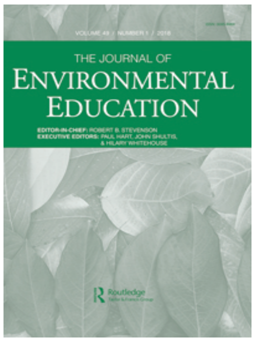

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RESEARCH ARTICLE

Nurture thru Nature: Creating natural science identities in populations of disadvantaged children through community education partnership

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ABSTRACT

In this article we describe the development, implementation, and some of the early impacts of Nurture thru Nature (NtN), an American after-school and summer program designed to introduce elementary school students in disadvantaged, urban public schools to natural science and environmental education. The program, which began operations in 2010 as a collaboration of Rutgers University, Johnson & Johnson, and New Brunswick, New Jersey, public schools, was motivated by broad concerns over the achievement gap in science and mathematics that has long characterized student performance in the state's suburban and inner-city schools. We present results from a classical experiment conducted in four elementary schools which suggest that NtN does improve grades and knowledge of science and nature.

KEYWORDS
Disadvantaged children; natural science education

Introduction

There is no shortage of research and commentary on the many challenges faced by poor and minority students in our inner-city schools and communities. These students are much more likely than their more privileged counterparts in suburban and small town school districts to face myriad obstacles that have been linked to poor academic performance: viz., poverty, inadequate school funding, poor or unqualified teachers, low levels of parental involvement, high levels of residential mobility, the need to work at a young age, and obligations to take care of younger siblings. Inadequate academic preparation in elementary and middle school places poor and minority children at a significant disadvantage for success in higher education, technical schools, and in the job market (Carneiro & Heckman, 2003; Heckman, 2013; U.S. Department of Commerce, 2011).

The gap in performance between disadvantaged and middle class students is especially large in mathematics and science whether measured by grades or by achievement tests like the National Assessment of Educational Progress (NAEP). In a 2006 report, the U.S. Government Accounting Office (2006) has documented the significant underrepresentation of young African Americans and Hispanics in Science, Technology, Engineering and Mathematics (STEM) jobs and has pointed to poor elementary and high school education as an important factor that discourages these students from pursuing such careers. In New Jersey, one of the wealthiest states in America, analyses conducted by the State Department of Education Report Cards (http://education.state.nj.us/re/) and Annual Accountability Reports (http://www.nj.gov/education/title1/accountabilty/ayp/1011/dini/identified.pdf) indicate that the state's many urban districts lag behind suburban schools in mathematics and language arts advanced proficiency and score

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/vjee.

lower on science achievement tests as well. Learning deficits in elementary and middle school create barriers that are extremely difficult for students to overcome in high school. The Nobel Laureate James Heckman (2013) has pointed out that the poor performance of disadvantaged children on cognitive skills like arithmetic reasoning, mathematical conceptualization and reading comprehension has been accompanied by a corroding of non-cognitive "soft skills" like self-discipline, persistence, dependability, and trustworthiness, which are essential to career success and long term employability. The research of Alexander, Entwisle, and Olsen (2007), Hanushek and Rivkin (2009) and Heckman and Masterov (2008) call attention to a learning gap that is cumulative, that widens with grade level, that is exacerbated by "summer fall back" in poor communities, and that especially affects skills in mathematics.

In this article we report results from an evaluation of Nurture thru Nature (NtN), an American natural and environmental science program that seeks to create student connections to nature and utilize those connections to improving the academic performance of disadvantaged elementary school students. NtN traces its underlying operational philosophy to the active learning approach articulated by Dewey (1976, 1990), extensions to Dewey's work in the area of outdoor education (Ord & Leather, 2011; Quay & Seaman, 2012) and to arguments for an ecologically, sustainable education advanced by Clark (2012), Sterling (2009), and others. We use a classical experimental design to assess NtN impact on math, science, and language arts grades as well as knowledge of natural science.

Nurture thru Nature's genesis and conceptual impetus

Nurture thru Nature efforts began in 2007, as the community partnership of Rutgers University, the largest public university in New Jersey, Johnson & Johnson, a Fortune 100 pharmaceutical company with world headquarters in New Brunswick, New Jersey, and the New Brunswick Public School (NBPS) system, a school system serving a largely disadvantaged black and Hispanic student population. NBPS has been struggling with the problem of low science and mathematics scores and reached out to two professors at Rutgers who were developing operational plans and curriculum for a 'nature-based' natural and environmental science program.

Motivating the Rutgers initiative were three factors, viz., the substantial evidence from evaluations of job training and education programs targeted at high school dropouts, welfare-to-work participants, and others later in the life cycle that yielded low rates of return to investments (Carneiro & Heckman, 2003; Decker, 2011; Michalopoulus & Schwartz, 2000); the importance of early intervention at the elementary school level for advancing technical skills (Heckman, 2013; Heckman & Masterov, 2008); and the promising research that identified the possibilities that "education outdoors" extended to students beyond the classroom (Hirschi, 2015; Louv, 2006; Orr, 2004; Quay & Seaman, 2012). An additional factor worthy of mention is the love for nature that had played such a critical role in the young lives of the two NtN designers.

Plans for a nature-based program in NBPS would have remained simply plans without the financial support of Johnson & Johnson (J & J). Since 1992, J & J had established one of its signature social initiatives, "The Bridge-to-Employment" program, to expose older adolescents to science and health careers in real work settings (Bzdak, 2007). A companion program designed to improve the science and math performance of younger students was seen by the company as an important expansion of this commitment.

The NtN program is designed to achieve five principal objectives:

1. Increase students' knowledge and understanding of the natural world through a science curriculum developed and administered by Rutgers University faculty and students, in consultation with NBPS teachers and consultants.
2. Enable students to apply their language arts and mathematics knowledge while generating hypothesis, answering questions, and experimenting with natural/environmental science issues in both an after-school and summer program settings.

3. Allow students to actively participate in the creation of neighborhood "naturescapes" that include organic gardens, ponds, and water features, butterfly and caterpillar gardens, bird feeding stations, among others.
4. Increase parental involvement in students' academic life through family participation in special events and projects focused on healthy eating/nutrition, water/air quality, and neighborhood ecosystems.
5. Provide tangible evidence to NBPS administration and teachers that NtN's nature based approach can significantly increase students' knowledge of science and can significantly increase science and mathematics grades.

These objectives place great emphasis on the centrality of firsthand experience for true understanding and recognizes the potential for conflict with science education that is confined to the traditional classroom.

Conceptual grounding

The objectives are a reprise of several pedagogical arguments advanced by John Dewey in the early to mid-twentieth century. In 1899, Dewey wrote in *The School and Society* (Dewey, 1976) that the public school had been so set apart from the conditions and motives of life that children were not exposed to "experience—the mother of all discipline." (p. 17) In this collection of essays, he goes on to promulgate an occupational approach to education (p. 92) under the rubric "The University Elementary School" that would optimize experience through a four stage process, viz., (1) start with interests—cooking, building, planting, outdoor exploration, etc.; (2) employ cumulative, deeper, and broader sequences of subject matter from year to year, (3) begin gradual specialization within real world problem contexts, and (4) introduce abstract concepts and symbols through textbooks and classroom instruction. (p. 318)

In "Experience and Education" (1988) Dewey makes clear that learning-by-doing or active learning is transactional in nature—doing something has learning consequences for the student and for the environment acted upon. It is this reciprocity that facilitates thoughtful reflection and the creation of meaning, i.e., true understanding.

Two principles of the Dewey paradigm are of particular importance to the structuring of NtN: e.g., (1) the need to connect a student's prior knowledge and experience, however limited, to current and future learning experiences, and (2) the need to situate the student's learning in the "here and now," providing opportunities to apply mathematics and science knowledge to everyday situations.

Also important to the genesis of NtN is the "out-of-doors" education movement (Louv, 2012; Ord & Leather, 2011; Orr, 2004) and to advances in "participatory action" curriculum development (Payne, 2006; Quay & Seaman, 2012). The influence of both of the amplifications has been critical in the program's structuring of inputs, processes, and expected outcomes.

Nurture thru Nature—empirical bases and program operations

Nurture thru Nature is certainly not the first program that has attempted to operationalize a natural science focus to improve the academic performance of disadvantaged students. Three broad approaches have been taken, sometimes separately and sometimes in combination: e.g., the intensification/enrichment of school curriculum, after-school programs which concentrate on science and math, and "summer learning loss" prevention efforts that emphasized math and language arts instruction in addition to science. Each of these methods has shown some promise in improving the math and science grades (and test scores) of elementary school students; however, much of the evidence of success has been confined to anecdotes or evaluations employing weak quantitative or qualitative research designs.

A highly influential report written by Lieberman and Hoody (1998) documents the success of a science curriculum they call the Environment as Integrating Context (EIC). The report describes how "hands-on" EIC changed student's GPAs, language arts and math grades and test scores in 40 elementary and high schools from across America. Another report issued by the Royal Horticulture Society

(2010) in Great Britain found that "hands-on" science and environment-based curriculum was increasing student academic performance there as well. Richardson, Sheffield, Harvey, and Petronzi (2016) report in their survey of 775 sixth graders from 15 schools in the United Kingdom that a student's connection to nature is positively correlated to performance in language arts, but not in math. Viewed as especially promising is an outgrowth of "hands-on" environment integrated curriculum termed garden-based instruction (Blair, 2009; Gaylie, 2011; Robinson-O'Brien, Story, & Heim, 2009). Gaylie (2011) asserts that the evidence is "overwhelmingly positive" in the ways that school gardens contribute to students' academic achievement. This sentiment is echoed by Jane Hirschi (2015) when she states that school garden teaching and curriculum positively impact both student grades and behavior.

After-school tutoring programs like 21st Century Community Learning Centers (CCLC) and Big Brothers Big Sisters of America have been applauded for their efforts to improve the reading and math grades of disadvantaged and minority youth (Levine & Zimmerman, 2010). A study conducted by Public/Private ventures from 2005 through 2007 found Big Brothers Big Sisters agencies did have significant effects on students' language arts and science classwork and homework. Other after-school programs like CCLC and the Quantum Opportunities Program (QOP), while showing promise, did not exhibit the impact of Big Brothers Big Sisters of America (Lauer et al., 2006).

Finally, intensive reading, math, and natural science programs, typically offered to elementary school students in July and August in the United States and Great Britain, have increased in scope and number in poor performing urban schools. The expansion has been fueled by the observation that the grades of poor and minority students "fall back" after summer more than do those of more privileged students (Alexander et al., 2007; Hanushek & Rivkin, 2009). The Building Educational Leaders for Life (BELL) program, for example, provides math and reading instructions over the summer—five days a week, 6.5 hours a day for five weeks to both elementary and middle school students. Some suggestive evidence of reading and math grade improvement has been reported for BELL (Somers, Welbeck, Grossman, & Gooden, 2015). McCombs et al. (2011) also cite a number of intensive summer programs with an environmental or natural science focus that have had some success in countering summer learning loss.

Deciding on which method or methods Nurture thru Nature should include was complicated by a research literature that indicated little more than short-term academic effects. Even after only one year of followup the impacts of environmental-based curriculum, school gardening, after-school and summer programs dissipated substantially or disappeared altogether (Blair, 2009; Hollister, 2003; Levine & Zimmerman, 2010; McCombs et al., 2011; Somers et al., 2015; Williams & Dixon, 2013). A theme reiterated in evaluations of these programs is the "underpowered treatment," with interventions too short in duration, students too sparse in attendance, and parents too often uninvolved.

The research on nature-based education identified a series of program inputs and student activities that could be linked, albeit in a preliminary fashion, to improved student performance on cognitive skill sets. Many of these features were incorporated by the Rutgers–J & J–NBPS partnership into a logic model that could be used to influence the form and guide the direction of NtN. As Frechtling (2007) notes, logic models can be thought of as theories of change which guide the program operations that need to be made, the hypotheses that need to be tested, and the empirical generalizations that are suggested. In addition to the immediate outcomes that are the focus of this study, the NtN logic model calls for the assessment of impact on longer-range objectives.

The 11 inputs in Figure 1 comprise the core structural components of NtN. A natural science and math curriculum aligned with the science curriculum taught by public school teachers is supported by NtN-sponsored science projects and experiments during regular school hours. This curriculum is continued, reinforced, and supplemented in a two-day per week after-school program and a 3-day, 7.5-hour day summer program in July and August. In Figure 2, we show examples of the science topics receiving emphasis in grades 4 through 7. NtN augments classroom teaching with "hands-on" learning opportunities at all grade levels. For example, lessons on bird life are advanced by student participation in FeederWatch, a program sponsored by the Cornell Ornithology Laboratory in Ithaca, New York, and cell biology instruction is assisted by using dissecting and compound microscopes-based observation with students preparing specimens, slides, and reports. Physics and astronomy classroom content

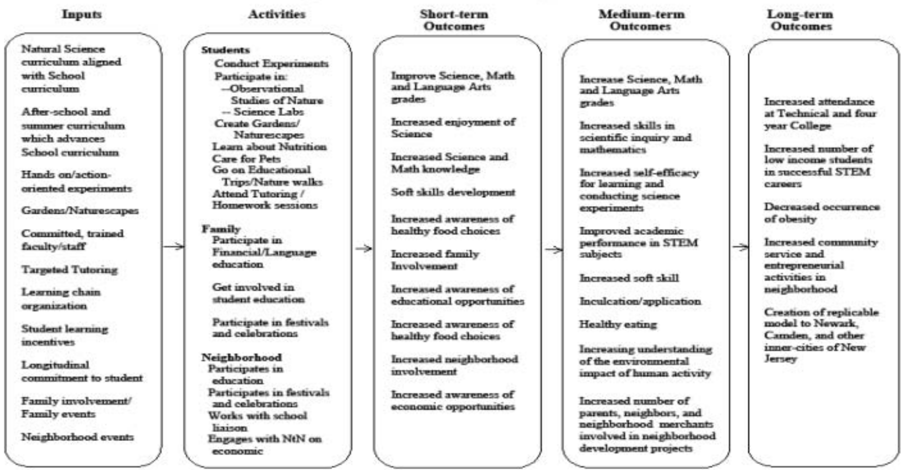

Figure 1. Nurture thru Nature (NtN) logic model.

is supported by field trips to Rutgers Astronomy and Geology Departments and the Liberty Science Center in Jersey City, New Jersey.

NtN summer and after-school instruction makes intensive use of the school naturescape/garden, a resource that offers students a place for observation and identification, quiet reflection, and problem solving. The basic design of an NtN naturescape is displayed in Figure 3. The principal components show an arched entranceway, a water feature (typically a pond with a waterfall), butterfly and caterpillar gardens, a vegetable garden, and a composting station. Students are intimately involved in the creation and maintenance of NtN naturescapes, labs, and gardens.

In addition to serving as an oasis for nature in the neighborhood or schoolyard, NtN naturescapes provide a venue for bringing parents, families, and neighbors together.

NtN instructors are faculty and students (both graduate and undergraduate) from a variety of disciplines at Rutgers University. An advanced degree or major in one of the "hard sciences" is not a requirement; however, a strong interest in the natural sciences or mathematics, and a commitment to working with children to inculcate those interests/skills are prerequisites. In addition to administering the science curriculum, NtN instructors conduct math and language arts tutoring, help with homework, and train older students (middle school) to tutor elementary school students. It is anticipated that this "learning chain" of teaching will extend to high school, with some NtN student-tutors continuing their role when they themselves become college students. Implicit in the "learning chain" organization is the longitudinal and developmental orientation of NtN as a means of overcoming the

Grade Level	School Curriculum Focus	NtN Instruction	
		After School Program	Summer Program
Fourth Grade	Basic Astronomy, The Human Body, Rocks and Minerals	Rocks and Minerals, The Human Body	Basic Astronomy, Birds, Insects, Reptiles and Amphibians
Fifth Grade	Mixtures and Solutions, Elements and Atoms, Principles of Anatomy	Principles of Anatomy, Mixtures and Solutions	Fish, Pond Life, Basic Horticulture, Flowers
Sixth Grade	Forces and Motion, Electricity, and Basic Physics, Heat Transfer, The Human Brain	The Human Brain, Newton's Laws, The Scientific Method, Experimentation	Naturalistic Methods, Evolution and Ecologic niches, Photosynthesis
Seventh Grade	Acids and Bases, Mitosis and Meiosis, Osmosis and Diffusion, Basic Cell Biology	Cell Biology, Lab Reports, Principles of Micro-Biology, Eukaryotic and Prokaryotic Cells	Microscopic Pond Life, Healthy Foods and Nutrition, Gardening Techniques / Naturescape Development

Figure 2. NtN augmentation and extension of the Public School Science Curriculum Grades Four through Seven.

Figure 3. Outdoor Garden Features: 33 Pine Street, New Brunswick.

phenomenon of "under-powered treatment" discussed earlier (Levine & Zimmerman, 2010; Somers et al., 2015).

Under medium-term outcomes NtN includes what the U.S. Department of Education (n.d.) has referred to as the three pillars of "Green Ribbon School," e.g., improving health and wellness, reduction of environmental cost, and the provision of sustainability education that engages STEM. Figure 1 also depicts an intervention that targets families and neighborhoods for change as well. Although extensive literature exists on the importance of parental involvement for student achievement (Hill & Tyson, 2009; Jeynes, 2003; Lee & Bowen, 2006), accumulating evidence indicates the influence of neighborhoods on educational outcomes. Better neighborhoods, i.e., neighborhoods that exhibit community solidarity, civic engagement, and watchfulness of persons and property exert positive influences on children's attitudes and behavior (Chetty, Hendren, & Katz, 2015; Ludwig et al., 2012; Samson, Jeffrey, & Thomas, 2002).

Evaluation method

NtN began operating as a pilot program in one New Brunswick, New Jersey, elementary school in May 2010, after 18 months of planning, partnership development, and site preparation. Using a lottery, a random sample of 24 students as well as a waiting list of 12 students was drawn from the 65 students who comprised the third grade class. This group of students is identified in the study as Cohort 1. All students not selected for NtN or the waiting list were placed in a control group. NtN, waiting list, and control group students received the same standard NBPS curriculum from the same faculty in their respective schools throughout the academic year.

The parents of the prospective NtN students were asked by the school principal and the NtN co-directors to sign a consent form memorializing their permission to allow their children to participate in the set of learning opportunities and activities identified as NtN. Eighteen parents returned signed consent forms, three could not be located, and three refused. The reasons given for refusal were an impending move from the school or school district, or a potential conflict with another program.

The consent form outlined (in English and in Spanish) the educational goals that NtN was seeking to accomplish, viz., (1) increase their child's performance in science and math, (2) promote positive health and nutrition behavior, (3) increase problem-solving skills, (4) enhance their child's communication and social skills, (5) encourage a deep appreciation of nature and the environment, and (6) provide a venue for parental and neighborhood engagement in the education process. The consent process also made parents aware of NtN's basic architecture as both a 2-day, 6 hours per week after-school program and a 3-day, 7.5 hours per day summer program that would continue from fourth grade through the end of seventh grade. Subsequent cohorts of students were randomly drawn from three additional elementary schools in New Brunswick using this same protocol; these are referred to in this study as Cohorts 2, 3, and 4.

NtN employs a classical experimental design to measure the impact of the program.

Experiments have the useful quality of controlling for both measured and unmeasured factors that could, in addition to the NtN intervention, be responsible for changes in knowledge, attitudes, or behaviors. Because random assignment helps to promote equivalency between groups at baseline, any differences in outcomes can be unambiguously attributed to NtN barring threats to internal validity such as differential attrition, interfering treatments, or treatment contamination.

In Table 1, we provide profiles of the NtN and Control group students in all four cohorts at baseline, i.e., at graduation from third grade, and before entering the NtN summer program as fourth graders.

It is clear from Table 1 that random assignment appears to be successful in creating an equivalency between NtN and control students at baseline on several measured characteristics, viz., race/ethnicity, poverty (school lunch program), Individualized Education Program (IEP), and average days of absence and tardiness. Although there appear to be differences in gender proportions (2 cohorts) and the percentage of homes where English is spoken primarily (1 cohort), these differences are not statistically significant. It should also be noted that interfering treatments did not pose an issue in a school district characterized by financial challenges. Attrition was an issue, but affected both NtN and control groups in much the same manner.

Cognitive outcome measures were collected at the beginning and end of the academic year. Student grades in mathematics, science, and language arts were gleaned from report cards and the NBPS academic reporting database. These measures were augmented by a 35–45 item science assessment (length dependent on grade level), designed by NtN staff and administered by school teachers to students in both the experimental and control groups. This instrument demonstrates a split-halves reliability of 0.87 and an alternative-forms reliability of 0.81. One form of the assessment appears as Appendix A. The content validity of the student assessment has yet to be established given that the domain of NtN science content is still evolving.

We follow the typical analytic strategy for experimental data, testing for equality of means and variances and reporting statistical significance. Alpha levels were set a 0.1 to acknowledge the small sample sizes; 90% confidence reduces the likelihood of accepting the null hypothesis under these conditions. It should be noted that the group comparisons were made independently for each year of the treatment.

Results

In Table 2, we show the four-year impact on the initial cohort of fourth grade students (Cohort 1). Here we see consistent, positive difference in math, language arts, and science grades between NtN and control group students that persist from fourth grade through seventh grade. None of the differences in mathematics are statistically significant; however, two of the four

Table 1. Descriptive data on NtN and control students at baseline—Cohorts 1–4.

	Cohort 1		Cohort 2		Cohort 3		Cohort 4	
Characteristic	NtN	Control	NtN	Control	NtN	Control	NtN	Control
Grade level	3	3	3	3	3	3	3	3
Female	55.6	38.5	50.0	56.1	57.1	45.2	35.7	47.9
Race/Ethnicity:	77.8	71.8	75.0	79.0	92.9	85.7	100.0	95.1
Hispanic	16.7	25.6	25.0	21.1	7.1	13.1	0.0	3.6
Black Asian	5.6	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Free or reduced lunch	100.0	97.4	95.0	96.4	100.0	100.0	100.0	100.0
Speak English at home	27.8	28.2	45.0	32.7	16.7	19.3	7.1	11.0
IEP	6.6	4.3	6.7	6.8	30.8	25.7	14.3	15.6
Average days absent	7.5	9.7	3.6	5.0	0.9	1.2	3.6	4.2
Average days tardy	n/a	n/a	1.2	1.9	5.6	2.4	0.9	1.4
Number of Students	18	39	20	57	14	84	14	140

Table 2. Four year impacts on initial NtN cohort.

Outcome Measure[a]	Year 1 (2010–11) Difference (NtN – Control) 4th Grade	Year 2 (2011–12) Difference (NtN – Control) 5th Grade	Year 3 (2012–13) Difference (NtN – Control) 6th Grade	Year 4 (2013–14) Difference (NtN – Control) 7th Grade
Average Grade in:				
Math	0.0	+2.0	+2.9	+3.6
Language Arts	+3.2	+4.0*	+2.9	+6.1*
Science	+2.5	+1.5	+6.5*	+5.2*
Student Assessment	+4.3	+11.4*	+3.5	N/A[b]

[a]Based on the grades of 16 NtN students.
[b]Assessment was not given in Year 4.
*Indicates statistically significant difference at $p < 0.1$.

differences in science and language arts reach significance. Table 2 also shows a widening of differences, which is notable since the general pattern in the science and math performance of disadvantaged children has been reported to be one of diminution with age (Grissmer, Flanagan, Kawata, & Williamson, 2000; Hanushek & Rivkin, 2009).

Table 2 also reports the differences between NtN and control students on a science assessment (Appendix A). NtN students do better in all years for which data is available, and in Year 2 the difference is statistically significant.

Some initial data from the three subsequent cohorts is provided in Table 3. Seven of the nine comparisons of grades show that NtN students have higher post-period performance; however, in only two instances are these differences statistically significant.

Discussion

Nurture through Nature is an environmental science program designed to excite students about the wonders of nature and natural science and use this excitement to improve science and math performance. Findings presented in this study indicate the program has some promise; however, conclusive evidence for NtN's impact requires additional replications both over time and across schools.

The study adds to the very short list of experimental evidence for the efficacy of nature and environment interventions designed to reduce the performance gap between disadvantaged and more

Table 3. One year impact of NtN on student grade: Three subsequent cohorts.

	Pre (2012—13)		Post (2013—14)	
Outcome Measure[a]	NtN	Control Group	NtN	Control Group
Cohort 2				
Average Grade in:				
Math	80.8	81.2	81.4	77.9
Language Arts	78.6	78.4	78.6	76.4
Science	78.0	77.6	89.1*	83.8
Cohort 3				
Average Grade in:				
Math	81.4	77.4	87.1*	82.4
Language Arts	82.3	80.1	82.3	81.3
Science	83.9	81.2	86.9	85.0
Cohort 4				
Average Grade in:				
Math	78.1	77.8	78.2	79.5
Language Arts	77.1	77.3	78.8	80.5
Science	86.3	82.4	80.8	80.6

[a]Based on the grades of 15–17 NtN students.
*Indicates statistically significant difference at $p < 0.1$.

privileged students (Blair, 2009; Clarke, 2012; Lauer et al., 2006; Levine & Zimmerman, 2010; Williams & Dixon, 2013).

Although far from overwhelming, the results from this experiment indicate that math and science grades can be positively influenced by a natural and environmental science program that is conceptually grounded in "active learning" and that bases program components on empirical findings. The four-year impacts on the initial cohort are especially noteworthy, with the growth in science performance most prominent. Future data from Cohorts 2, 3, and 4 will determine if this pattern of effects is replicated. NBPS and J & J have taken note of these initial impacts and have requested that NtN be brought into four additional elementary schools. They have also proposed that a form of NtN be developed for middle and high school.

Nurture through Nature is a good example of the eminent practicality of good theory. It marks an attempt to institute what John Dewey termed the University Elementary School (1976, p. 92) that develops student interests into specialized knowledge and abstract thinking. NtN's reliance on outdoor gardens, naturescapes, personalized science projects, hands-on experiments, and natural science curriculum is critical, we believe, in fostering the development of this type of thinking and learning.

Of course, we are not alone in bringing back John Dewey into current discussions and the critical importance of the firsthand knowledge of nature for student learning. Louv (2006), Orr (1992, 2004), Payne (2006), Quay and Seaman (2012), Singleton (2015), and many others have documented the problems in education that accompany classroom instruction confined to the classroom and school buildings. Louv (2006) has traced such instruction to "nature-deficit disorder" with symptoms of diminished use of senses, attention difficulties, and a higher rate of physical and emotional illnesses (p. 34). Orr (2004) delineates the "dangers, problems and business" of education that constructs barriers to a firsthand knowledge of nature from which he maintains real intelligence grows. Bonnett (2013) and Louv (2006, p. 144) assert that classroom instruction too often associates nature and natural science with fear and catastrophe instead of awe and wonder. Clarke (2012) and Sterling (2009) are perhaps even more ominous, tracing an education without connection to nature to the creation of identities that are atomistic and reductionist. Dewey (1990) clearly recognized this potential conflict between the traditional classroom and hands-on, out-of-door teaching but saw an opportunity for a compromise between subject-matter and experiential learning (Quay & Seaman, 2012). NtN provides one operational definition for this compromise.

Concluding remarks

NtN's attempt to operationalize the "University Elementary School" is subject to challenges that were all but impossible to see a century ago, or for that matter, even 50 years ago: viz., skyrocketing single-parent households, escalating levels of drug use and gang violence, rising poverty rates, etc. Transporting young students into the world of exploration, excitement, and wonders that we experienced as elementary school children is made a great deal more difficult in neighborhoods and communities filled with very real dangers.

In addition to myriad social problems that swirl around students from disadvantaged school districts, numerous within-school challenges are certain to confront the planning and implementation of any supplemental learning program like NtN. First, and perhaps foremost, is the capacity of the program to attract outside funding and resources to the school district. In a time of increasing budget constraints due to skyrocketing pension costs, health insurance, etc., it is most likely that schools will be limited to providing in-kind contributions such as space, transportation, and some security. Absent these outside resources, schools might rely on community groups, NGOs, or 4-H to help staff and resource science and/or environmental clubs, but this would presume the availability of qualified science and mathematics instructors residing in some of these outside groups—a presumption that might not be warranted.

A second consideration is the resistance or even outright hostility that a supplementary program may encounter from school administrators, teachers, and even some parents and students. In a resource-depleted school environment, supplementary programs like NtN bring opportunities to some but not all.

Equity issues can result, as can the problems that accompany interference with the status quo, new accountability demands, more responsibilities for administrators, janitors, security personnel, etc.

A third challenge redounds to level of commitment. Successful implementation of NtN has required that NtN staff perform roles and accept duties that would seem outside the boundaries of delivering a natural science curriculum in a more privileged school district. Visiting homes, meeting with parents at their work sites, babysitting (in class) younger siblings, accommodating a pregnant student, coordinating with a drug rehabilitation program, etc., must become integral components of the education process if the problem of the underpowered treatment is to be avoided.

In addition to these principal considerations, members of any public-private partnership need to carefully monitor their motivations for involvement. University participation that views the public school as a laboratory where professional papers, master's theses, and research data are the raison d'etre for collaborating, a successful, long-term partnership may be at serious risk. Schools expect the educational needs of their students to come first. As in this case, research data and publications may result, but there is no guarantee.

In a nation with little appetite for new initiatives in legislative and/or judicial school desegregation, policy and programmatic initiatives have concentrated limited resources on improving poor performing schools and school districts. In a growing consensus, child development experts and labor economists are calling for "educational predistribution" on the early intervention in the academic lives of children (Magnuson, 2013; Heckman, 2013; Shonkoff & Phillips, 2000). NtN offers some promise that a natural and environmental science program rooted in the experiences of students and directed by teachers who are committed to expanding this experience both within and beyond neighborhoods of disadvantage can be a viable form of such predistribution.

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Appendix A

Student Assessment

Spring 2012 (Post)

Directions: Please circle the response you think best answers the question or provide a short answer in complete sentences.

1. The part of the plant that holds the embryo (or sprout) is known as ___________.
   a. Stem
   b. Leaf
   c. Seed
   d. Root

2. Which one of these body parts is NOT a body part of a butterfly?
   a. Thorax
   b. Head
   c. Larynx
   d. Abdomen

3. When liquid changes into water vapor it is called ___________.
   a. Condensation
   b. Contraction
   c. Evaporation
   d. Expansion

Explain your thinking

____

____

____

4. The Monarch butterfly caterpillar is one of the very few butterfly caterpillars that eats ___________.
   a. Thistle plants
   b. Milkweed plants
   c. Tomato plants
   d. Poison Ivy

5. Which of these is a fruit?
   a. A string bean
   b. A tomato
   c. A radish
   d. A cucumber

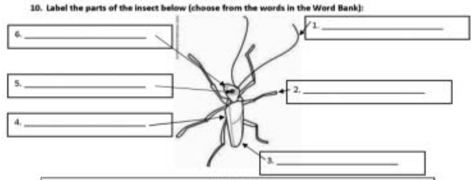
6. A butterfly goes through four life stages. These are ___________.
   a. Egg, nymph, pupa, adult
   b. Egg, larva, pupa, adult
   c. Nymph, larva, pupa, adult
   d. Egg, nymph, larva, adult

7. Which of these animals is an amphibian?
   a. Black, rat snake
   b. Eastern fence lizard
   c. Green frog
   d. Box turtle

8. The water quality of a river is affected by ___________.
   a. The kind of fish that swim in the river
   b. The number of people that live near the river
   c. The type of boats that travel on the river
   d. Fish, people, and boats

9. When the pH in a pond become too high, ___________.
   a. The water becomes very warm
   b. The animals and plants in a pond die
   c. Too many plants begin to grow
   d. The water becomes very cold

10. Label the parts of the insect below (choose from the words in the Word Bank):



Word Bank:

Head Abdomen Antennae Compound Eye Leg Thorax

11. When a plant's leaves turn yellow, it means ___________.
    a. The plant is not getting enough water
    b. The plant is getting too much water
    c. The plant is getting too much sun
    d. The plant needs some fertilizer

12. Which one of these butterfly caterpillars eats common milkweed?
    a. Black swallowtail
    b. Giant swallowtail
    c. Monarch
    d. Spring azure

13. Fish breathe ___________ and plants breathe ___________.
    a. Oxygen, carbon dioxide
    b. Oxygen, nitrogen
    c. Nitrogen, carbon dioxide
    d. Carbon dioxide, chlorine

14. ___________ is not part of the digestive system.
    a. Liver
    b. Rectum
    c. Gall bladder
    d. Bladder

15. Science of the Earth and its history is known as ___________.
    a. Paleontology
    b. Zoology
    c. Biology
    d. Geology

16. You have to move two boxes: Box A and Box B. Box A weights more than Box B. You need ___________.
    a. Less force to move Box A
    b. Less force to move Box B
    c. You need equal force to move both boxes
    d. You do not need any force to move boxes

17. A ball at the top of the hill has more ___________ than an identical ball at the bottom of the hill.
    a. Inertia
    b. Kinetic energy
    c. Potential energy
    d. Force

18. The elements on the periodic table are organized by ___________.
    a. Number of protons
    b. Number of electrons
    c. How much they weigh
    d. Randomly

19. One of the biomes has a permanently frozen ground. Its top layer melts in the summer to make the ground "squishy". This biome is known as ___________.
    a. Taiga
    b. Deciduous Forest
    c. Tundra
    d. Savanna

20. A group of animals and plants living together in the same place is known as a(n) ___________.

- **a. Ecology**
- **b. Community**
- **c. Habitat**
- **d. Niche**

21. Organisms require both living and non-living factors to survive. An example of a non-living factor that is crucial for plant's ability to make food is ___________.

- **a. Water**
- **b. Sun light**
- **c. Nutrients**
- **d. Wind**

22. Objects all around us are made of simple machines. Our body is also made of a simple machine. Our leg is an example of a(n) ___________.

- **a. Lever**
- **b. Inclined plane**
- **c. Pulley**
- **d. Wheel and axle**

23. All cacti have ___________.

- **a. Needles**
- **b. Water inside**
- **c. Fruits**
- **d. Ants living inside them**

24. Mammals were named for the mammary gland. This gland makes ___________, which is unique to mammals.

- **a. Hair**
- **b. Fur**
- **c. Milk**
- **d. Saliva**

25. All the animals below breathe using gills at some point in their life cycles except ___________.

- **a. Bull Frog**
- **b. Newt**
- **c. Rattlesnake**
- **d. Trout**

26. The measure of the rate of motion in a specific direction, expressed as distance/time-direction, is ___________. Ex: 35 miles per hour north.

- **a. Velocity**
- **b. Acceleration**
- **c. Friction**
- **d. Speed**

27. Which animal group does not <u>usually</u> lay eggs?

- **a. Fish**
- **b. Reptiles**
- **c. Amphibians**
- **d. Mammals**

28. Which of the following is <u>not</u> a method of manual separation?

- **a. Screen separation**
- **b. Evaporation**
- **c. Hand separation**
- **d. Filter separation**

29. Which part of a fish is a row of scales that runs down each side of the fish's body, from head to tail, and helps them detect vibrations under water?

- **a. Caudal fin**
- **b. Heterocercal**
- **c. Lateral line**
- **d. Ventral fin**

30. Reptiles are said to be cold blooded animals. This means___________.

- **a. They have a blood temperature of below 53° F**
- **b. They use outside sources to control their body temperature**
- **c. They need to be kept warm at all times**
- **d. They have scales**

31. Which of the following subatomic particle carries a negative charge?

- **a. Proton**
- **b. Electron**
- **c. Neutron**
- **d. Positron**

32. Adaptation is a characteristic that___________.

- **a. Can be passed on from parents to children**
- **b. Develops because the environment changes**
- **c. Only animals develop**
- **d. Few organisms develop**

33. A mixture is different from a solution because ___________.

- **a. A mixture is made up of many more things**
- **b. A solution is liquid but a mixture is not**
- **c. A mixture can be separated through manual means but a solution can't**
- **d. A solution can only be made of two things**

34. Amphibians need to live near water because ___________.

- **a. They all eat fish**
- **b. They all lay eggs that shrivel up out of water**
- **c. They all spend their entire lives in water**
- **d. They all breathe using gills for their entire lives**

35. A pond has four kinds of habitats: bottom, open water, top, and shore. Arrowweed and frogs are found in the ___________ habitat.

- **a. Bottom**
- **b. Open water**
- **c. Top**
- **d. Shore**

36. When identifying birds, the back of the bird's neck is called the ___________.

- **a. Crown**
- **b. Nape**
- **c. Bill**
- **d. Belly**