4a (Pre-K) attended with their class contained similar aspects in which the
students were able to play with soil, dig using real tools into the soil, and climb onto the compost
piles. Teacher 1 (3rd) spoke upon the Garden helping to build [student] knowledge, while
Teacher 4b (Pre-K) stated the school program solidified the information for their students.
Having a common experience that the teacher can always refer to is an important benefit to
Teacher 1 (3rd) and Teacher 4a (Pre-K). The Education Program charges a small fee per student
for any program that is a structured and scheduled visit. Teacher 1 (3rd), Teacher 2 (3rd), and
Teacher 3 (K) said the price was very accessible and affordable. Teacher 1 (3rd), Teacher 2 (3rd),
Teacher 4b (Pre-K), and Teacher 5b (Pre-K) mentioned the proximity and distance from their
respective school was an additional benefit. Teacher 2 (3rd), Teacher 4b (Pre-K) and Teacher 3
(K) mentioned the novelty factor that their students experienced when they came to the gardens.
One teacher tries to overcome this factor by bringing their students to the Duke Gardens an hour
before their scheduled school program. Teacher 3 (K), mentioned going on a hike through the Gardens was beneficial for the kindergarten students because of the amount of magic in the Gardens—the students just want to see everything. Teacher 2 (3rd) will be bringing their class to the Gardens four times during the 2017-2018 school year. They mentioned their excitement for their students to see the changes in the Gardens over the four seasons.

Four of the teachers felt the school program flowed well and that it was very organized. Teacher 4b (Pre-K) was impressed with how concrete and focused the lesson was and how the program maintained the focus on the topic during the entire duration. Teacher 1 (3rd) appreciated the nature museum (an area inside the Duke Gardens multi-purpose classroom with various items such as seeds, insects, egg casings, birds nest, etc.) in the classroom at Duke Gardens. They mentioned that Duke Gardens uses appropriate models that students do not typically see in their classroom.

**Preparations**

The responses relating to the preparations theme were coded under three sub-sections: (a) timing of school program, (b) teacher preparation, and (c) pre-lesson plans. Sub-section (b) was further separated into two sections (1) preparing for the field trip logistically and (2) preparing the students.

**Timing of School Program**

When asked at what point the teachers brought their class to the Duke Gardens for the program, all the teachers ideally wanted the visit to be in the middle of their curriculum. They expressed strong benefits to having the program in the middle.

“*Sometimes you plan, God laughs, and you think it’ll be in the middle, but it’s before.*

*Sometimes it is just when we get to the gardens, and we try to work with the date we get.”*
Teacher 1 (3rd), 2 (3rd) and 3 (K) all mentioned that they came to the gardens are various times. If done in the beginning, then the field work becomes the jumping off point for the content; if done in the middle, this helps to keep the questions coming, said Teacher 1 (3rd). A factor of timing also relies on the availability of the schedule and competing with other schools and teachers. Teacher 3 (K) suggested to other teachers at their school to schedule the field trip to Duke Gardens in advance, since the dates and times fill up quickly. Timing of school breaks and holidays is an additional factor that Teacher 5a and 5b run into when scheduling their visit. Their theme runs for the whole month in which they introduce the topic, see it hands-on then reference the material at school.

When asked a follow-up question about the success of the various times, Teacher 1 expressed success regardless of when they go, but would prefer to attend the school program in the middle or the end. When attending in the end, Teacher 1 (3rd) found the program validating, because the students knew everything and were able to ask more in-depth questions during the field trip. Additionally, if the class attends the program at the end of their unit, Teacher 1 found this can show retention, or lack thereof. Teacher 1 (3rd) gave the example of a student asking, “Are bees the only pollinators?” to the docent. This shows that the students already knew about the word pollinator and what insect is a pollinator.

“*Asking thoughtful questions is more meaningful, than them [the students] knowing all the answers.***”

– Teacher 1 (3rd)

Teacher 1 (3rd) mentioned that students asking thoughtful questions is more meaningful to them, than them only knowing answers. Teacher 4b (Pre-K) stated that when they went to
Duke Gardens it was the right timing, because the end of the project was nearing, and they knew it was time for a field experience based on the interest of the students and the project itself.

Teacher Preparation

Teacher preparation includes preparing the field trip logistics and preparing the students for the field trip.

Preparing for the Field Trip logistically

All the teachers said they plan for the field trip several weeks in advance, which does not include the initial plan of signing up for the field trip. Teacher 1 (3rd), 3 (K), 4a (Pre-K), and 5a (Pre-K) gave parents at least a week advance notice to coordinate chaperones and/or drivers for the field trip. Teacher 1 (3rd) has three class parents who help to organize the field trip and spread communication. They are the ones who schedule the field trip drivers and provide information to other parents about the field trip. Teacher 5b (Pre-K) scanned the Duke Gardens guidelines on the computer and sent them to the parents. They wanted the parents to emphasize the rules at home as well. Providing information to the parents about what it means to be a chaperone was mentioned twice, Teacher 4b (Pre-K) and Teacher 5a (Pre-K). Teacher 4b (Pre-K) and Teacher 5a (Pre-K) revealed that the parents become a distraction to the students when they are socializing on the side or want to take pictures of everything; which slows the group down. Teacher 5b wished that the parents used the field trip as an opportunity to spend time with their child in a potentially new environment. Overall, the teachers all expressed that being organized and planning in advance are ways they logistically prepared for the field trip.

Preparing the students

Preparing students is also a significant aspect of organizing a successful field trip. Every teacher prepares their students before coming, in similar and different ways.
Differences were mainly found between the teachers of older students, Teacher 1 (3rd) and 2 (3rd) and teachers of younger students, Teacher 3 (K), 4a (Pre-K), 4b (Pre-K), 5a (Pre-K), and 5b (Pre-K). The main difference is how in-depth the teachers went with the older students before the field trip. The teachers went more in depth into the content with the 3rd graders, compared to the kindergartners and preschoolers. Teacher 1 (3rd) mentioned that the students are provided with a period of research and times for wondering to stimulate their curiosity.

“It is not about us knowing the information. But about the kids coming up with questions and exploring those answers themselves.”

— Teacher 1 (3rd)

Both Teacher 1 (3rd) and Teacher 2 (3rd) conducted scientific experiments in their classroom before they attended the field trip. Teacher 1 (3rd) talked significantly about seeds. The students named seeds and dissected seeds when preparing for the Plant Power field trip. Meanwhile, Teacher 2 (3rd) had students collect soil samples, do observational drawings and conduct simple science experiments to see changes in the soil when preparing for the Soil City field trip.

On the other hand, more broad and open-ended questions and discussions occurred with the younger students. “When we go to Duke Gardens, what do you think you will see?” was a sample question that Teacher 5a (Pre-K) asked the students. This was to get them thinking and to start asking questions of their own. Depending on the day of the field trip, Teacher 5a (Pre-K) would spend time each day during the week leading up to the field trip to prepare the students.

Similarities were found in the pre-field trip experiences even among different age groups. Teacher 4a (Pre-K) and 4b (Pre-K) go through a significant preparation process before they attended the field trip. Their preparation includes consistent field experiences at their own
school, including the playground, throughout the year. This helps to build their confidence in their skills as observers and explorers. Since they are often outside and connecting to the environment, this takes away the novelty factor. A similar story was mentioned in the interview with Teacher 1 (3rd). Their class spent a significant amount of time zooming in on the content and had a lot of experience with outdoor education before attending the field trip. Teacher 4a (Pre-K) and 4b (Pre-K) allow in-class time to have short conversations the week before to set expectations and reference the questions they had in regard to their project. Teacher 3 (K) made the preparation aspect a part of their class project. They addressed what behaviors are expected, ways to respect the environment and other people that will be around.

Pre-Lesson Plans

Each teacher interviewed wanted a pre-lesson plan given to them before they attended the field trip. However, they expressed varying kinds of pre-lesson plans. Teacher 1 (3rd) wanted the pre-lesson plan to be an entry point as to what they would see. On the other hand, Teacher 2 (3rd) mentioned having specific content information so they could rebuild their background knowledge of the content area. Teacher 3 (K) mentioned specific activities that they would want to be provided within a pre-lesson plan.

“Suggestions of books to read, songs, and observational activities that can be done before they come.”

– Teacher 3 (K)

Teacher 2 (3rd), 3 (K) and 4b (Pre-K) all mentioned that the phrase “prior knowledge”. Teacher 2 (3rd) and 3 (K) wanted the pre-lesson plans to tap into the students’ prior knowledge and build upon it. Teacher 4b (Pre-K) indicated the students have sufficient prior knowledge. They wanted questions for the students to think about and questions to specifically ask the
students. Teacher 5a (Pre-K) wanted anything that the students can see visually and an activity that would allow them to be outside.

The teachers also desired more logistical information; as to what to expect when arriving to Duke Gardens. Teacher 5a (Pre-K) prepared the students with the guidelines and information about where they were going beforehand. Teacher 1 (3rd) would also agree with this statement. They wanted to prime the students for what they will see but also be given basic vocabulary of what the students needed to know before they attended the field trip. Teacher 1 (3rd) and Teacher 5a (Pre-K) and 5b (Pre-K) practiced the skills the students will need for the field trip as a preparation technique before they attended the field trip. Teacher 1 (3rd) did this to allow the students to think more critically during the school program, rather than be fascinated with ways to make observations or using the scientific tools.

**Teacher Observations of Duke Gardens Experience**

The responses relating to teacher observations of the Duke Gardens Experience were coded further under (a) Pacing and (b) Behavior of Students. Sub-section (a) was further separated into three sections (1) Physical Exertion and (2) Information Given and (3) Activities Done by Students.

**Pacing**

For this context, pacing related to how fast or slow and how long or short various aspects were of the guided school program lesson.

**Physical Exertion**

Overall the physical exertion on the students was the right amount for the various school programs. Teacher 3 (K) did find that the exertion level was too little for her students. Teacher 4a mentioned it was the perfect level of exertion because they all took naps that day. Teacher 1
took their students outside even with a drizzle and said that they are not sensitive to weather or walking, because they walk everywhere. Teacher 5b (Pre-K) would sympathize with Teacher 4a (Pre-K) in that, none of their students left crying when they finished the program.

“Even the kids with impulse issues, were not jumping out of their skin.”

-Teacher 5b (Pre-K)

Teacher 1 (3rd) appreciated the aspect that students were able to walk at their own pace and process at their own pace. Teacher 5b (Pre-K) stated that the students were not panting and were not exhausted at the end of the program.

Information Given

The school programs are conducted by docent volunteers who went through initial training and are consistently given opportunities to learn new ways in executing the lesson. Since this is the case, the amount of information given can vary depending on the student’s interest, the docent’s depth of knowledge in certain subjects, and when magic moments happen. Teacher 1 (3rd) was concerned about the various amounts of information given, while Teacher 3 (K) said the information given was too much for their kindergarten students. Teacher 4a (Pre-K) and 5b (Pre-K) both gave positive feedback relating to information given. They emphasized the age-appropriateness of the lesson.

[The program was] very much age and developmentally appropriate. [The docent] allowed enough time at the various stops.

– Teacher 4b (Pre-K)

They additionally mentioned how well the docents read the students on when to move on, but also allowing enough time to complete the various activities. Teacher 5b (Pre-K) mentioned that the field trip was the right length of time and the words used were very appropriate. Teacher 3 (K) stepped in a few times during the field trip to tell the docent when an activity went on for
too long or if there was too much talking, and information being given. They felt the information was not matching up to the age of the students. Teacher 2 (3rd) approved of the relaxed pacing and felt comfortable being in the docent’s hands because they believed the docents knew the students well.

Activities Done by Students

The overall feeling regarding the pacing of activities done by the students was that the activities were substantive. Teacher 2 (3rd) expressed the activities to be on level. Teacher 4b (Pre-K) mentioned the level of engagement by their students.

“Our kids were always engaged. I mean we all were. Their behavior was a testament to all the different components of the program that allowed them to be who they are in that environment.”

- Teacher 4b (Pre-K)

Teacher 4a (Pre-K) felt that the students were not “squirmy” because of all the walking involved and the amount of hands-on activities the students did. Teacher 5b (Pre-K) valued the limited number of activities. They mentioned that the activities were nicely paired down which allowed the students to process the information. Some of the activities done by the students included, interactive games, digging in the compost and mulch, planting a seed in a newspaper pot, looking at the carnivorous plants, and reading a content related story, just to name a few. There were enough activities that flowed well and held the attention spans of the students, said Teacher 5b (Pre-K).

Behavior of students

Teacher 3 (K), 4a (Pre-K), and 5a (Pre-K) described their students as excited about learning and more engaged during the field trip. Teacher 1 (3rd) saw no behavioral differences because environmental education is important at their school. Teacher 1 (3rd) found that she managed the students more when they are physically inside the classroom. They stated that small
things such as who sits where, who can touch first, and when things can be touched can become bigger issues inside. However, they expressed this was not the case when they were outside during the field trip. Teacher 4a (Pre-K) related the programmatic components of the field trip to the student’s behavior. They believed that the walking around, digging, and exploring in the compost were all engaging activities that provided the students the opportunity to be who they really are.

“Their behavior was a testament to all the different components of the program that allowed them to be who they are in that environment.”

– Teacher 4b (Pre-K)

Teacher 4b (Pre-K) mentioned little redirecting was necessary which allowed the experience to be less stressful on the teachers and the kids. Teacher 5a (Pre-K) said the arrival is the hardest part of the trip with the change in routine. Once the program began the students were ready to go, said Teacher 5a (Pre-K). They stated the students were more engaged and completely focused on everything during the field trip. Teacher 2 (3rd) spoke about students who have tactile sensitivity pushing themselves to touch a worm or touch dirt. They were willing to experience new things and leave their comfort zone. Teacher 5b (Pre-K) said although the experience was so new and different to them, the students were very engaged in the program.

**Moments**

Overall, the active and exploratory aspect of the school program were moments the teachers mentioned. Teacher 1 (3rd) stated that they enjoyed observing their students as they learned. Climbing on top of the compost and peeking over the fence gave the students a behind the scenes look, said Teacher 4a (Pre-K). Teacher 3 (K) recalled seeing a structure made out of trees in the Historic Gardens.

“The weaving, the Patrick Dougherty structure, on the field totally floored everyone. Totally human-made but totally made out of nature.”

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Teacher 2 (3rd) remembered seeing their students taking turns digging in the soil, holding the worms, and naming the turtles in the pond.

“Digging, they could have done that for a long time.”
- Teacher 4b (Pre-K)

Teacher 5b (Pre-K) recalled a student attempting to eat a worm, and saw students who changed their minds about touching the worms. Teacher 5a (Pre-K) expressed that the students were able to see a “real duck” in action.

“We were beginning to cross over the bridge and the students got so excited to see ducks swimming in the stream, going towards the pond; this was how the program started, so I knew we would have a good day.”
- Teacher 5a (Pre-K)

Teacher 2 (3rd) personally enjoyed the space just by walking around, being in a thoughtful space, and being out in nature. They also mentioned students running down the hill after lunch and naming the turtles in the pond (this occurred after the guided programming).

Expectations

The responses relating to teacher expectations were coded further under (a) Met and (b) Not Met. Met indicated that the teacher was pleased, and not met indicated that the teacher was disappointed.

Met

Teacher 2 (3rd) and 4b (Pre-K) indicated early on in their response to this question the quality of the docents. Teacher 4b (Pre-K) said they felt comfort in the leader from the beginning based on the docent’s balanced control of the group when they first arrived. Teacher 4a (Pre-K) mentioned that the docent set the tone right away. Teacher 4b (Pre-K) and Teacher 5a (Pre-K) were both impressed with the age-appropriateness of the school program.
“Pre-K is a different worm.”

– Teacher 4a (Pre-K)

The variety of experiences and approaches met the expectations of Teacher 2 (3rd), Teacher 3 (K) and Teacher 4a (Pre-K). Approaches such as physical interactions with nature, talking, looking, seeing visuals were found to be very fun and hands-on based on Teacher 2 (3rd).

Teacher 5a (Pre-K) felt that the children were fulfilled. Teacher 1 (3rd) mentioned that the students enjoyed being able to take something back from the field trip, which in this case was a newspaper pot with seeds from a collard plant.

Teacher 1 (3rd) said the expectations of the role of the chaperone were very clear. Teacher 4b (Pre-K) said the program was great from arriving to leaving. Teacher 4a (Pre-K) stated that the directions were very clear on where to meet, who to look for, and what time to be there.

Not met

The teachers provided very specific expectations that were not met. Teacher 3 (K) said there was too much talking during the program since they were kindergarten students. Teacher 4b (Pre-K) felt unprepared when arriving to the Gardens for their school program. They said they went into the program blindly due to the lack of coordination with the Education Program Coordinator. Since they knew Duke Gardens already, this gave them some comfort in knowing the place they planned to take their students.

The role of the teacher was an important aspect of expectations that were not met for Teacher 1 (3rd) and 2 (3rd). Teacher 1 (3rd) described a lack of standardization of content, expectations, and location. They found themselves unsure of the expectations placed upon the teacher and the students.

“The students also want to live up to the expectations, but sometimes they don’t know what the expectations are.”

- Teacher 2 (3rd)
They did not know when to step in and help or when to stand back. Teacher 1 (3rd) and 2 (3rd) expressed that the docents can have very different management styles compared to their management style. Having clear expectations of who says ‘yes’ and who says ‘no’ would have been beneficial to Teacher 1 (3rd). Teacher 3 (K) wanted to know what the docent’s expectations and boundaries are for the program, since boundaries are different for the docents and the teachers. They further state, that they would prefer for the docent to talk to the teacher about what to expect and what role the docent wants them to play. Teacher 5a (Pre-K) and 5b (Pre-K) did not provide a comment for this section.

**Curriculum Ties/Standards**

Overall, the information the teachers sought to be communicated during the school program was covered. Pre-K at the two independent schools do not have specific standards that they must adhere too. The philosophy of Teacher 5a (Pre-K) and 5b’s (Pre-K) school is “Learn through Play”. This means they are focused on hands-on and experiential learning. Their month of April theme was gardening and using descriptions such as feel, see, touch, and hear. Based on all the activities the students did during the school program, the teachers said that everything was covered for them. Teacher 4a (Pre-K) and 4b (Pre-K) rely on curriculum benchmarks for literacy, science, social studies, math, and foundations. The students were working on a soils project for almost 6 weeks. The teachers used the Dirt & Worms program to do provide a field experience that was outside of their school grounds.

Teacher 2 (3rd) also teaches at an independent school, where they solely use the NCSCS as a guide of what information to cover in each grade, but they do not have to adhere to it. The *Soil City* program covered the various soil topics she wanted their students to know. But field trip was used mostly by Teacher 2 (3rd) to enrich what the students learned in school.
Teacher 1 (3rd) and Teacher 3 (K), at the time of the program, taught in a charter school. Teacher 1 (3rd) strictly uses the NCSCS science strands to guide their projects and relies on the NCSCS in planning the field trip. The 3rd grade curriculum covers plants, life cycle of plants, and parts of a flower. The programs *Discovery Garden* and *Plant Power* covered the material needed for the students to complete the field work aspect of their project. Teacher 3 (K) mentioned that their students needed to learn about life cycles, nutrients, have writing and reading components, look at patterns and use observational skills. During the program, Teacher 3 (K) pointed out that the students used their observational skills, the docent read a book, and the students learned where food comes from and about different types of plants.

**Evaluating Student Learning**

The responses relating to how student learning was evaluated were coded further under (a) Post-lesson Plans, (b) Student Information Learned, (c) Methods, and (d) Student Takeaways.

**Post-lesson Plans**

Teacher 1 (3rd), Teacher 2 (3rd) and Teacher 4b (Pre-K) mentioned they were not able to fully recall the field trip, making it hard to connect with what happened. Teacher 4b (Pre-K) went onto say the students also needed help in recalling the experience.

> "As teachers we are trying to take it all in, manage the kids, monitor everything, and talk to parents to get off their phone. It is a lot! [Post-lesson plans] would be helpful in recalling the experience and helping the kids recall their experience."

- Teacher 4b (Pre-K)

The teachers wanted lessons that would help them extend the field trip into their classroom and think outside of the field trip, in relation to the subject area. Teacher 4a (Pre-K) and Teacher 5b (Pre-K) planned on using the post-lesson plans provided to help turn their creativity wheels regarding new ways for students to reflect on the field trip.
Teacher 3 (K) and Teacher 4b (Pre-K) had their students create a representation of what they learned. The parents came in to their school to see the work the students accomplished over the course of the project. Teacher 2 (3rd) and Teacher 3 (Pre-K) provided specific examples as to what they do in their classroom. Teacher 3 (K) asked students to make a book about worms, make stuffed worms, create their own worm compost bins, sing a worm song and do a worm dance. They wanted their students to celebrate everything they learned from their project, including what they experienced from their field trip. Teacher 2 (3rd) mentioned they extends their lesson by talking about erosion and weathering of soils, and ways their students can help the environment. Teacher 2 (3rd) wanted a type of assessment and a follow-up questionnaire that they can ask their students. Planting the seed in a newspaper pot became an extension for both Teacher 5a (Pre-K) and Teacher 5b (Pre-K). The students took care of their plant either inside or outside the classroom, depending on the teacher’s preference. Teacher 5a (Pre-K) created a class book based on the verbal responses of the students regarding their favorite part of the field trip. Additionally, the students drew a picture of their favorite part, which was added to the class book.

Student Information Learned

Teacher 3 (K), 4a (Pre-K), and 5b (Pre-K) agreed that the information they learned at Duke Gardens reinforced what they already knew.

Differences in reinforcement were found between the responses. Teacher 3 (K) said the students knew a lot before they came, but they heard it again in another environment and saw the results of worms all around them at Duke Gardens. Teacher 3 (K) went on to say that this reinforced the information since they were able to see everything on a more “real level”. Teacher
4a (Pre-K) found the student’s knowledge reinforced and applied during the field trip. The students were very familiar with the terminology and saw diagrams of soils.

“When they began digging with real tools they knew they were digging in the topsoil, and connected this to where life is sustained.”

– Teacher 4b (Pre-K)

The student knowledge was reinforced through comparison. Teacher 5b (Pre-K) mentioned the students compared their compost at school to the Duke Garden compost; which showed they remembered the things they did. Teacher 2 (3rd) simply said yes, the students learned the objectives of the program.

Teacher 1 (3rd) stated that they personally learned something new in terms of worms.

“I also learn from the experience.”

– Teacher 2 (3rd)

During the visit, the students were able to see differences in flowers by seeing them up close, said Teacher 1 (3rd). They saw differences in the stamen, the petals and the locations of these flower parts. Although the students of Teacher 4a (Pre-K) and 4b (Pre-K) knew a lot about soils, they saw different ways to compost, learned new information about decomposers and saw how soil affects water color.

Methods

In four out of five interviews, the teachers mentioned that the students shared to each other, in different ways, what they learned. This is one way the teachers evaluated what the students learned or took away from the field trip. Teacher 2 (3rd) admittedly said, assessing what they learned is the area they want to work on. Teacher 5a (Pre-K) said they sat in a circle and discussed what they saw, heard, did not like, liked, touched, etc. Through asking questions and the class book, Teacher 5a (Pre-K) assessed what the students gained from the experience.

Whereas, Teacher 1 (3rd), Teacher 3 (K), and Teacher 4a (Pre-K) and Teacher 4b (Pre-K), did a
project share on a presentation day by creating a representation. Teacher 3 (K) invited other classes, especially the older students to presentation day. They prepared the older students on how to be a good audience and what type of questions they should ask. The family members came in for the representations and presentation day in the classes of Teacher 1 (3rd), Teacher 3 (K), and Teacher 4a (Pre-K) and Teacher 4b (Pre-K).

Student takeaways

The students left having an increased excitement and engagement in the content they learned at Duke Gardens was a common thread found from the interviews. The students were excited about holding the worms. In turn they were more eager about the information they learned, said Teacher 1 (3rd).

“Students want to improve. They were telling me stuff about worms and were excited about composting which was eye opening.”

- Teacher 1 (3rd)

Teacher 2 (3rd) accounts that going to Duke Gardens expands the students’ world a little. They see new things in a different place and get to hear different perspective. Teacher 2 (3rd) believed going to Duke Gardens created a transference of knowledge to explore something in a different setting. Teacher 5a (Pre-K) stated that their students felt like they had ownership over the information. Connections were created in the student’s mind, according to Teacher 1 (3rd), Teacher 4b (Pre-K), and Teacher 5a (Pre-K). The students connected with the book that was read during the school program, said Teacher 4a (Pre-K). They also recalled what they saw at Duke Gardens by saying, “I remember that from Duke Gardens!” mentioned Teacher 5a (Pre-K). The students of Teacher 1 (3rd) realized pictures of flowers looked very different compared to seeing them in person, and that not all flowers look exactly the same. On the other hand, Teacher 3 (K)
mentioned that the kids never really said much about the guided aspect of the field trip. Rather the students talked about the unstructured activities of their day at the Gardens.

“Imagining themselves as worms as they walked through all the nooks and crannies of the Blomquist Garden—this is what they remembered.”

– Teacher 3 (K)

Teacher 1 (3rd) stated that the students used the information they knew to become better thinkers, learners, and questioners. They found that the students realized that all the answers were not available.

**Suggested Improvements from Teachers**

Over the course of the interview and when asked if the teachers had additional thoughts or comments, 4 out of the 5 interviews provided suggested improvements. These improvements related to logistics, content, publicity and programmatic aspects. Teacher 1 (3rd) suggested for the school programs to have four ideas or concepts that every group would learn about to ensure the groups all gained the same information. They always want their students to have something to make and take to help the students remember their experience. Lastly, Teacher 1 (3rd) wanted the process of the school programs to be more standardized allowing the program to feel more predictable. Teacher 3 (K) suggested the Education Program provide scholarships for low-income students to pay for the field trip. Incorporating more physical aspects in the program was an additional suggestion along with creating a program about bees and pollinators. Lastly, Teacher 3 (K) wants the field trip to feel more like an adventure. Teacher 4a (Pre-K) and Teacher 4b (Pre-K) suggested having a pre-lesson plan to explain more information to the kids. Additionally, having direct communication with the Education Program Coordinator any time after 3pm on certain days to allow easier communication was another suggestion by Teacher 4b (Pre-K). Teacher 5a (Pre-K) and Teacher 5b (Pre-K) suggested that the Education Program improve on publicizing themselves to different schools.
5. Project Discussion and Evaluation Recommendations

Based on my evaluation work of the materials and of the teacher perceptions, I have eight recommendations about the guided school programs for my client.

The Education Program should continue to develop pre-lesson plans for the participating teachers. The pre-assessment questions the docents asked the student at the beginning of the guided school program showed that the knowledge of the students varied. The pre-lesson plan has the potential to give the students base knowledge before attending the guided school program. Some of the docents wrote that some of the students mixed up the insect terminology, such as “pupa”, “cocoon”, and “cicada.” Pre-visit lesson plans will increase the likelihood that the students all have the same base knowledge of information when coming to Duke Gardens for the guided school program.

Furthermore, all the teachers interviewed mentioned various aspects of how they prepared their students for the field trip and how they prepared logistically for the field trip. All the teachers wanted pre-lesson plans that included, questions to ask students, hands-on activities, scientific skill-building activities, and content information. By providing the teachers with pre-lesson plans, the students will be exposed to information that they should know before attending the guided school program. This will provide the teacher and students with the proper information about what the students will learn during the guided school program at The Gardens.

Eshach (2007) recommends teachers conduct relevant scientific activities in their class before going to the fieldtrip, so students will build skills and background information to help them fully benefit from the new experience. All the teachers interviewed had their students build upon varying scientific skills before attending the field trip, such as observations, collecting data, and using scientific tools. Teacher 2 (3rd), specifically led a pre-lesson plan asking student collect
soil samples and conduct varying experiments with the soil, including soil art. While, Teacher 4a (Pre-K) and 4b (Pre-K) use any outdoor opportunity to provide their students with a learning experience in using their senses to observe the playground, the soil or trees nearby.

Based on the teacher interviews, the Education Program should provide teachers with the slideshow presentation before their class arrives for a guided school program at Duke Gardens. There are significant implications that accrue with teachers preparing for the field trips. The literature mentions the importance of teacher preparation before attending the field trip. The teacher should feel comfortable and less unfamiliar with the environment once arriving with the students. “If teachers prepare their students for the fieldtrip beforehand, the children will feel much more comfortable, while experiencing less anxiety from their exposure to the new situation, and as a result will be more willing to learn” (Eshach, 2007). The literature highly suggests sharing the purpose of the visit with the children before they visit and expressing expectations of the students beforehand (Eshach, 2007). Teacher 4b (Pre-K) mentioned that they wanted additional information about what to expect before they came. A suggestion that came from this was for Education Staff to have designated hours in which they are readily available to speak to a teacher on the phone after any questions they may have. I worked with the Education Program to create a slideshow presentation that includes logistical information in a visually appealing way and incorporated an observation activity.

The findings from the interviews with local teachers showed that the overall experience in attending a guided school program at Duke Gardens was important and beneficial to both the students and the teachers. “Field trips offer a unique opportunity for students to create connections, which will help them gain understanding and develop an enjoyment of learning” (Behrendt & Franklin, 2014). Some of the docents mentioned in the post-field trip reflection that
the students were engaged, enthusiastic and explored everywhere. From both the teachers’ and docents’ perspectives, the students enjoyed the various aspects of the field trip. Teacher 4b (Pre-K) mentioned that their students were always engaged and that the teachers were also too. The teacher went onto to further mention that since the students were very familiar with the terminology and the layers of soils, they were able to connect the information to what they were physically doing during the school program. Field trips that are outdoors offer a unique opportunity for students to develop increased perception, improved vocabulary and greater interest in the outdoors (Behrendt & Franklin, 2014). Teacher 4b (Pre-K) mentioned that during the school program their students mentioned words such as topsoil while they were digging into the topsoil at the Gardens.

Teacher 3 (K), Teacher 4a (Pre-K), Teacher 5a (Pre-K), wanted their students to be more immersed by going beyond their school environment, while the two 3rd grade teachers (Teacher 1 and 2) wanted their students to apply what they are learning in the classroom through their field experience. Teacher 1 (3rd) and Teacher 4a (Pre-K) made it clear that the visit is a learning experience and a time for them to ask more questions and take ownership of their learning. Overall the teachers want the students to be thinking critically and generating their own questions about the content. Teacher 1 (3rd) demonstrated this in their example of the students knowing what a pollinator was, but not knowing all the different types of pollinators.

The Education Program should continue to incorporate hands-on activities in their guided school program curriculum. Hofstein and Rosenfeld (1996) state that field trips can provide students with concrete experiences, allowing them to interact physically and manipulate objects that are not usually available in the formal science classroom. Teacher 1 (3rd) and Teacher 4b (Pre-K) mentioned experiential learning during their respective interviews. Experiential learning
is authentic, first-hand, sensory-based learning that includes activities such as exploring, touching, listening to, watching, and moving things (Behrendt & Franklin, 2014). After the Go With the Flow on-site program, a docent wrote on their post-field trip reflection form that the teacher was pleased with the hands-on experiments.

The Education Program should incorporate more scientific and realistic applications of the Go With the Flow experiments. From direct observations and docent reflections, improvements were necessary for the evaporation experiment activity. This school program occurred on a sunny, hot day which allows evaporation to occur at a faster rate. Additionally, the experiment does not accurately portray how hydrologists measure the evaporation rate of various surfaces. Moreover, the guided school programs are meant to be available for teachers at any point over the course of the year. The Education Program currently requested a current PhD candidate at the Nicholas School of the Environment to provide further feedback and improvements about the activities and discussion points for the lesson. These improvements and feedback will be incorporated and used in the future.

Based on the responses of Teacher 1 (3rd) and Teacher 2 (3rd), the teacher’s role during the field trip is an aspect of the Duke Gardens’ Education Program that should be addressed in future docent trainings. Alon & Tal (2016) wrote about some barriers to outdoor learning which includes the teacher’s role during a field trip. There is a need to clarify roles and responsibilities of classroom teachers and nonformal educators, so each person will know what is expected from the other during the field trip (Alon & Tal, 2016). They provided key factors that contributed to building successful collaboration: shared goals, shared language, and awareness of each other’s culture and perspective (Alon & Tal, 2016). Few studies have been conducted relating to the direct relations between teachers and the guides who are employed by the nonformal
organizations and institutions (Alon & Tal, 2016). They went on to say that teachers can play a meaningful role in the field trip within the social or cognitive aspects (Alon & Tal, 2016). The teachers can help make connections to what is being taught in school and to what the students experience every day (Alon & Tal, 2016). Teacher 1 (3rd) and Teacher 2 (3rd) specifically wanted to know what the specific boundaries of the docent leading the field trip, so they could provide the students and docent with a positive experience.

The Education Program should continue to encourage teachers to bring their classes on multiple visits to reduce the novelty effect and promote more in-depth learning. A potential barrier to learning occurs when students are placed in a new environment which will potentially hinder learning. To Teacher 3 (K), building a sense of trust with nature, curiosity and having the awe factor were three reasons they continued to have the kids being outside. Eshach (2007) states that a fieldtrip is always an irregular occurrence. Falk, Martin, and Bailing (1978) suggested that novel field trip situations lead to the students having an adaptation or adjustment process. Assimilation occurs when the learner already has a basic knowledge of what is around them, the new setting is assimilated into the previously existing structures (Falk et al., 1978). Whereas, accommodation may occur when the setting is completely novel. Formations of new structures and placing the new information into those structures are occurring at the same time.

“Field trips are not meant to be short-term teaching instruments. Students may acquire short-term learning, but without reinforcement from reflection or debriefing, the learning or interest development may only be temporary” (Behrendt & Franklin, 2014). This shows the importance of using post-lesson plans in the classroom after an experience such as a field trip. Eshach (2007) states that if teachers do not necessarily have explicit goals for the visit, they may have trouble connecting the experience to the classroom curriculum. The field trip is only one
aspect of the student’s representation, but the field trip experience provided students with more concrete knowledge to be able to complete summative evaluations, such as projects. Teacher 1 (3rd) expressed that the other teachers in their school would appreciate simple lesson plans that can easily be done in their classroom. Teacher 4a (Pre-K) specifically wanted post-lesson plans to help them personally to recall the information, to be a better resource for their students after the field trip.

Based on teacher responses, the Education Program should continue in the development of post-lesson plans to be sent to participating teachers at the same time as the pre-lesson plans. Nonformal learning may provide an opportunity to develop intrapersonal intelligence (Eshach, 2007). Teacher 5a (Pre-K) and 5b (Pre-K) found the importance of asking their students about the field trip and allowing them to draw their favorite part. Eshach (2007) stated, asking students questions such as, how they felt in the field and why? What parts they enjoyed and what parts they didn’t. What did they learn and how? provides the students the opportunity to develop their intrapersonal intelligence through self-reflection.

In completing the evaluation of the specific on-site programs, Go With the Flow and Bug’s Life and the evaluation of the guided school programs, the Education Program should conduct regular evaluations of the guided school programs. Based on these evaluations, the Education Program will be able to use the recommendations provided to improve the guided school programs.

6. Limitations and Future Work

There were various obstacles that occurred during the acquisition of data. A primary limitation was the involvement of the teachers. Due to the time constraints of teachers, this led to a lower number of teachers interviewed. This also led to a lower variety of teachers from
different school types. Additionally, the pre- and post-lesson plans of the specific curriculum were not able to be evaluated. A secondary limitation related to the times and scheduling of the guided school program, *Go With the Flow*, and the teacher interviews, because of the various persons involved in this study.

There is significant potential in enhancing this study. For future study, an outside researcher could conduct a long-term study to see the effects of attending either a school program or multiple school programs over the course of the school year. A more complete evaluation that included a long-term study with one or multiple kindergarten to twelfth grade classes would potentially give a more comprehensive outlook on the effectiveness of botanical gardens on children’s learning. In a future study, working with a public school could provide more insight into teacher-student interactions with field trips to the Duke Gardens. A meaningful and strong partnership is necessary between the school and Duke Gardens. From the administration, to the teacher(s), students and family members of the students at the school and with the Education Program staff. One obstacle is collaborating with schools and teachers to conduct a study of this magnitude. Through this future study, both qualitative and quantitative data can be obtained. Interviews of teachers, administration and students would provide a significant amount of data about the entire field trip experience. Whereas, student retention via projects, tests or homework, can provide more quantitative data. Analyzing this data together can determine the true effectiveness that the guided school programs at Duke Gardens have on the students who attend.

7. **Conclusion**

In summary, the Children’s Education Program should regularly evaluate the guided school programs; the teachers interviewed found multiple benefits in attending a guided school
program; this study provides a basic framework for evaluating nonformal education program; and, all in all, my client benefited from this project.

As has been noted, environmental education seeks to develop a world population that is aware and concerned about the environment, knowledgeable and motivated. In addition, for people of all ages to possess the skills to help find solutions to current problems and prevent new ones from occurring. Based on teacher observations, docent observation, and my direct observations of the students during the guided school program, learning at Duke Gardens potentially helped to foster a connection to the concepts taught. Overall, this exploratory study showed that through nonformal educational experiences at a botanical garden, students are more likely to be engaged and excited about learning about the environment.
8. Literature Cited

https://doi.org/10.1007/s11165-016-9531-0


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9. Appendix
Appendix 1
## Appendix 2

### Earth Systems, Structures and Processes

#### Essential Standard and Clarifying Objectives

8.E.1 Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans.

8.E.1.1 Explain the structure of the hydrosphere including:
- Water distribution on earth
- Local river basin and water availability

8.E.1.2 Summarize evidence that Earth’s oceans are a reservoir of nutrients, minerals, dissolved gases, and life forms:
- Estuaries
- Marine ecosystems
- Upwelling
- Behavior of gases in the marine environment
- Value and sustainability of marine resources
- Deep ocean technology and understandings gained

8.E.1.3 Predict the safety and potability of water supplies in North Carolina based on physical and biological factors, including:
- Temperature
- Dissolved oxygen
- pH
- Nitrates and phosphates
- Turbidity
- Bio-indicators

8.E.1.4 Conclude that the good health of humans requires:
- Monitoring of the hydrosphere
- Water quality standards
- Methods of water treatment
- Maintaining safe water quality
- Stewardship
Appendix 3

Go With the Flow
Program Length: 90 min

Materials:
- Clipboard
- Field Notebooks
- Containers to/for collect water
- Thermometers
- Paper cups
- Tape measurer
- Pencils
- Pipettes
- Colored pencils
- Paint brushes

Objectives – The students will:
- Explain the structure of the water distribution on earth, regionally and in the local river basin
- Use a float method to find the streams velocity
- Identify different infiltration rates using various land & path surfaces
- Know vocabulary related to the hydrosphere
- Examine how water is used in the Gardens, natural and human-made

Lesson Plan:
1. Welcome & Intro**: Rules and brief overview of lesson
2. Distribute clipboards & Field Notebooks to students. (Explain to the students what they will be using the field notebooks for)
3. Why is water important? To nature? To humans? To animals?
4. Review the water cycle:
   a. Precipitation (in various forms: rain, sleet, snow, hail, mixtures)- precipitation is how water is delivered to watersheds. Without precipitation, all water would eventually end up in the oceans
   b. Runoff to a lake or stream or infiltration into groundwater
   c. Evapotranspiration & evaporation (liquid to gas state)- much of the Earth’s evaporation takes place over the ocean
   d. Sublimation (solid to gas state), occurs in the mountains, reduces runoff because there is less snow to melt in the spring
   e. Condensation (gas to liquid state)- in some systems (e.g. cloud forests) this is the main source of water to the plants
   f. Freezing (liquid to solid state)- this is one way to store water in an area (e.g. glaciers which hold much of the world’s freshwater)
   g. Deposition (gas to solid state) ➔ then back to precipitation!
5. A watershed is the area of land where all of the water that falls in it and drains from it and goes to a common outlet. Duke Gardens is a local watershed among a bigger watershed, the Sandy Creek Watershed (4324 Acres- 4000 football fields). The topography (the arrangement of the natural and artificial physical features of an area into high and low areas) of the land will determine the direction and flow of water. Guide students to think about the slopes of the paths they will walk on.
   a. Based on what we talk about today, I want you all to be thinking where the destination of the water is within Duke Gardens. Where is the common outlet in the Gardens?
   b. Breakdown of percentages of water
1. 71% of Earth’s surface is water
   1. 97% of that is saltwater
   2. 3% is freshwater
      a. 77% of freshwater is frozen
      b. 23% is not frozen in lakes, rivers, groundwater

6. History of water management in the gardens
   a. The garden is within a 160-acre watershed
   b. Some of the land was repurposed (i.e. the woodland garden which used to be farm land).
   c. Natural and human-made plumbing (mention the drains & have students predict where the water might be flowing; what type of experiment could be done to find out this answer?).

7. The order of your activities will depend on the total number of groups and routes. Things to cover and potential locations include:
   A) Stormwater/Green infrastructure (millstone pond, North Pond, Welch Overlook, rain gardens)
   B) Stream Velocity (McNabb stream, Woodland stream, Japanese peace pond stream)
   C) Water Evaporation Rate (Fisher Amphitheater, terraces, sunny pond)
   D) Water filtration & Soils types (CBDG, Peace Garden House, prairie classroom)
   E) Drawing surface water flow on map (important: groundwater does not all flow based on surface topographic features) (any place the students can sit)

8. Ask students where they believe the common outlet of the Duke Gardens is at. The common outlet is the South Lawn. All the water in the gardens drains into the south lawn and onto other streams and creeks in Durham and eventually drains to New Hope Creek and eventually into Jordan Lake Reservoir.

9. Wrap-up**

Activities:
Before beginning the activity: Ask students to open their field notebooks and explain the scientific method briefly; provide students with the boundaries of the activity; divide the groups into 3-4 students/group and remind them to always stay with their group. After each activity, you can instruct students to mark an “X” on their map of their current location.

A) Green Infrastructure
   a. Explain stormwater
      i. Definition: Runoff that occurs when rain water falls onto impervious surfaces like roads, roofs, driveways and parking lots and does not soak into the ground.
      ii. Stormwater management is managing runoff from a storm, especially in urban areas with significant amounts of impermeable surfaces
   b. Garden Design
      i. Purposeful riparian vegetation/buffer to help filter out pollutants and slow down water going into the stream to slow down erosion.
      ii. The streams were put in a place that follows the natural direction of water flow. Humans are working with nature in this instance.
      iii. Some streams are recirculating (i.e. woodland stream, McNabb stream)
      iv. Other streams are filled from stormwater runoff from surrounding impervious surfaces (i.e. Duke Gardens main parking lot, medical center buildings, Duke’s central campus, and admissions building)
   c. Urban stream characteristics/syndrome
i. Ask students if they can spot streams that may be experiencing this syndrome (best example is in the iris stream across from Dawn redwood)

ii. Characteristics: the bank is vertically steep, exposed soil, closest vegetation is primarily tree cover, water surface is significantly below the bank

iii. “Flashiness”- urban streams are very flashy, which means they have very variable flow. After rainfall they tend to have a lot of flow very suddenly and then taper off, whereas streams with less impervious surface around them will not increase in flow so much or so quickly

iv. Some streams may look in good physically, however, chemically the stream may have hazardous (bad) chemicals which makes it unfit for drinking.

d. Types of infrastructure
   i. **Bio-swales**: vegetation based swales
   ii. **Rain gardens**: filled with wet & drought resistant plants
   iii. **Permeable surfaces/paving**: allows water to infiltrate
   iv. **Cisterns**: collects rainwater
   v. **Green roofs**: vegetation cover roof, helps to slow down the water before hitting the ground
   vi. **Riparian vegetation**: vegetation that is along the edges of a stream.

**B) Stream Velocity Activity**

a. In this activity, the students will use the float test method to determine the velocity of the stream. The float test method uses an object that floats to determine the velocity of a stream or river. Based on the length and width of the stream, students can figure out the velocity of the stream.

b. Each group receives **1 tape measurer**.

c. Let students know they have ___ minutes to conduct their experiments. (Write procedures down as a group)

d. The students can collect 3 of the same object that will float (i.e. leaves, gum balls, pine cones, mulch).

e. Using a tape measure, the students should measure/estimate the length of their starting point to their ending point and measure/estimate the width and depth of their stream.

f. One student should start the timer as soon another student drops one of the objects and it hits the water.

g. They should stop the timer when the object passes the ending point.

h. Repeat step “d” for the next 2 objects.

i. Students can then average (take the mean) of the times (in seconds).

j. Calculate the rate by dividing the length (distance) over time.

k. (optional) Calculate the discharge by multiplying velocity x stream width x stream depth
C) **Water Evaporation Rate Activity**  
   a. In this activity, students will have the opportunity to test how fast the water evaporates on different surfaces with varying degrees of sunlight. Instruct students that they can design their own experiments to test the water evaporation rate.
   b. Each group receives **2 pipettes, 3 cups, 1 thermometers, 1 paint brush.**
   c. Ask the students to find different surfaces (i.e. concrete, gravel, wood, bare soil, stone, plant leaf) with their groups within shade, sun or shady/sunny areas to conduct their experiment.
   d. Provide students with water in 3 cups. (Water will be provided to you in a container or you will need to scoop up water)
   e. Demonstrate to students how to use the pipette and when to start timing.
   f. Let students know they have ___ minutes to conduct their experiments.
   g. They can use their finger, paint brush or pipette to spread the water on the surface.
   h. Check the temperature readings last. (make sure thermometer is set upright)
   i. Based on the volume of water used in one spot, divide this by the time it took to evaporate (no water can be seen or felt).
   j. Alternatively: have several small pieces of Tupperware filled with different soil types, maybe one could have a small plant growing in it.
   k. Add water and weigh the whole thing.
   l. Record that weight, and then leave the Tupperware somewhere while the group works on the other experiments
   m. Come back and weigh it again. The difference between the two measurements is how much water has evaporated.

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**Discussion Points:**

- Variables of the experiment: precision & accuracy of experiment; interference of other objects in the stream, taking the average of 1 person’s time or each person/trial, rotating jobs changes the methodology, time limit if object gets caught and does not reach final destination
- The United States Geological Survey (USGS) collects streamflow data at more than 8,000 stream gauges nationwide. These stream gauges are a vital part of our infrastructure, just like bridges and roads. Durham County has 15 total stream gauges.
- **Hydrologist** measure discharge by measuring the depths and velocities (with a flowmeter below the surface of the water) at many points across the stream, and they do this when the water is at different heights. They use this data to construct a “rating curve”, or a relationship between water height and water discharge (e.g. in cubic feet per second). Most continuous monitoring sites then measure water depth, either through a float, a pressure conductor, or with radar, and calculate the discharge at each time point using their rating curve. Every stream has a different rating curve. Reliable stream flow data information is needed for many purposes: for flood warming and forecasts, drinking water management, hydroelectric power production, water quality standards, recreation, and preservation of aquatic habitats.
- The float method is also known as the area cross-sectional method. Hydrologists usually also measure the **depth** of the stream along with the width of the stream.
- **Streamflow velocity** can depend on many factors: stream bed type (rocky/rough or smooth/muddy/sandy); width; steepness; meandering or straight stream.
• Set a time limit (time frame) on how often to check the areas the students chose.
• Float around to each group and answer questions.
• Ask several groups what their results were and what conclusions did they make.

Discussion Points:
• Variables of experiment: the amount of water used in one area, the porosity of the surface used, how much the water was spread on the surface
• The sun drives the entire water cycle and evaporation is one of the main processes. The heat from the sun rises the temperature of the water and the surface. Once the water reaches the boiling point it evaporates water. The water molecules move and vibrate so quickly they escape into the atmosphere.
• Air temperature and land surface temperature can determine the rate of evaporation. Hotter land surface will lead to quicker evaporation rates.
• Some of the water falls seen throughout the garden are losing water due to evaporation as the water droplets change from one elevation to the next.
• **Humidity** (the amount of water vapor in the atmosphere) can also change the rate of evaporation. If we have a humid day, there will be less evaporation since the atmosphere is already saturated with so much water. On a less humid day, the evaporation rate will be much higher.
• Once the water (liquid form) changes into water vapor (gas form) what happens next? The water vapor condenses then freezes into a cloud.
• When trees take up water, some of this water evaporates off their leaves, this process is called transpiration. **Evapotranspiration** is the sum of the evaporation from the land surface plus the transpiration from plants. Another aspect of the water cycle and how the gardens is a watershed.
• A atmometer or evaporimeter measures evaporation rate.
• A bucket that weighs how much water comes in and out of a system is called a lysimeter.
• When hydrologists measure evapotranspiration in the field, they use either lysimeters or “Eddy Flux towers” – towers with instruments that measure concentrations of different gases like water vapor and carbon dioxide.

**This activity is not full proof since the water also could infiltrate into the ground before evaporating depending on the surface used**

D) Water Filtration & Soil Types Activity
a. In this activity, students will determine the permeability of different soils and paths that are found in the garden and measure the infiltration rate.

b. Instruct students that they will be conducting an experiment to figure out the infiltration rate of various surfaces and slopes of their choosing.

c. Each group receives 3 cups.
   o Ask each group to find various land surfaces or paths to test. Try on different slopes with different vegetation types.

d. Provide students with water in 3 cups. (Water will be provided to you in a container or you will need to scoop up water) In this science experiment, the control should be the same amount of water (tell students to mark a line in their cup for the consistent volume of water).
e. Tell students to spill the water onto their first surface and begin timing.
f. They should stop timing when they do not see the water anymore and the surface feels dry.
g. Let students know they have ___ minutes to conduct their experiments.
h. Instruct them to record their times in the field notebook.

Discussion Points:
- Variables of experiment: when to begin timing (when the first drop hits or when all the water is poured out); knowing when to stop timing on certain surfaces;
- **Permeable surfaces** allow water to percolate into the soil to filter out pollutants and recharge the groundwater to lift the water table (planting beds, gravel, mulched beds, grass).
- **Impermeable/impervious** surfaces are solid surfaces that don’t allow water to penetrate, forcing it to run off (ex: asphalt, concrete, stone, bricks, roofs).
- After a rain event, the water that reaches the land surface can either runoff the surface or infiltrate into the ground. This is dependent on the slope, vegetation, precipitation amount, type of surface, soil type, saturation of the soil.
- Vegetation and shallow slopes have a greater ability to allow water to infiltrate compared to steep slopes and bare land.
- The three main components of soil (clay, sand, silt) all have different permeability: clay (least permeable), silt (moderate), and sand (highly permeable). Water takes a longer time to pass through clay compared to sand.
- **Infiltration** is important to recharging our groundwater so that we can have drinking water and for farmers who use the water for agriculture in watering crops.
- **Bioremediation** is a treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non-toxic substances.
- The streams in the gardens allow for less nutrient buildup to occur with continuous flushing of water into the duck pond.

** This activity is not full proof since the water also could evaporate before infiltrating into the ground depending on the surface used- this is a complication that even professional hydrologists struggle with. Science is not always exact, often we use our best judgement**

E) **Map out surface water flow**

a. In this activity, students will be asked to draw the flow of water on the route they were taken on. They can do this by drawing arrows showing the flow direction and lines tracing the route on the map. They can color in the water features they saw in the Garden today as well. Students can write a “H” for the point of highest elevation and “L” for the point of lowest elevation they experienced.

b. Additionally, the students can hypothesize the flow direction of the surface water for the rest of the garden based on their observations.
Water Cycle Background Info

The sun drives the entire water cycle and is important to two main processes: evaporation and condensation. When the sun heats the surface of water, it evaporates and ends up in the atmosphere as water vapor. It cools and rises, becoming clouds, which eventually condense into water droplets. Depending on the temperature of the atmosphere and other conditions, the water precipitates as rain, sleet, hail or snow. Some of this precipitation is captured by tree canopies and evaporates again into the atmosphere. The precipitation that falls to the ground becomes runoff, which courses over the surface of the earth in streams. (Runoff also comes from snowmelt, which occurs when the sun and climate changes melt snow and ice.) Runoff can infiltrate the ground and accumulate, becoming groundwater. Permeability is a measure of the ability of a rock or sediment to transmit water or other liquids. Water does not pass through impermeable materials. A substantial amount of water is stored in permeable soil and rock underground. An aquifer is a large deposit of groundwater that can be extracted and used. Finally, runoff makes its way back into lakes and oceans, where it is again evaporated by the sun.

Figure 2 Source: https://water.usgs.gov/edu/
History of water at Duke Gardens

In the original plans for Duke University, most of the area that is now Duke Gardens was planned to become a big lake. A stream was to run from the lake to Duke Chapel. J. B. Duke’s original idea for West Campus was to have large fountains cascade down terraces into the ravine between the traffic circle and the main quadrangle in front of the Chapel. Funding for this plan ran out, so it was never developed. The site became a dumping ground for debris during construction of the Medical Center and West Campus. At the time, dumping was not a concern because everyone expected the debris to be covered with water when the lake was completed.

When the garden began, the main water focus was on controlling flooding. As early as the summer of 1934, heavy summer rains caused the small stream that ran through the garden to overflow its banks and washed away many of the flower beds that were on the south lawn. Flooding remained a problem until the construction of the Asiatic Pond. Since its completion, the pond has held excess water (which used to flood the gardens after heavy rains). Water flows into the pond from parking lots and roads as far away as the Durham Freeway. More and more of the 160 acres of the stream’s watershed are being paved over, increasing the amount of water entering the stream.
Water Features in Each Garden

General Info
❖ Use 4-6 million gallons per year for everything—irrigation, building use, drinking fountains
❖ 15-20% of garden is automatically irrigated
❖ Blomquist and Asiatic are entirely manual

Doris Duke Garden
❖ Doris Duke Garden
  o Virtue peace pond contains 60,000 gallons of water. The water is dyed black to discourage algae growth (black-water systems are natural in many places in the world). The water lilies help ensure the well-being of the pond. They provide shade to keep the water temperature down. They also provide shelter for fish that live in the pond. Lilies help absorb nutrients that are in the water.

Charlotte Brody Discovery Garden
- 7500 gallons of cistern storage—plumbed together, gravity feed one another (one at higher elevation, lower one buried 5-6 feet underground), 1 inch of rain on barn roof=750 gallons, used to irrigate veggie beds, green handle spigots=cistern water, blue handles=city water
- Bio-swales are the little dams along the walkway in the garden. They slow down and capture rain water as it goes downhill. This encourages absorption rather than runoff. These plants can tolerate wet and dry conditions. Water collected here is gradually absorbed into the ground, filtering pollutants (bioremediation) and preventing flooding.
- Rock lined ditches collect and slow water, and channel water to rain gardens, which slow it down
- Rain garden located near the entrance if often dry, but captures run off that is channeled down from the hill. Water collected here percolates into the ground and replenishes the groundwater. It filters pollutants. The plants are native and do well in both dry and wet conditions. This also helps to prevent runoff.

Woodland Garden Pond/Stream
- Soil is clay (natural liner), slow percolation
- Weir in stone wall is for overflow
- Welch overlook rain garden- filled with gravel to help drainage from path
- Stormwater ravine, lined with clay which percolates water slowly
- Woodland bridge is the longest bridge
- The creek bed at the headwater of the stream is usually dry→ catches and directs runoff from rain

W.L. Culberson Asiatic Arboretum
- Culvert: a tunnel carrying a stream or open drain under a road or railroad
- North pond is a catch basin for runoff. It captures rain from surrounding impervious surfaces→ 4 pipes positioned along north edge feed runoff into the pond. This pond is a forebay (a small pond situated before a larger pond). It lets silt settle out before it flows on. Water is directed from here to the Asiatic pond (i.e. the duck pond).
- Japanese garden waterfalls are a stand-alone, recirculating water feature.
- Water from large pond is pumped up to the peace viewing shelter and flows back down to the large pond
- Asiatic pond- the dam was installed to control flooding. The 1.5 acre pond captures runoff from the garden, roads, and parking lots nearby. The weir (the square brick structure) helps to regulate
water level. When the water level gets as high as the openings at the top of the weir, it spills down into the weir and is slowly directed downstream through pipes.

- North pond → large pond → iris stream → south pool

**Historic Gardens**
- Cherry Allee has little dams on both sides of the walkway. These act as speed bumps to slow down the flow of rainwater as it goes down the hill.
- Roney fountain is a recirculating fountain.
- Rose garden uses drip irrigation.
- Koi Pond has a cistern below that is 25,000 gallons. This is filled from the large pond and it irrigates terraces and south lawn.
- Waterfalls at rock garden uses recycled water.
- All of the water in the Gardens drains to the reflecting pool. Underground pipes that run under the terrace patio by the fish pond carry water into the pool. The pool has a spillways that runs under the bridge at Flowers Drive and onto Jordan Lake.
- Large Square pipes under low terrace patio pipes water onto the reflecting pool.
- Cistern at terraces holds 24,000 gallons of water that is used for irrigation.

**H. L. Blomquist Garden**
- Overall water here is recycled.
- The mill stone pond was hand dug and is fed by a small natural spring. A spring is where the groundwater reaches the surface. The water close to the pavilion is deep.
- The McNabb stream and mill stone pond are not connected water sources.
- Bog Garden (a wetland that gets water only from rain and snow) → note the Venus fly traps and pitcher plants.
- Sunny Pond (36th parallel latitude) and Bog is fed water from runoff of the nearby administration building. Overflow runs down the lawn around the reflecting pool.
- Wildlife Garden waterfall was made from what used to be stairs. The spring uses recycled water.
- McNabb stream follows path of stormwater from parking lot. The stream recirculates and can take on new stormwater.
## Appendix 4

### Go With the Flow

**Program Length:** 90 min

**Materials:**
- Clipboard
- Field Notebooks
- Containers to/from collect water
- Thermometers
- Paper cups
- Tape measurer
- Pencils
- Pipettes
- Colored pencils
- Paint brushes

**Objectives:** The students will:
- Explain the structure of the water distribution on earth, regionally and in the local river basin.
- Use a float method to find the streams velocity.
- Identify different infiltration rates using various land & path surfaces.
- Vocabulary related to the hydrosphere.
- Examine how water is used in the Gardens, natural and human-made.

**Lesson Plan:**
1. **Welcome & Intro**: Rules and brief overview of lesson.
2. Distribute clipboards & Field Notebooks to students. (Explain to the students what they will be using the field notebooks for.)
3. Why is water important? To nature? To humans? To animals?
4. **Review the water cycle**:
   a. **Precipitation** (in various forms: rain, sleet, snow, hail, mixtures)
   b. **Runoff** to a lake or stream or **infiltration** into groundwater
   c. **Evapotranspiration & evaporation** (liquid to gas state)
   d. **Sublimation** (solid to gas state), occurs in the mountains
   e. **Condensation** (gas to liquid state)
   f. **Freezing** (liquid to solid state)
   g. **Deposition** (gas to solid state) → then back to precipitation!
5. What is a watershed? An area of land where all the water that falls in it goes to a common outlet.
   a. **Topography** (the arrangement of the natural and artificial physical features of an area) of the land will determine the direction and flow of water.
   b. Based on what we talk about today, I want you all to be thinking where the destination of the water is within Duke Gardens. Where is the common outlet in the Gardens?
6. History of water management in the gardens

#### Activities:

- **Stormwater/Green infrastructure**
- **Stream Velocity**
- **Water Evaporation Rate**
- **Water filtration & Soils types**
- Drawing surface water flow on map (important: groundwater does not all flow based on surface topographic features)

8. The common outlet is the South Lawn. All the water in the gardens drains into the south lawn and onto other streams and creeks in Durham and eventually drains to New Hope Creek and eventually into Jordan Lake Reservoir.

9. **Wrap-up**

### A) Green Infrastructure

- **Explain stormwater & stormwater management**
  i. Definition: Runoff that occurs when rain water falls onto impervious surfaces like roads, roofs, driveways and parking lots and does not soak into the ground.

- **Garden Design**
  i. Purposeful riparian vegetation buffer to help filter out pollutants and slow down water going into the stream to slow down erosion.
  ii. The streams were put in a place that follows the natural direction of water flow.
  iii. Other streams are filled from stormwater runoff from surrounding impervious surfaces.

- **Urban stream characteristics/syndrome**
  i. Ask students if they can spot streams that may be experiencing this syndrome.
  ii. Characteristics: the bank is vertically steep, exposed soil, closest vegetation is primarily tree cover, water surface is significantly below the bank.

- **Types of infrastructure**
  i. Bio-swales: vegetation based swales
  ii. Rain gardens: filled with wet & drought resistant plants
  iii. Permeable surfaces/paving: allows water to infiltrate
  iv. Cisterns: collects rainwater
B) Stream Velocity Activity
   a. Students will use the float test method to determine the velocity of the stream. The float test method uses an object that floats to determine the velocity of a stream or river. Students can figure out the velocity of the stream.
   b. Each group receives 1 tape measure.
   c. Let students know they have ___ minutes to conduct their experiments. (Write procedures down as a group)
   d. The students can collect 3 of the same object that will float (i.e. leaves, gum balls, pine cones, mulch).
   e. Using a tape measure, the students should measure/estimate the length of their starting point to their ending point and measure/estimate the width of their stream.
   f. One student should start the timer as soon another student drops one of the objects and it hits the water.
   g. They should stop the timer when the object passes the ending point.
   h. Repeat step “f” for the next 2 objects.
   i. Students can then average (take the mean) of the times (in seconds).
   j. Calculate the rate by dividing the length (distance) over time.

C) Water Evaporation Rate Activity
   a. Students will have the opportunity to test how fast the water evaporates on different surfaces with varying degrees of sunlight. Instruct students that they can design their own experiments to test the water evaporation rate.
   b. Each group receives 2 pipettes, 3 cup, 1 thermometers, 1 paint brush.
   c. Ask the students to find different surfaces (i.e. concrete, gravel, wood, bare soil, stone, plant leaf) with their groups within shade, sun or shady/sunny areas to conduct their experiment.
   d. Provide students with water in 3 cups. (Water will be provided to you in a container or you will need to scoop up water)
   e. Demonstrate to students how to use the pipette and when to start timing.

D) Water Filtration & Soil Types Activity
   a. Students will determine the permeability of different soils and paths that are found in the garden and measure the infiltration rate.
   b. Instruct students that they will be conducting an experiment to figure out the infiltration rate of various surfaces and slopes of their choosing.
   c. Each group receives 3 cups.
      o Ask each group to find various land surfaces or paths to test.
      Try on different slopes with different vegetation types.
   d. Provide students with water in 3 cups. The control should be the same amount of water (tell students to mark a line in their cup for the consistent volume of water).
   e. Tell students to spill the water onto their first surface and begin timing. They should stop timing when they do not see the water anymore and the surface feels dry.
   f. Let students know they have ___ minutes to conduct their experiments.

E) Map out surface water flow
   a. Students will be asked to draw the flow of water on the route they were taken on. They can do draw arrows showing the flow direction and lines tracing the route on the map. They can color in the water features they saw in the Garden today as well. Students can write a “H” for the point of highest elevation and “L” for the point of lowest elevation they experienced.
   b. Additionally, the students can hypothesize the flow direction of the surface water for the rest of the garden based on their observations.
Map of Duke Gardens and Major Water Features
Partner(s) Scientist:

Title:

Procedures/Materials:

Hypothesis/Hypotheses:

Data/Results:

Conclusion:

Additonal Notes:
Partner Scientists(s):

Title:

Hypothesis/Hypotheses:

Procedures:

Data/Results:

Conclusion:
Additonal Field Notes:
Additional Field Notes:
Appendix 6

Go With the Flow

What is a watershed? Why is the water cycle important? Students will learn about the hydrosphere and how Duke Gardens is a watershed within an urban city.

Grade Level: 8th Grade

Standards: North Carolina Essential Standards

- 8.E.1: Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans
  - 8.E.1.1: Explain the structure of the hydrosphere
  - 8.E.1.3: Predict the safety and potability of water supplies in North Carolina based on physical and biological factors.
  - 8.E.1.4: Conclude that the good health of humans requires: monitoring of the hydrosphere, water quality standards, methods of water treatment, maintaining safe water quality, and stewardship.

Lesson Objectives:
The students will be able to:
- Explain the structure of the water distribution on earth, regionally and in the local river basin
- Learn vocabulary related to the hydrosphere
- Understand water quantity and quality issues nationally and globally.

Key vocabulary words:
- Legacy effects
- Hydrosphere
- Watershed/river basin
- Stormwater
- Impermeable/impervious
- Infiltration
- Hydrological cycle
- Groundwater

Essential Questions:
- Where does all the water flow?
- How does surrounding surfaces affect where water flows?
- How do human impacts affect watersheds?
# Table of Contents

## Pre-Activities:
The following activities are available resources for you to use before attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

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## Post-Activities:
The following activities are available resources for you to use after attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

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## Independent Practice:
The following activities are available resources for you to use after attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

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## Online Resources:
The following activities are available resources for you to use after attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

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<td>D. Where the River Meets the Sea</td>
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<td>E. What’s your water footprint?</td>
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Pre-Activities
A Historical Look
Approx. Activity Time: 45-60 minutes

Description: In this activity, students will have the opportunity to read through the United States Environmental Protection Agency History. The first part can be done as a whole class activity or as an individual or in groups. The second part is research/poster that can be done as an individual or in groups.

Materials:
- Poster
- Markers

Technology Needs:
- Computer
- Projector
- Website: https://www.epa.gov/history#timeline & https://www.epa.gov/history/historical-environmental-topics

Activity:
1. Read through the EPA historical timeline slideshow to understand the importance of this governmental agency.
2. Instruct students to research one of the water-based environmental policy or acts.
3. Once finding the information, ask students to create a poster about the act or policy with pertinent information & drawn/computer images, including:
   a. Name of policy or act
   b. Date of policy or act
   c. Purpose
   d. What issue does it address?
   e. Stewardship/Action steps for Citizens
North Carolina River Basins*

Description: This activity allows students to use a booklet created by North Carolina Department of Environment and Natural Resources to learn a spectrum of information in regards North Carolina’s River Basins. This is a good introductory lesson for talking about river basins and other aspects about water resources.

Materials:
- Handout
- Website: http://www.eenorthcarolina.org/Documents/RiverBasin_pdfs/final_web_BO OKLET.pdf

Technology Needs:
- Computer (or print out the booklets)

Activity:
1. Provide students with the handout and the booklet/website.
2. Instruct students to read through the booklet and the answer questions.

Additional questions can be added or changed based on your preference. The following are a baseline of questions.

*Components from:
**River Basin Activity**

**Purpose:** To become familiar with North Carolina’s river basins.

**Directions:** Answer the questions below based on the map and booklet provided.

**Questions:**

1. What 4 river basins are found only in NC?
   
   a. __________________________
   
   b. __________________________
   
   c. __________________________
   
   d. __________________________

2. Which river basin is the biggest?
   
   __________________________

3. Which river basin has the least amount of land inside of NC’s borders?
   
   __________________________

4. Which river basin is the furthest to the east?
   
   __________________________

5. Which river basin is the furthest to the west?
   
   __________________________

6. Where do the rivers in the river basins appear to flow (i.e. where do they dump out)?
   
   __________________________

7. How many river basins appear to stretch down into South Carolina? _________
   They are: __________________________

8. Which river basin do we live in here in south Charlotte?
   
   __________________________

9. Why might South Carolina sue the city of Charlotte over its water usage & pollution?
   
   __________________________

10. Why are there so many more river basins in the western part of NC than in the eastern part of NC?
    
    __________________________
Figure 3 Source: http://www.eenorthcarolina.org/riverbasins.html
**Water Features Map Pt. 1**

*Approx. Activity Time: 60 minutes*

Description: In this activity, students will be creating a map of different water features within a river basin/watershed. They will need to draw the features found in the handout and include definitions of the items as well.

Materials:
- Poster/Butcher Paper
- Water Features Map Handout
- Markers, Colored pencils, crayons, pens
- Printer paper

Activity:
1. Pass out the poster/butcher paper.
2. Explain to the students the instructions from the Water Features Map Pt. 1 handout.
3. Ask students to show an initial draft of their feature placement.
4. Handout coloring and writing materials to the students.

*See handout for complete activity instructions.*
Water Features Map Pt. 1

In groups/by yourself you will be making a map of a variety of ocean, shoreline, and surface water features. You can design the map how you wish, but you must include and label each of the features and a definition for each one (the definition may be written by each feature or else along the sides).

The drawings and descriptions should be clear, legible, and well-thought out. You should do a rough sketch beforehand to make sure you all your features are well spaced out. The drawing of each feature should represent what the actual feature (although we do not expect everyone to be great drawers); for instance, you should not just write “estuary” where a river meets the sea, but should instead have some sort of bay or lagoon where fresh and salt water can mix. Likewise, a “meandering” stream should be in a flat area and watershed divides should be along ridges.

Be creative! You are encouraged to give the different features names. Do not, however, add in any human constructions (except those listed), such as roads or buildings, although we may add some at a later date.

Features to include:
You may have more than one of any of the features. The ocean part should take up less than a third of your map.
(next to each feature on this sheet (one per group) write the initials of the person(s) primarily responsible for that one)

- _____River (at least one major one)
- _____Smaller streams (at least six, including at least three that are tributaries of the river, at least one should be meandering)
- _____Watershed divides –generally on ridges (draw dotted lines for the watershed of each stream & remember that every land surface is part of a watershed and drains to a stream)
  - _____Beach
  - _____Sea stack
  - _____Estuary
  - _____Bay
  - _____Lagoon
  - _____Barrier islands
  - _____Groin
  - _____Breakwater
  - _____Seawall
  - _____Floodplains
  - _____Stream banks
  - _____Lake
  - _____Pond
  - _____Reservoir
  - _____Delta
  - _____Swamp
  - _____Marsh
Post-Activities
Taboo! Hydro Style

Approx. Activity Time: 15-30 minutes

Description: In this activity, students will have the opportunity to play Taboo! using vocabulary words related to the hydrosphere. This activity is intended to be done in groups playing against each other.

Materials:
- 1 set of Hydrosphere Taboo! cards/group
- 1 Timer/group

Pre-Activity:
1. Reformat cards to fit landscape as seen below.

![Image of Taboo! cards]

2. Print sets out for the number of groups you wish to have.
3. Laminate the cards if wanted for future use.
4. Cut out each individual card.
5. Read Taboo! rules for reference, if needed.

Activity:
1. Provide students the rules of Taboo! and the topic of the game.
2. Give each group a timer.
3. Instruct the students that they are trying to get through as many cards until time is up (usually 20-30 seconds).
4. Once their time is up, the leftover cards go to the next group.
### Hydrosphere Taboo

<table>
<thead>
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<th>Infiltration</th>
<th>Groundwater</th>
<th>River</th>
</tr>
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<tbody>
<tr>
<td>— headwater</td>
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<td>— Earth</td>
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<td>— permeable</td>
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<th>Rain Garden</th>
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<tr>
<td>— flow</td>
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<td>— pass</td>
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<tr>
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<td>— plants</td>
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<td>— precipitation</td>
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<td>— wet</td>
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<td>— dry</td>
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<td>Soil</td>
<td>Water</td>
<td>Sustainability</td>
<td>Snow</td>
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<td>♦ clay</td>
<td>♦ H₂O</td>
<td>♦ Green</td>
<td>♦ Ice</td>
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<tr>
<td>♦ sand</td>
<td>♦ chemistry</td>
<td>♦ Resources</td>
<td>♦ Cold</td>
</tr>
<tr>
<td>♦ silt</td>
<td>♦ drink</td>
<td>♦ Generation</td>
<td>♦ Fall/falling</td>
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<td>♦ underground</td>
<td>♦ rain</td>
<td>♦ Long</td>
<td>♦ Mountains</td>
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<th>Stewardship</th>
<th>Evaporation</th>
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<td>♦ Water</td>
<td>♦ Trash</td>
<td>♦ Help/helping</td>
<td>♦ Condensation</td>
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<tr>
<td>♦ Flow</td>
<td>♦ Oil</td>
<td>♦ Action</td>
<td>♦ Water vapor</td>
</tr>
<tr>
<td>♦ Impermeable</td>
<td>♦ Air</td>
<td>♦ Poster</td>
<td>♦ Gas</td>
</tr>
<tr>
<td>♦ Land</td>
<td>♦ Water</td>
<td></td>
<td>♦ Air</td>
</tr>
</tbody>
</table>
Soil Drainage & Water Infiltration

Approx. Activity Time: 30 minutes

Description: In this activity, students will have the opportunity to determine the infiltration differences based on the soil type. This is a hands-on scientific experiment that will take additional set-up time.

Materials:
- Soil: clay, silt, sand (& gravel) /group
- 4 Plastic (to-go sauce) cups/group
- 1 Measuring cup/ group
- Paper towel
- Water
- Small empty containers
- 1 timer/ group

Pre-Activity Set-up:
1. Poke a pencil tip size whole on the bottom of the plastic cups (this will allow the water to infiltrate)
2. Cut paper towel into small enough squares to fit into plastic cup.

Activity:
1. Instruct students that they will be conducting an experiment to determine which soil has higher permeability/faster infiltration rate.
2. Based on your student’s readiness level, ask students to gather their group’s supplies or separate out the supplies beforehand.
   a. Each group should have 4 plastic cups, water or a water source, 1 measuring cup, each type of soil, and at least 4 paper towel squares, 1 empty container, a timer
3. Students will need to place the paper towel square on the bottom of the plastic cup, then add one soil into the same plastic cup. Repeat for each type of soil.
4. For each soil type, ask students to measure out the same amount of water to pour onto the soil in the plastic cup.
5. Instruct students to begin timing once the water is poured. Record the time for seeing the first water droplet drop into the empty container. Additionally students can record how long the water takes to infiltrate completely/partially through the soil.
6. Based on this, students should order their soil types in order based on permeability.

*Below you will find a sample table for students to record their data.*

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Time (s) (how long to see the first water drop in the container)</th>
<th>Total Infiltration Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Water Features Map Pt. 2

Approx. Activity Time: 60 minutes

Description: In this activity, students will be using the same map from Water Features Map Pt. 1 and will now include human impacts. They will need to draw on the human impact and explain the environmental issue.

Materials:
- Water Features Map Pt. 1
- Water Features Map Handout
- Markers, Colored pencils, crayons
- Paper

Activity:
5. Pass out the students’ maps from Water Features Map Pt. 1.
6. Explain to the students the instructions from the Water Features Map Pt. 2 handout.
7. Provide/Ask students for examples of environmental issues that could spur from certain types of changes to the natural environment.
8. Handout coloring and writing materials to the students.
9. If time permits, ask students to present their maps to the class and point out human impact features.

See handout for complete activity instructions.
Water Features Map Part II: Human Impacts

Using your map from last time, you will draw in the following artificial features and discuss the environmental impacts they make. You can design them how you wish, but you must include and label each of the features and a description of the environmental impact of each (the description may be written by each feature or else along the sides).

For example, if you are drawing a gas station with a leaky underground storage tank, you will a) draw the gas station, b) explain the environmental issue, and c) draw in where the effects of the gas station could be noticed (e.g., in the groundwater, perhaps showing up in a well).

Be creative! You are encouraged to give the different features names.

Features to include:
You may have more than one of any of the features (next to each feature on this sheet (one per group) write the initials of the person(s) primarily responsible for that one)

- Wells (some to show the impacts of over-pumping of wells and some to show polluted water from other sources).
- Septic Tanks
- Gas stations with leaky underground storage tanks
- Coal ash
- Farms with fertilizers
- Farms with pesticides
- Dead zones
- Eutrophication
- Chemical pollution from factories
- Dams
- Garbage
- Oil leakage on land
- Oil pipeline breaking
- Oil tanker spill/drilling spill
- Subsidence due to groundwater overpumping
- Leaky sewers
Independent Practice

Description: The following are handouts, worksheets, and assignments that can be used for independent practice at home or in class.
Newspaper Articles:

The following are newspaper articles that discuss different water quality and quantity issues in the United States and abroad. These can be assigned as homework readings, warm-up, or independent time:

5) https://www.nytimes.com/2016/05/04/opinion/indias-water-crisis.html
Water! Water! Water!
### Word Bank:

<table>
<thead>
<tr>
<th>Surface Water</th>
<th>Well</th>
<th>Alluvial fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed</td>
<td>Wetland</td>
<td>Delta</td>
</tr>
<tr>
<td>Water table</td>
<td>River</td>
<td>Lake</td>
</tr>
<tr>
<td>Infiltration</td>
<td>Pollute</td>
<td>Springs</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Carrying capacity</td>
<td>Artesian</td>
</tr>
<tr>
<td>Aquifer</td>
<td>Discharge</td>
<td>Karst</td>
</tr>
<tr>
<td>Stream banks</td>
<td>Oxbow</td>
<td>Unsaturated</td>
</tr>
<tr>
<td>Meander</td>
<td>Permeability</td>
<td>Porosity</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>Saturated</td>
<td>Geysers</td>
</tr>
</tbody>
</table>

### Across

2. The ability of a stream to transport material
4. This type of soil is above the water table; contains air in pores
6. Areas underground where groundwater exists in sufficient quantities to supply wells or springs.
7. An area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions, as swamps, bogs, fens, marshes, and estuaries.
9. The ground bordering the stream on each side
13. The ability of rock or sediment to let fluids pass through its open spaces or pores
15. A bend or curve in a stream channel caused by moving water is called a
16. Heated water emerges as hot springs or ________.
17. A ________ is the triangular deposit that forms where a stream enters a large body of water
18. This type of well that will produce water without pumping due to the pressure of the water
21. The land area from which surface water and runoff drains into a stream, channel, lake, reservoir, or other body of water; also called a drainage basin.
22. The blocked-off meander becomes an ________ lake (which eventually dries up).
24. The upper surface of the zone of saturation; the upper surface of the groundwater.
25. To make dirty or contaminate
26. Landscape underlain by a limestone cavern system

### Down

1. The process by which lakes become rich in nutrients from the surrounding watershed, results in a change in the kinds of organisms in the lake.
3. In dry regions, mountain streams commonly flow down narrow valleys onto broad, flat valley causing the stream to drops its sediments as a fan-shaped deposit
5. The measure of the volume stream water that flows over a particular location within a given period of time.
8. A depression in the surface of materials of a landscape that collects and hold water
9. This type of soil is below the water table; all spaces are filled with water
10. All water on the surface of the Earth including lakes, ponds, rivers, oceans, streams, puddles, and runoff
11. Water found under the ground, in aquifers and between soil particles
12. Water-bearing capacity of subsurface rock
14. The gradual downward flow of water from the surface into the soil.
19. A large natural stream of water emptying into an ocean, lake, or other body of water and usually fed along its course by converging tributaries.
20. Where the groundwater reaches the ground this may result
23. Underground water can be reached through this__________

Crossword Puzzle Key

Surface Water All water on the surface of the Earth including lakes, ponds, rivers, oceans, streams, puddles, and runoff
Watershed The land area from which surface water and runoff drains into a stream, channel, lake, reservoir, or other body of water; also called a drainage basin.
Water Table The upper surface of the zone of saturation; the upper surface of the groundwater.
Infiltration The gradual downward flow of water from the surface into the soil.
Groundwater Water found under the ground, in aquifers and between soil particles
Aquifer Areas underground where groundwater exists in sufficient quantities to supply wells or springs.
Well Underground water can be reached through this__________
Wetland An area that is saturated by surface or ground water with vegetation adapted for life under those soil conditions, as swamps, bogs, fens, marshes, and estuaries.
River A large natural stream of water emptying into an ocean, lake, or other body of water and usually fed along its course by converging tributaries.
Pollute To make dirty or contaminate
Carrying Capacity the ability of a stream to transport material
Discharge The measure of the volume stream water that flows over a particular location within a given period of time.
Streambanks the ground bordering the stream on each side
Meander A bend or curve in a stream channel caused by moving water is called a _________.
Oxbow The blocked-off meander becomes an ________ lake (which eventually dries up).
Alluvial fan In dry regions, mountain streams commonly flow down narrow valleys onto broad, flat valley causing the stream to drop its sediments as a fan-shaped deposit
Delta A _____ is the triangular deposit that forms where a stream enters a large body of water
Lake A depression in the surface of materials of a landscape that collects and hold water
Eutrophication The process by which lakes become rich in nutrients from the surrounding watershed, results in a change in the kinds of organisms in the lake.
Permeability The ability of rock or sediment to let fluids pass through its open spaces or pores
Porosity Water-bearing capacity of subsurface rock
Springs Where the groundwater reaches the ground this may result
Artesian This type of well that will produce water without pumping due to the pressure of the water
Karst Landscape underlain by a limestone cavern system
Geysers Heated water emerges as hot springs or _________.
Unsaturated This type of soil is above the water table; contains air in pores
Saturated This type of soil is below the water table; all spaces are filled with water
Journey through the Water Cycle

Directions: Write a story about your journey through the water cycle as a water molecule. This should be written in the first person. Be sure to include the following terms and as you move through the water cycle show through your descriptions that you understand the meaning of each of the terms. Include the places you go, and the changes you make as you travel through the cycle. Show what you know and be as creative as possible.

Key vocabulary: condensation, evaporation, precipitation, temperature, heat, gas, liquid, solid, runoff, transpiration, sublimation, groundwater

You can choose from the following options to describe your journey through the water cycle (choose only one):

- Narrative
- Comic strip
- Screenplay
- Song
- Poem
- Other (approved by teacher first)
## Water Cycle Journey Rubric

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Cycle Process</strong></td>
<td>Your water molecule travels through the entire water cycle in the correct order.</td>
<td>Your water molecule travels through the entire water cycle, but not in the correct order.</td>
<td>Your water molecule travels through part of the water cycle in the correct order.</td>
<td>Your water molecule travels through part of the water cycle, but not in the correct order.</td>
</tr>
<tr>
<td><strong>Transitions</strong></td>
<td>The transition between each stage of the water cycle is clearly explained in detail. The author explains how the water molecule travels from one stage to the next.</td>
<td>The transition between each stage of the water cycle is explained. The author mentions how the water molecule travels from one stage of the cycle.</td>
<td>The transition between each stage of the water cycle is mentioned. The author mentions how the water molecule travels from one stage of the cycle.</td>
<td>The transition between each stage of the water cycle is not mentioned. The author does not mention how the water molecule travels from one stage of the cycle.</td>
</tr>
<tr>
<td><strong>Vocabulary Word Usage</strong></td>
<td>All vocabulary words from the water cycle are used correctly in the story.</td>
<td>75% of the vocabulary words from the water cycle are used correctly in the story.</td>
<td>50% of the vocabulary words from the water cycle are used correctly in the story.</td>
<td>25% of the vocabulary words from the water cycle are used correctly in the story.</td>
</tr>
<tr>
<td><strong>Overall Grammar</strong></td>
<td>0-3 errors found in the story.</td>
<td>4-7 errors found in the story.</td>
<td>7-10 errors found in the story.</td>
<td>More than 10 errors found in the story.</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td>The story contains many creative details and/or descriptions that contribute to the reader's enjoyment. The author has really used their imagination.</td>
<td>The story contains a few creative details and/or descriptions that contribute to the reader's enjoyment. The author has used their imagination.</td>
<td>The story contains a few creative details and/or descriptions, but they distract from the story. The author has tried to use their imagination.</td>
<td>There is little evidence of creativity in the story. The author does not seem to have used much imagination.</td>
</tr>
<tr>
<td><strong>Use of class time</strong></td>
<td>Used time well during each class period. Focused on getting the project done. Never</td>
<td>Used time well during each class period. Usually focused on getting the project done and never distracted.</td>
<td>Used some of the time well during each class period. There was some focus on getting the project done but occasionally distracted others.</td>
<td>Did not use class time to focus on the project OR often distracted others.</td>
</tr>
</tbody>
</table>

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Newspaper Opinion Editorial

Each student will pick an environment hazard and write a two to three paragraph newspaper article about the issue. This is an opinion article to be submitted to Herald Sun, News & Observer or the Triangle Tribune. Be specific – for instance, make up names for the people who you quote, but be sure to explain what happened and why the issue matters.

Pointers:
- Make one single point.
- Put your main point at the beginning.
- Offer specific recommendations.
- Provide a graphic (drawn or computer image).
- Make your ending a winner!
Online Resources

Description: The following are resources that be used for warm-up, guided practice, or independent practice.

1. The Blue Traveler: A Trip through the Water Cycle
   a. Students will be able to take an interactive journey through the water cycle. Adobe flash player needed and headphones for sound effects.
   b. Website: http://www.discoverwater.org/blue-traveler/

2. Explore Watersheds
   a. An interactive activity about watersheds that guides students to learning key vocabulary words and human impacts on the watershed. Adobe flash player needed and headphones for sound effects.
   b. Website: http://www.discoverwater.org/explore-watersheds/

3. Discover Water: The Role of Water in Our Lives
   a. Students can watch a video demonstrating a watershed.
   b. This website also has other interactive activities about the importance of water in nature and earth stewardship. Adobe flash player needed for some activities and headphones for sound effects.
   c. Website: http://www.discoverwater.org/videos/explore-watersheds/

4. Where the River Meets the Sea
   a. A combination of a video and activities about estuaries and human impacts on river and ocean conditions. Headphones and Adobe flash player are needed.
   b. Website: http://games.noaa.gov/oscar/welcome.html

5. What’s your water footprint?
   a. A calculator that helps to estimate your water use both direct and indirect forms of water use.
   b. Website: http://www.watercalculator.org/
Appendix 7

Bug’s Life

What is an insect? Where do they live? Students will learn about and compare the life cycles of garden insects by studying them in their natural habitat.

Grade Level: 2nd Grade

Standards: North Carolina Essential Standards
- 2.L.1: Understand animal life cycles
  - 2.L.1.1: Summarize the life cycle of animals
  - 2.L.1.2: Compare life cycles of different animals

Lesson Objectives:
The students will be able to:
- Name the parts of an insect’s anatomy
- Describe how to identify an insect
- Describe an insect life cycle

Essential Questions:
- Why are bugs important to our earth’s ecosystem? What are ways we can disturb bugs’ habitats? Why are life cycles important?

Key vocabulary words:
- Entomologists
- Exoskeleton
- Invertebrates
- 3 body parts- Head, Thorax, Abdomen
- Compound eyes
- Metamorphosis- complete and incomplete
- Anatomy
- Insect
# Table of Contents

## Pre-Activities:
The following activities are available resources for you to use before attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

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<th>Lessons</th>
<th>Page #</th>
</tr>
</thead>
<tbody>
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<td>D. Paper Plate Butterfly Life Cycle</td>
<td>4-5</td>
</tr>
<tr>
<td>E. Life-stage Insect Cards</td>
<td>6-9</td>
</tr>
<tr>
<td>F. Insect Matching</td>
<td>10-12</td>
</tr>
</tbody>
</table>

## Post-Activities:
The following activities are available resources for you to use after attending this program at Duke Gardens. Additionally, you will find additional online resources and independent practice that can be used in the classroom or at home.

<table>
<thead>
<tr>
<th>Lessons</th>
<th>Page #</th>
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<tbody>
<tr>
<td>D. Bug Research Poster</td>
<td>14-15</td>
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<tr>
<td>E. Insect Parts Foldable</td>
<td>16-17</td>
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<tr>
<td>F. Create your own insect</td>
<td>18-19</td>
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## Independent Practice:

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<tr>
<td>E. Butterfly Life Cycle Labeling</td>
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<tr>
<td>F. Insects Word Search</td>
<td>22</td>
</tr>
<tr>
<td>G. Insect Anatomy Labelling</td>
<td>23</td>
</tr>
<tr>
<td>H. Dragon Fly Life Cycle</td>
<td>24</td>
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</table>

## Online Resources:

<table>
<thead>
<tr>
<th>Lessons</th>
<th>Page #</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Life Cycle Game (Sheppard Software’s Life Cycle)</td>
<td></td>
</tr>
<tr>
<td>G. Butterfly Life Cycle Labelling</td>
<td></td>
</tr>
<tr>
<td>H. Butterfly Life Cycle Animation</td>
<td></td>
</tr>
<tr>
<td>I. Honey Bee Life Cycle Video</td>
<td></td>
</tr>
<tr>
<td>J. Animal Life Cycles</td>
<td></td>
</tr>
</tbody>
</table>
Pre-Activities
Paper Plate Butterfly Life Cycle*

*Approx. Activity Time: 45 minutes*

Description: This activity the students will have a visual representation of the butterfly’s life cycle using a paper plate, images and labeling of the stages.

Materials:
- 1 paper plate/student
- Markers, colored pencils, crayons
- Glue sticks
- Scissors
- 1 set of pictures/student: egg, larva or caterpillar, chrysalis, adult butterfly

Activity:
1. Distribute the paper plates to each student. **Depending on your student’s readiness level, you can pre-draw the four equal quadrants or demonstrate with the students during the activity**
2. Guide students in drawing the four stages in the butterfly life cycle or instruct students to cut and paste the 4 stages in the proper quadrant:
   a. Upper right quadrant: Egg
   b. Bottom right quadrant: Larva or caterpillar
   c. Bottom left quadrant: Chrysalis
   d. Upper left quadrant: Adult butterfly
   **Note:** Remind students that the butterfly is an insect and must have the correct amount of legs and body parts. Instruct students to label their pictures by the stage name.
3. Then have students draw arrows showing the direction of the life cycle.

Life Stage Cards*

Approx. Activity Time: 50 minutes

Description: This activity allows students to compare different life cycles of frogs, butterflies, and dragonflies. This activity can be done individually or with groups of 3-4 students.

Materials:
- 1 set of Life stage cards/student or 3-4 students
- Cardstock paper (or laminate the cards)
- Color construction paper
- Scissors
- Glue

Technology Needs:
- Computer
- Projector
- **if available: 1 computer/student or groups of students with headphones to individually listen to video

Activity:
1. Distribute one copy of the Life Stages Cards handout to each individual or group
a. Assign each person in the group a different animal represented in the handout: frog, dragonfly, or butterfly.
2. Cut along the dotted lines to separate the cards.
3. Have students watch this video: https://unctv.pbslearningmedia.org/resource/tdc02.sci.life.cyc.metamorph/metamorphosis-change-of-plans/#.WOEcNfkrK00
4. Then arrange the Life Stage Cards in the correct order to show the life cycle of their animal (make sure they arrange the cards in a circle).
5. Instruct group members to explain the life cycles of the different animals to each other by discussing their similarities and differences.
6. You can have students glue down the cards to a piece of colored paper or if cards are laminated or on card stock, can be reused again for practice.

* Components drawn from:
Frog
Dragonfly
Insect Matching*
Approx. Activity Time: 20 minutes

Description: This activity allows students to label insects and place pictures next to the names of the insects. The activity can be used as a warm-up activity, guided practice, independent practice, or as an assessment (depending on the needs for your students).

Materials:
- 1 matching handout/student
- 1 set of insect pictures/student
- Scissors
- Glue stick
- Marker

Activity:
1. Pass one handout per student and one set of pictures per student
2. Instruct students to cut out each insect individually in a square or a circle.
3. Insect Name:
   a. Top left- cicada
   b. Top right- bee
   c. Middle left- butterfly
   d. Middle right- beetle
   e. Bottom left- praying mantis
   f. Bottom right- wasp
4. Next steps:
   a. You can provide the students with the insect names and as a class identify which insect picture matches. The students can then write the name of the insect in the box then glue the picture next to it.
   b. You can provide the students with a word bank and allow students to identify the insects on their own by writing the name and gluing their respective picture.

* Components drawn from:
Google search: clip art bee, cicada, butterfly, beetle, praying mantis, wasp
Insect Matching

<table>
<thead>
<tr>
<th>Insect Name:</th>
<th>Picture:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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Post-Activities
Bug Research Poster*

Description: The goal of this activity is for the students to use the information they learned and create an informational poster about one insect. This activity can be done individually or within a group.

Materials:
- Construction paper (brighter colors work best)
- Markers, crayons, colored pencils
- Scissors
- 1 research poster handout/student or 1/group of 2-3 students
- Books about different types of insects

Technology needs:
- Computer

Activity:
1. Pass out to each student or group of students, one insect research handout.
2. Instruct students choose their favorite insect or assign an insect to the student/group.
3. Based on available resources, allow students to research their insect to answer the questions on the research handout and to use information they learned from the field trip.
4. Ask students to cut out each of the squares and circles.
   a. Instruct students to glue down their squares and circles onto construction paper.
   b. Or,
5. Ask students to take their handout and glue it onto construction paper.

* Components drawn from:
Insect Parts Foldable*

* Approx. Activity Time: 60 minutes

Description: This activity the students will create a foldable that dissects the three parts of an insect. Each part the students will write important facts (the amount is up to you) about the part of the insect.

Materials:
- Construction paper (brighter colors work best)
- Markers, crayons, colored pencils
- Scissors
- White board markers/chalk

Activity:
1. Pass out 1 construction paper per student.
2. Demonstrate to the students to fold their paper “hot dog” style (the paper should be long)
3. Instruct students to then carefully cut 3 equal parts out of ONLY the top flap of their paper. ** Depending on your student’s readiness level you can pre-fold or pre-draw the equal lines or also pre-cut each of the three parts**
4. Based on what is available in your classroom, show the students as a group the three parts of an insect.
5. Instruct students to write on the top of each flap, the parts in order from left to right: **Head—Thorax—Abdomen**
6. On the other side of the flap, the students can write the following facts:
   a. The insect’s head has a pair of antennae, and a pair of compound eyes. Compound eyes have many lenses for each eye. This provides them with very good eyesight.
   b. The thorax contains the legs for walking, swimming, jumping or digging. The thorax may also have wings for flying.
7. The abdomen contains many body organs, such as the heart, respiratory system, digestive system, and reproductive system. Underneath each flap, the students should draw each body part separately with the proper characteristics i.e. legs, wings, compound eyes, antennae, etc.

* Components drawn from:
Google search: clip art insect body parts
Create Your Own Insect*

Approx. Activity Time: 30 minutes

Description: This activity allows the students to use the information that they learned to create their own insect using the characteristics that define an insect.

Materials:
- 1 Create your own insect handout/student
- Markers, crayons, colored pencils

Activity:
1. Pass out the create your own insect handout to each student.
2. Review the three main parts of an insect and other specific characteristics about insects:
   a. **Head—Thorax—Abdomen**
   b. The insect’s head has a pair of antennae, and a pair of compound eyes. Compound eyes have many lenses for each eye. This provides them with very good eyesight.
   c. The thorax contains the legs for walking, swimming, jumping or digging. The thorax may also have wings for flying.
   d. The abdomen contains many body organs, such as the heart, respiratory system, digestive system, and reproductive system
3. Read through the instructions written on the Create Your Own Insect handout.
4. Continue to reiterate that their insect must only have six legs and must have the three body parts.

* Components drawn from:
Create Your Own Insect

Read the facts below about insects. Then create your own insect.

All insects have the following body parts:

- **Head** at the front of the body
- **Thorax** in the middle of the body
- **Abdomen** at the back of the body
- **Six Legs** (3 legs on each side of the thorax)
- **Two antennae**
  attached to the head
- **Two eyes** on the head
- Some insects also have **wings**.

**Directions**: Create your own insect. Include all the body parts listed above.
Independent Practice

Description: The following are handouts, worksheets, and assignments that can be used for independent practice at home or in class.
Butterfly Life Cycle Labeling

eggs  caterpillar  chrysalis  hatching  butterfly

* Components drawn from:
https://www.teacherspayteachers.com/Product/Butterfly-Cross-Curricular-UnitCommon-Core-Aligned-1237587
Insects

ant  cocoon  grasshopper  moth
bee   cricket  horsefly  praying mantis
beetle  dragonfly  insect  six
butterfly  firefly  ladybug  termite
cockroach  flea  mosquito  termite

* Components drawn from:
http://bogglesworld esl.com/insect_ worksheets.htm
Insect Anatomy

Word Bank
abdomen
antennae
head
legs
thorax
wings

* Components drawn from:
https://www.google.com/search?q=insect+anatomy+labeling&rlz=1C1GCEA_enUS759US759&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjbu2I6vve9AhXo1IMKHV5pI7gAUIgB

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Want more cool critters? Please visit www.NatureGifts.com for other complete LIFE kits containing all sorts of fascinating critters.
Online Resources

Description: The following are resources that be used for warm-up, guided practice, or independent practice.

6. Life Cycle Game (Sheppard Software’s Life Cycle)
   a. Provides step by step placement of a frog, butterfly and birds’ life cycle stage.
   b. Website: http://www.sheppardsoftware.com/scienceforkids/life_cycle/games.htm

7. Butterfly Life Cycle Labelling
   a. Students will identify and label the stages by dragging and dropping onto picture.
   b. Website: https://www.turtlediary.com/game/butterfly-life-cycle-labeling.html

8. Butterfly Life Cycle Animation
   a. Students learn about the different stages of butterfly life cycle with an animated lesson and practicing with simple exercises.
   b. Website: https://www.turtlediary.com/game/butterfly-life-cycle.html

9. Honey Bee Life Cycle Video
   a. A 10-minute video that goes over honey bees’ life cycle, honey bee hives and insect life cycles.

10. Animal Life Cycles
    a. A slideshow that covers life cycles of different animals.
Appendix 8

Bug's Life - 2nd Grade (February 2016)

Insect Anatomy & Identification, pp. 1-2
Insect Life Cycles, pp. 3-4
Program Length: 1-2 hours

Materials:
- Bugs Are Insects book/laminated pages
- sponges, straws, clothespins
- compound eyes
- hand lenses
- life cycle songs
- containers to collect insects for a closer look
- clipboards
- insect Explorer/Final Buzz sheet
- vocabulary cards
- life cycle cards
- pencils
- bug boxes with bugs

Objectives – The students will:
- name the parts of an insect's anatomy
- describe how to identify and insect
- describe an insect life cycle
- look for insects in the garden
- work in a group to identify insects

Lesson Plan:
1. Welcome & Intro**: Rules and brief overview of lesson
2. Introduction
   Today we are going to be entomologists.
   - What does that mean?
   - How do you identify an insect?
3. Read (Show) some of pages 4-15 from Bugs are Insects by Anne Rockwell
4. Insect anatomy activity and song-20 minutes
   Review:
   - How can you identify insects?
   - How are they different from us? Compare and contrast.

Vocabulary & Information:
- Entomologists - someone who studies insects
- Invertebrates - do not have an internal backbone like humans
- Exoskeleton - backbone, skeleton is on the outside of their body
- Insect Body Parts
  - head
  - thorax
  - abdomen
  - 2 antennae
  - 6 Legs
  - mouth
  - compound eyes
  - Some have wings
  - Some insects eat plants (herbivores) and some eat other insects (carnivores)
  - They have specialized mouth parts to help them eat.
  (Use sponges, straws and clothespins to demonstrate different kinds of specialized mouths)
   Sponges represents the absorbing mouth of
   - Flies
   Straws represent the sucking mouth of
- butterflies,  
- moths  
- honeybees  
Clothespins represent the chewing mouth of  
- beetles,  
- ants  
- dragonflies  
- caterpillars  
- All insects have **compound eyes.**
  - Pass out compound eyes for students to share and look through; collect them once everyone has had a turn.

**Song:** *(to the tune of “Head, Shoulders, Knees and Toes”)*
Head, thorax, abdomen, abdomen and 6 legs  
Head, thorax, abdomen, abdomen and 6 legs  
Antennae, mouthparts, compound eyes,  
Head, thorax, abdomen! (And 6 legs!)

5. **Life cycle activity and song (20 min)**
- Insects’ bodies change in life stages, called **metamorphosis.** Imagine if you were a crawling worm, then zipped up inside a sleeping bag, to emerge one day with wings on your back!
- Students might not know there is more than 1 kind of insect life cycles- **complete and incomplete metamorphosis.** We will demonstrate 2 examples using our bodies.

**Complete metamorphosis** - *ex: Butterflies, mosquitoes, beetles, bees, ants, wasps)*
- **Egg**- Students scrunch down into a ball  
- **Larva** - Eat food to get enough energy to transition to adult stage- *(called caterpillar for butterflies)*
  - Students stand and hold both hands in front of mouth palms facing out, wiggling fingers and saying munch, munch, munch  
  - Larvae expand and molt their skins 4-5 times as they grow- can grow up to 100 times their original size!
- **Pupa**- Resting stage- *(called cocoon for moths & chrysalis for butterflies)*
  - Students stand up straight with arms held down at sides and close to their bodies  
- **Adult** – Stage to find a mate, wings to fly to help you out  
  - Flap arms slowly pretending to pump blood into expanding “wings,” then dry out “wings”, gradually extending arms and flapping more vigorously before “flying” away

**Incomplete metamorphosis** - *ex: Dragonfly, mayfly and other aquatic insects, cicada, grasshopper)*
- **Egg**- Students scrunch down into a ball  
- **Nymph** - Students stand and hold both hands in front of mouth palms facing out, wiggling fingers and saying munch, munch, munch, then burst out of skin (molt) by moving hands quickly up above their heads  
- **Repeat nymph stage multiple times**- sing or chant, “Eat, eat, eat, molt – expand- repeat!”  
- **Adult** - Students hold arms out to side and bent slight; flap arms slowly to dry out “wings”, gradually extending arms and flapping more vigorously before flying (walking around) away

**Optional Life Cycle Game:** Using body motions above, play “Metamorphosis.”
- Each child starts as an “egg” or their chosen insect with complete metamorphosis (butterfly, bee, ant, etc.)  
- To advance to the next stage, play “paper, rock, scissors” with another “egg.” The winner becomes a “larva,” the loser stays an egg.  
- The “larva” then finds a larva partner, plays “Paper, rock, scissors,” the winner advances to pupa. The loser stays a larva.
• Pupas then find a partner and play, winner advances to adult and flies around- can find a “mate” and “lay eggs,” starting over again as eggs to play again.
• Can also be played with incomplete metamorphosis
• Sing life cycle song (See Double Exposure Lesson Plan)

6. Exploration (20 min)
• Go into the garden to observe insects.
• Suggested locations:
  o Discovery Garden
  o 7-tiered pagoda lawn in the Asiatic Arboretum
  o Terraces
  o Pollinator Garden
  o Wildlife garden in Blomquist
  o Fall webworms on cherry trees- Cherry Allee
  o Water insects- Sunny pond, Peace pond
  o White Garden
  o Roll logs in Story Circle- beetles, ants, etc
• Give each student a clipboard with Insect Explorer/Final Buzz sheet and a pencil to sketch or describe the insects they see.
• Regroup to report on observations.

**Optional:**
• bring containers to carefully collect insects for a closer look
• bring bug boxes with bugs in them to use if no insects are found

7. Review (10 min)
• Final review of insect anatomy and any new vocabulary words

8. Wrap-up**
Appendix 9

**Structures and Functions of Living Organisms**

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<tr>
<th>Essential Standard</th>
<th>Clarifying Objectives</th>
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| 2.L.1              | Summarize the life cycle of animals:  
|                    | • Birth  
|                    | • Developing into an adult  
|                    | • Reproducing  
|                    | • Aging and death  
| 2.L.1.2            | Compare life cycles of different animals such as, but not limited to, mealworms, ladybugs, crickets, guppies or frogs. |

**Evolution and Genetics**

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<thead>
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<th>Essential Standard</th>
<th>Clarifying Objectives</th>
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<td>2.L.2</td>
<td>Identify ways in which many plants and animals closely resemble their parents in observed appearance and ways they are different.</td>
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<td>2.L.2.2</td>
<td>Recognize that there is variation among individuals that are related.</td>
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Appendix 10
Docent Post-Field Trip Reflection:

1. What was your overall experience during the school program today?

2. What information did the students know more about? What information did the students know less about?

3. What type of questions did the students ask throughout the program? Please provide specific examples if possible.

Circle one of the following and provide comments based on your response.

4. Were the students able to answer your pre-assessment questions correctly? If not, what answers did they provide?

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<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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Comments:

5. Did the students seem knowledgeable about the subject?

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<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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Comments:
Appendix 11

Date: _______________ Program: ________________________

Docent Name/s: ______________________________________

Please write student responses below:

Pre-Assessment Questions

1) What is an insect?

2) What are the characteristics of an insect?

3) What are examples of an insect?

4) What is a life cycle?

Pre-Assessment Questions

1) What is an insect?

2) What are the characteristics of an insect?

3) What are examples of an insect?

4) What is a life cycle?
Appendix 12
Dear __________ (Teacher Name),

At Duke Gardens, we work to continually improve the school programs we offer. Our goal is to align our program content with your curriculum so that a visit to Duke Gardens is an extension of your classroom.

This semester, we are working with Duke graduate student, Katrina Herrera, who is conducting research on the benefits of outdoor learning for her master’s project. She is looking for teachers who have brought their students to Duke Gardens to share some information about their experience in an interview with her. This is a chance for you to give feedback about the values you see in outdoor learning, as well as improvements that can be made to your field trip experience at Duke Gardens. If you are available to talk with Katrina for 30-45 minutes before September 22, please reply as soon as possible to Katrina’s email.

Katrina will provide you with the questions beforehand. During the interview, she will ask about your experience, your students’ experience and any observations you saw. She can meet you at your school or at another location such as a cafe or the library. We look forward to hearing from you soon and thank you for all that you do!

More from Katrina:
During the 2015-2016 academic year, I was in the Master of Arts in Teaching program in which I completed a 27-week internship in two public schools in Durham. In August 2016, I began my second master’s program at the Nicholas School of the Environment. In this program, we are tasked with completing a Masters Project (MP). My MP involves the Education Program at Sarah P. Duke Gardens on Duke University’s campus. For my two part project, I first created a new middle school program on the Watershed of Duke Gardens and for my second part, I am seeking feedback from teachers who attended a program at Duke Gardens.

Thanks for considering our request—we know this is a busy time of year!
Appendix 13

Teacher’s Name:
Teacher’s Grade Level:
Number of years of teaching:
School Program:

Introduction: My name is Katrina Herrera and I am a Duke Graduate student in the Nicholas School of the Environment. I am working on my masters project which entails conducting research for the Education Program at Sarah P. Duke Garden to continually improve the school programs that are offered at the Gardens. I am speaking with teachers who attended a school program with their class at Duke Gardens and seek to hear experiences, observations, and improvements that can be made as well. Your answers will be beneficial to the Education Program at the Gardens for their future programming. This interview will take about 45 minutes to an hour and I will ask you a series of questions. I would like to retain your name and affiliation, so that Kavanah, from Duke Gardens, could contact you for future clarification, if that is ok? Also, I would like to record our interview so that I can provide you with my undivided attention during our conversation now, and I will also then be more accurate in my report too, if that is ok?

Questions:

Section A

I see that you came to duke gardens on ______ day for ______ school program,

1. Have your classes been here more than once?
2. Why did you decide to come back again?
3. Why did you choose to take your class on a field trip specifically to Duke Gardens?
4. Have you and/or your classes been to Duke Gardens for more than one program? Why did you decide to come back again?

I understand planning a field trip is a lot of work.

5. Tell me why you chose to provide your students with this outdoor education experience?
6. Why did you choose to take your class on a field trip specifically to Duke Gardens?

Section B
Based on your most recent scheduled class visit to Duke Gardens,

7. I am interested in timing of the visit compared to class time on the content. Did you bring your class to the Gardens for the field trip before the students learned the curriculum, in the middle of the students learning the curriculum, or after the curriculum was already taught?
8. Can you suggest some areas of the North Carolina Standard Course of Study the field trip covered?
9. What areas of your curriculum did the field trip cover?

Section C

The Education Program at Duke Gardens is in the process of developing pre- and post-lesson plans for the school programs, including ones in which you participated in.

10. Would you be interested in pre-lesson plans that you could use in your classroom before visiting Duke Gardens?
   1. It would be an entry point as to what they would be knowing
      a. If yes, describe what activities would be most beneficial?
      b. If no, why is this the case?
11. Would you be interested in post-lesson plans that you could use in your classroom after your class’s visit to Duke Gardens?
    a. If yes, describe what activities would be most beneficial?
    b. If no, why is this the case?

Because these were not available when your class attended the school program at Duke Gardens, I am interested in knowing whether or not...

12. …you spent any time with the class preparing for the field trip ahead of time?
    a. If yes, can you tell me more about what you did?
    b. If not, can you tell me whether you think you would in the future? What would allow this to be a possibility for you?
13. How much time did you have or take out for preparations?

Section D

14. Based on your last visit, how was the pace of the program, in terms of information provided?
15. What about the activities done by the students?
16. Was the level of physical exertion on the students too much, too little, or the right amount? Why do you say that?
17. How prepared did you feel in knowing what to expect when arriving to Duke Gardens?
    a. With what aspects did you feel most comfortable?
    b. With what aspects did you feel less comfortable?
Section E

We are interested in learning more about the potential changes in your students during the program and even afterwards as well.

18. Did you find that the Duke Gardens program your class attended was beneficial for you and/or for your students?
   a. If yes, can you describe the benefits?
   b. If not, can you reflect on why or what would have made a better program for you?
19. Based on your observations of your last visit, what behavioral observations of your students did you find interesting from being in a non-formal setting, at the Gardens, compared to the formal setting, in your classroom?
20. Can you tell me what you think the students took away from the program?

We hoped that the students left knowing more about __________, based on the objectives of the program.

21. Do you think that they did? Can you describe reasons for your opinion?
22. What types of methods did you use to determine what the students learned or took away from the field trip?

Section F

23. Based on your last visit, what aspects of the program met your expectations?
24. What aspect of the program did not meet your expectations?
25. What is a memorable moment you have from your last visit?
26. Did anything about your visit surprise to Duke Gardens you or your students?

Additional Thoughts:
Appendix 14

**Code Book:**
The following are definitions of the themes listed under *Teacher Perceptions*:

- **Interviewee Demographic:** Teacher Number, School Type, Grade Taught, Number of years teaching, school program attended at Duke Gardens, how often they attended programs at Duke Gardens.
- **Benefit of Field Trip:**
  - Outdoor Education: In this theme, I coded responses when the interviewees overall mentioned anything about being outside or in any environment that was duke gardens.
  - Duke Gardens: In this theme, I specifically coded responses when the interviewee mentioned Duke Gardens, or gardens, or any aspect related to the Duke Gardens.
- **Preparations:**
  - Timing of school program: In this theme, I coded responses when the interviewee mentioned information relating to at what point during their curriculum do they come to the gardens and/or when they prefer to come to the gardens for a field trip.
  - Pre-lesson plans: In this theme, I coded responses when the interviewee mentioned information relating to lessons that are done before attending the field trip.
  - Teacher preparation: In this theme, I coded responses based on the interviewee’s preparation for field trip’s logistically and the interviewee’s preparation for their students before the field trip.
- **Teacher Observations of Duke Gardens Experience:**
  - Pacing
    - Physical Exertion: How much effort and energy was placed on the students during the program
    - Information Given: How much information was relayed to the students by the docent during the program
    - Activities done by students: how many activities the students were asked to do during the program
  - Behavior of students: Observations of the students compared from a nonformal setting to a formal setting
- **Moments:**
  - Times the interviewee’s mentioned an experience they had with their students.
- **Expectations:**
  - Met: Whether the expectations of the program were met
  - Not Met: Whether the expectations of the program were not met
- **Standards:**
  - Whether the school program covered the curriculum and/or the standards set by the state, school or interviewee.
- **Evaluating Student Learning:**
  - Post- Lesson Plans: In this theme, I coded responses relating to information geared towards activities to be used in lesson plans after the program for teachers
  - Student Information Learned: what information the
- **Methods**: Ways the interviewee’s assessed their student learning after the field trip at Duke Gardens
- **Student Takeaways**: what the interviewee thought the students took away after the program’s completion.

  - **Suggested Improvements from Interviewees**:
    - These were unsolicited comments that the interviewee’s mentioned throughout the interview