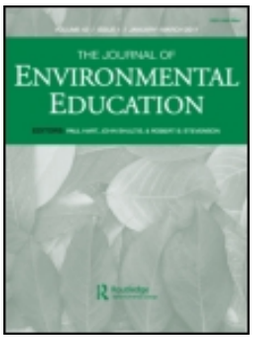

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EMPIRICAL RESEARCH

How Do Sustainable Schools Integrate Sustainability Education? An Assessment of Certified Sustainable K–12 Schools in the United States

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We provide an overview of research in sustainability education. We argue that the interconnectedness of environmental sustainability programs at K–12 schools is one metric by which sustainability education can be conceptualized. We present a new measure of whole-school sustainability, or "interconnectedness," and then use it to compare U.S. Department of Education Green Ribbon Schools. In total, we compare 59 different schools, with a total of 289 sustainability projects. Finally, we provide an analysis of differences between schools that are certified as sustainable. Using the results from our cross-school comparison, we provide recommendations and strategies that appear to promote interconnectedness or whole-school sustainability.

Keywords *certification, Green Ribbon School program, sustainability education, interconnectedness, policy assessment, solutions-based learning, U.S. Department of Education*

INTRODUCTION

Solutions-based education is among the numerous reforms currently happening in K–12 education that attempt to integrate problem-solving skills into curriculum to provide students with multifaceted problem-solving skill sets (Luft, Bell, & Gess-Nawsome, 2008; Thomas, 2000). Solutions-based learning, the foundation of sustainability education, provides K–12 schools with opportunities to expand their traditional curriculum into the real world to create real change for

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the betterment of the environment and our society (Eflin & Sheaffer, 2006). For the purposes of this article, sustainability education is defined as an approach to education that generates, integrates, and links use-inspired knowledge to provide solutions to environmental-social problems (van Kerkhoff & Lebel, 2006; Wiek, Withycombe, & Redman, 2011). Sustainability education is grounded in environmental education and responds to calls for the bolstering of K–12 student problem solving capacities (Schmidt, 1996). It builds from environmental education by incorporating complex social issues, such as the links between environmental quality, natural resource allocations, human equality, and human rights (Henderson & Tilbury, 2004). To develop solutions to complex environmental problems, the next generation of problem solvers will require an understanding of these relationships between our natural and built environments. This type of interdisciplinary approach to education is essential to provide students with the skills to resolve complex environmental problems, which often originate in and impact our society in unexpected ways (National Council for Science and the Environment, 2003). Educating students about the interactions between scales and disciplines must be accomplished if our students are to solve complex problems today, and in the future.

Sustainability education is gaining popularity in K–12 schools in the United States as a new solution-based educational paradigm among environmental educators. The word "sustainability" is increasingly displayed in schools' course listings and mission statements. It is easy for school administrators, environmental educators, and students alike to support sustainability education due, in part, to the increasing litany of calls for solution-based K–12 education in the United States (Apple, 2012; Cochran-Smith & Lytle, 2009; Coffey & Alberts, 2013). For this reason, educational policy makers at the state and federal levels have begun supporting rapid increases of sustainability programs on K–12 campuses. This support has resulted in programs designed to support current and future sustainability efforts in K–12 education (Rowe, 2007), but due to its relative infancy, much ambiguity surrounds sustainability education. Environmental educators and school administrators realize the importance of solution-based education, but they have few tools to guide their efforts in designing sustainability programs in schools. This has resulted in a barrage of criteria, laundry lists, and certifications all claiming to define and measure sustainability education (Porter & Córdoba, 2009; Shriberg, 2002).

The ambiguity regarding assessment tools and metrics for sustainability education has led to the application of many different approaches in U.S. K–12 schools, and we know little about the relative success of these different approaches (Veronese & Kensler, 2013). In this research, we have attempted to inform the sustainability education dialogue between researchers and policy makers about sustainability education by analyzing the U.S. Department of Education's Green Ribbon School program. We provide a new metric to measure the "interconnectedness" of schools that have been awarded the title of "Green Ribbon School" using schools' Green Ribbon School program applications. This idea of interconnectedness has also been called "whole-school" sustainability (Henderson & Tilbury. 2004), and we define it as the facilitation of the interactions, collaborations, and integrations between diverse and relevant disciplines, ideas, and educational stakeholders in order to teach students that our actions may, and often do, result in unintended consequences. It is widely agreed that interconnectedness should be a major component of any sustainability education framework (Frisk & Larson, 2011; Rowe, 2007; Wiek et al., 2011), and it underlies the U.S. Department of Education's approach to sustainability education. Using our new metric, we relied on Green Ribbon School program applications to categorize the efforts made by Green Ribbon Schools to achieve this title. We do this to understand what approaches

are most likely to integrate sustainability education across schools' curricula, campuses, and communities.

In this article, we provide an overview of research in sustainability education. We argue that the interconnectedness of solution-based sustainability education initiatives at K–12 schools in the United States is one metric by which sustainability education can be conceptualized, measured, and pursued. We present a new measure of whole-school sustainability, or interconnectedness, and then use it to compare sustainable schools. We use this metric to help us conceptualize the interconnectedness of sustainability initiatives in K–12 schools. Then, we present an empirical study of Green Ribbon Schools in the United States. We use our new metric to compare sustainability programs at 59 different K–12 Green Ribbon Schools. We look at the types of schools that are most successful in implementing sustainability education programs according to our interconnectedness metric, and then we provide analysis to explain their successes. Finally, we look for commonalities among those most interconnected schools and describe and discuss these commonalities and provide recommendations and strategies that appear to promote whole-school sustainability.

THEORETICAL ANALYSIS OF SUSTAINABLE SCHOOLS

A small but growing literature exists that attempts to define metrics to evaluate and measure sustainability education in the United States. We have reviewed research in sustainability education, in both higher education and in K–12 education, which measures or valuates whole-school sustainability using explicitly defined metrics, indicators, and competencies. We have used this review of relevant theoretical and empirical contributions to develop our idea of interconnectedness in schools. Filho (1999), for example, describes a set of conditions and elements needed to successfully implement sustainability in higher education across campuses. These include curriculum "greening," networking, facility-oriented energy-saving programs, sustainability awards, and teaching training. These same conditions can be applied in K–12 education in a similar way. Wright (2002) outlines themes that can be used to construct and develop sustainability education initiatives within schools; these include energy and water-efficient buildings, interdisciplinary curriculum, and partnerships with community stakeholders. Shriberg (2002) evaluates different types of valuation tools designed to measure sustainability education in both higher and K–12 education, and argues that schools must pursue institutional changes before sustainability education may permeate across disciplines.

Rowe (2007) argues that K–12 curriculum needs to reflect the interdisciplinary nature of sustainability, and that students should engage their local communities and businesses through solution-based learning. She goes on to argue that currently, sustainability education is just "another item on an already full plate," and that rather, sustainability needs to be a main focus of our efforts in education. Wiek et al. (2011) provide four key sustainability education competencies: systems thinking, futures thinking, normative competence, and action orientation, that they argue should be used to design and manage sustainable schools. Similarly, Frisk and Larson (2011) argue that the connectedness of disciplines, degree of action-orientation, collaborative nature, and farsightedness of curriculum determine the sustainability of a school.

It is apparent that education researchers have oriented toward a few common themes in their efforts to define sustainability education. In the broadest sense, this literature can be aggregated

into a basic idea: sustainability education produces solution-based knowledge to support transitions toward more sustainable futures. This is generally the common finding in sustainability education research. However, this idea is relatively intangible and difficult to measure in terms of an actual sustainable K–12 school. As school administrators and environmental educators attempt to translate this research into real-world initiatives, we are left with a wide range of projects, certification metrics, and definitions of sustainability education due to differences in the interpretations of the research. Much of the literature mentioned previously has made this point.

In our effort to distill the idea that sustainability education needs to produce solution-based knowledge to support transitions toward more sustainable futures into something more tangible, we see that two related themes emerge. First, sustainability education should provide students and communities with the ability to create solutions to complex environmental-social problems. This is relatively straightforward, but it is difficult to measure due to different stakeholders' perceptions of problems and solutions. And second, sustainability education in K–12 schools should facilitate the interaction, collaboration, and integration between environmental education and other diverse and relevant disciplines, ideas, and actors in order to teach students that our actions may, and often do, result in unintended consequences in both our environment and our society. We call this "interconnectedness." While this second point is still rather abstract, we have designed a metric to measure the interconnectedness of schools' sustainability programs to compare sustainable schools, and to understand the state of interconnectedness in different K–12 schools in the United States.

The philosophical foundation for our new metric to measure and compare the interconnectedness of sustainability education initiatives was developed using the "three pillar" concept (Elkington, 1997; Kajikawa, 2008). The three pillars are prominent in sustainability research because they consider the interconnectedness between the environment, and our economic and social systems, which is needed to meet our development needs over the long term. The pursuit of this challenging balance is, then, the central focus of our metric. Our metric, shown conceptually in Figure 1, explicitly links educational scales at three interconnected levels (Elser, Pollari, Frisk, & Wood, 2011):

1. *Curriculum*: projects focus on classroom activities, teacher/student interaction, content and class programming, professional development and training, etc.,
2. *Campus:* projects relate to school and school district operation, which include staff and administration practices, physical facilities, school grounds and open space, operation and maintenance, etc., and
3. *Community*: projects focus on a school's wider influence and partnerships including parent participation, collaboration with the business community, interaction with government and non-profits or NGOs, (non-governmental organizations) etc.

Due to its solution orientation, sustainability education must also promote curriculum that links the educational scales described above to the following components of sustainable solutions:

1. *Healthy environment*: projects must promote the improvement of both the local environment, and enable the understanding of the science behind the degradation and restoration of human and natural habitats;
2. *Population wellness:* projects must incorporate problems and solutions that exist in schools' communities and regions, including poverty, nutrition, and health. This type

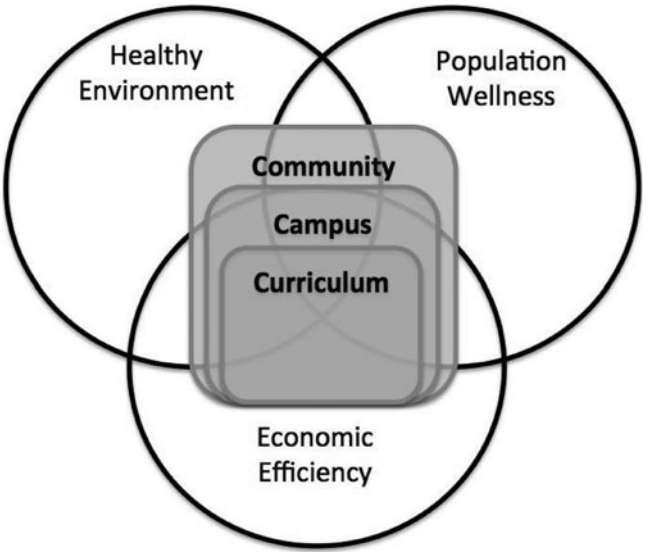

FIGURE 1 Sustainable education framework (Elser et al., 2011).

of interconnected education needs to include both the reasons for, and the solutions to problems in the larger community; and

3. *Economic efficiency:* projects must enable understanding of how and why resources are devoted to certain objectives in the schools' communities, and not others.

This metric was designed to help environmental educators and researchers conceptualize sustainability education initiatives within K–12 schools, because it requires the linking of solution-oriented projects to campuses, to schools' curriculums and to larger communities, which is at the core of sustainability education programs. This interconnectedness of solution-oriented, K–12 sustainability education across the environment, the economy, and the community, and into schools' curriculums and campuses is a primary indicator of sustainability education. A school must be interconnected to its community to allow students to develop an understanding on complex problems.

EMPIRICAL ANALYSIS OF SUSTAINABLE SCHOOLS

In our effort to understand and compare how sustainability education programs are being conceptualized and applied by K–12 schools in terms of interconnectedness, and to compile and discuss factors that may increase schools' focuses on links between each of the three pillars, we used a newly documented collection of schools deemed sustainable by the U.S. Department of Education's Green Ribbon Program (USDE, 2012a). Certifications to recognize schools' sustainable achievements are critical elements of interconnected environmental and sustainability education programs (Henderson & Tilbury. 2004). Schools' certifications can motivate involvement

and realization of sustainability programs by providing recognition to schools working towards sustainability.

The U.S. Department of Education's Green Ribbon Schools (ED-GRS) award was launched in 2011 to recognize the "highest performing sustainable schools in the nation" (USDE, 2012a). The award honors achievement in sustainability education, indicated by reduced environmental impact and costs, improved health and wellness, and effective environmental and sustainability education. In 2012, the Department of Education refined their Green Ribbon indicators by providing schools with a framework for their evaluation. Their framework expanded on the three original indicators by providing specific categories, objectives, and resources within each. For a school to achieve Green Ribbon certification, state and regional governments must nominate schools, and then nominees are evaluated by the Department of Education using the sustainability criteria as defined by the ED-GRS framework. In broad terms, Green Ribbon Schools must meet the following criteria (USDE, 2012a):

- Reduced environmental impact and costs:
  - Reduced greenhouse gas emissions;
  - Improved water quality, efficiency, and conservation;
  - Reduced solid and hazardous waste production;
  - Expanded use of alternative transportation; and
- Improved health and wellness:
  - An integrated school environmental health program based on an operations and facility-wide environmental management system that considers student, visitor and staff health and safety;
  - High standards of coordinated school health for both students and staff; and
- Effective environmental and sustainability education:
  - Interdisciplinary learning about the relationships between environmental, energy and human systems;
  - Use of the environment and sustainability to develop knowledge and skills to prepare graduates for the twenty-first century economy; and
  - Development of civic engagement knowledge and skills, and students' application of these to address sustainability issues in their community.

One of the apparent themes in the ED-GRS framework is interconnectedness, or, whole-school sustainability. Within each of the indicators in the ED-GRS framework, there are calls for projects to be implemented across scales that require schools to explore and describe the linkages between their curriculum, campuses, and communities. The difficulty, however, is measuring the concept of interconnectedness at any one school, and then comparing these results between schools. Furthermore, it is difficult to use schools' self-reported data to understand how their projects are connected throughout disciplines and scales. Self-reported data raises issues of consistency because schools are often not consistent in their data collection and distribution methods. While issues regarding self-reported data are difficult to overcome entirely, we attempted to alleviate these inconsistencies in our study by coupling the self-reported data with data collected by our research team. We collected the additional data to add to our understanding of schools' Green Ribbon programs, and to verify and elaborate on the self-reported data. We defined a Green Ribbon program as the collection of projects within each certified school that

were undertaken to achieve the status of ED-GRS. A challenge, however, arises in the future application of our new metric. Verification and elaboration on self-reported data are expensive undertakings in terms of time and resources, yet they are crucial to the success of our metric. We address these concerns over the future use of our metric in the conclusion section of this article.

The analytical process for this analysis began by transforming our theoretical metric into an initial coding scheme, which was based on our theoretical analysis of interconnectedness. We identified codes, based on our theoretical metric, to categorize every project at each school in our study. We developed 25 codes in total. Our coding scheme is shown in Figure 2.

We used the codes shown in Figure 2 to categorize textual and transcript data obtained from Green Ribbon Schools. Our data consisted of text from Green Ribbon School certification applications, schools' environmental and sustainability reports and briefs, and interviews with teachers and administrators. Our sampling frame included all schools selected as 2012 U.S. Department of Education Green Ribbon Schools (USDE, 2012b). In total 78 schools were selected in 2012. Schools were discarded from our sample if we were unable to verify the relationships between different components of Green Ribbon School certification applications due to the inability of a school to respond to repeated inquiries. In total, our sample consisted of 59 of the 78 schools in our sampling frame. Our sample included 26 elementary schools (grades K–6), 21 high schools (grades 9–12), nine middle schools (grades 6–8), and three schools that housed grades K–12. School sizes varied greatly across our sample because the ED-GRS program was open to all K–12 schools from all 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands. Students per grade-level ranged from less than 25 to over 600. School-demographics ranged widely; some served primarily low-income student populations, others served student bodies' with almost no low-income students, and most served populations that included some socio-economic diversity.

We analyzed each of the 59 school's data sets and documented every project they used or initiated as part of their effort to achieve their Green Ribbon School certification. Within a research-workshop setting, we coded individual projects at each school as belonging to one of the nine scale/focus categories shown in Figure 2. Then, we determined if and how each project was interconnected to the remaining scale/focus categories. We defined interconnectedness as

		Sustainability focus					
		Healthy Environment		Population Wellness		Economic Efficiency	
Educational scale	Curriculum	*1*	*a*	*2*	*b*	*3*	Process of influence
		c	*d*	*e*	*f*	*g*	
	Campus	*4*	*h*	*5*	*i*	*6*	
		j	*k*	*l*	*m*	*n*	
	Community	*7*	*o*	*8*	*p*	*9*	
		Process of influence					

FIGURE 2 Coding framework.

the existence of a link from one project within one scale/focus category, into another scale/focus category (represented by letters a–p in Figure 2). Inter-rater agreement and inter-coder reliability was achieved through a workshop-style consensual qualitative coding process. Using this consensual qualitative research method described by Hill, Thompson, & Williams (1997), we organized and coded school data. Workshop attendees were sustainability education researchers. In total, nine researchers participated in this workshop-style coding process. Participants questioned and debated the categorization of data until consensus was reached, and ultimately coded Green Ribbon projects and interconnections for the 59 schools, which included 289 sustainability projects.

In an effort to maintain consistency throughout our coding effort, we first analyzed and coded every Green Ribbon project based on each school's Green Ribbon School application. Then, we supplemented and verified this coding effort with schools' environmental education and sustainability reports, websites, and 42 teacher interviews. Interviews were conducted via telephone. Interviewees were selected on the basis of leadership roles in each school's Green Ribbon program. We further analyzed interview transcriptions using conventional content analysis (Hsieh & Shannon, 2005), in which we did not use predefined categories. We allowed the coding categories to emerge from the transcribed interviews. To ensure inter-rater agreement in our interview transcript analysis, two researchers coded interview data independently and then coded data was compared, revised, and shared in our research workshop and revised again. The results of this analysis provided insight into how each school's context affected their ability to undertake interconnected sustainability programs. Results from this analysis are presented in the discussion section of this article.

We used a project's level of interconnectedness across scale/focus categories as a new metric to understand how Green Ribbon certified schools approach sustainability education, and to compare different approaches. We provide an example of this metric for one hypothetical school in Table 1. At the broadest level, within our coding effort we conceptualized Green Ribbon Schools as implementing projects at different scales and at different sustainability foci to achieve EDGRS status. We categorized combinations of these scales and foci into nine different scale/focus categories, labeled as 1–9 in Figure 2. For example, code #1 (e.g., the curriculum/environment category) was used to categorize curriculum-based projects that were focused on the environment. The lettered codes between the scale/focus categories represent the interconnectedness categories. A school's Green Ribbon project was coded as being interconnected to another scale/focus category if the project promoted or enabled sustainability efforts in the other category. For example, if a campus garden (shown in bold text in Table 1), built and maintained by an after-school environmental club to provide fresh produce to its members, is also used for parent-teacher club workshops focused on healthy eating, then that project (initiating in sustainability area #5) would be considered interconnected to scale/focus category #7. We would record and code this interconnection in box "k."

The hypothetical school, depicted in Table 1, implemented 10 projects to gain their Green Ribbon certification. The projects are numbered 1–10 and are shown in the sustainability areas. Each of these projects may, or may not be interconnected to one or more sustainability areas. The squares between each scale/focus category represent those projects that are interconnected to multiple scale/focus categories. The numbers associated with the interconnections correspond to the projects in the scale/focus categories. There are seven interconnections within this school's Green Ribbon program, which consists of 10 projects. Using our new metric, the

TABLE 1
Coding Example for a Hypothetical Green Ribbon School

		Sustainability focus			
	Item	*Healthy environment*		*Healthy population*	*Economic efficiency*
Educational scale	Curriculum	(8) Biology curriculum has integrated local riparian habitat into lessons in grades 9 and 10. Students take regular field trips to the site to collect samples, which are then analyzed in class.		(1) Wellness classes are required for all 11th grade students. Classes focus on nutrition and exercise.	
			(2) Students learn about food systems, animals, and the environment by caring for the garden and the three schoolyard chickens. Teachers have begun incorporating the garden into their curriculum.	(1) Students use nutrition criteria to help design the school's meals. Their ideas are implemented by the school's administration. (1) Kitchen staff is trained and heavily involved in educating about the school's innovative all-organic, from-scratch, and increasingly local breakfast and lunch program.	(10) Maintenance personnel are giving "mini-lectures" in industrial arts classes to introduce students to electrically efficient technologies.
	Campus	(6) The school purchases only renewable wind energy. (7) The school reduced dumpster collection from once a week to once every other week.		(2) *School built a campus garden and chicken coop with funds from a state grant; the school administration matched the grant funds. The garden and coop were built by the school's environment club, with guidance from biology teachers.* (3) All students begin the day with 12 to 15 minutes of yoga. A teacher leads the school in these exercises over the school's closed circuit television network.	(10) The school administration, in collaboration with maintenance personnel, designed and implemented an energy savings program focused on replacing inefficient lights and equipment.
					Process of influence

(Continued on next page)

TABLE 1
Coding Example for a Hypothetical Green Ribbon School (Continued)

		Sustainability focus				
	Item	*Healthy environment*		*Healthy population*	*Economic efficiency*	
Educational scale	Community	(8) 9th and 10th grade students present their findings from their riparian studies to community members at city council meetings. (4) The school offers reasonably priced local produce shares, and free health, wellness, and cooking workshops to the school community. (9) At least 10 home gardens have come out of campus gardening workshops.	(2) Students meet with local farmers to choose what they grow in the schoolyard garden. (2) *Throughout the garden harvest process, the school runs workshops with parents to show what students have done in garden and to teach them how to grow at home, no matter the space available to them.*	(5) The school facilitated the education of students' parents, who then led workshops at the school for other parents on green cleaning supplies in the home, and helped two unemployed mothers start a green-cleaning business.		*Process of influence*
			Process of influence			

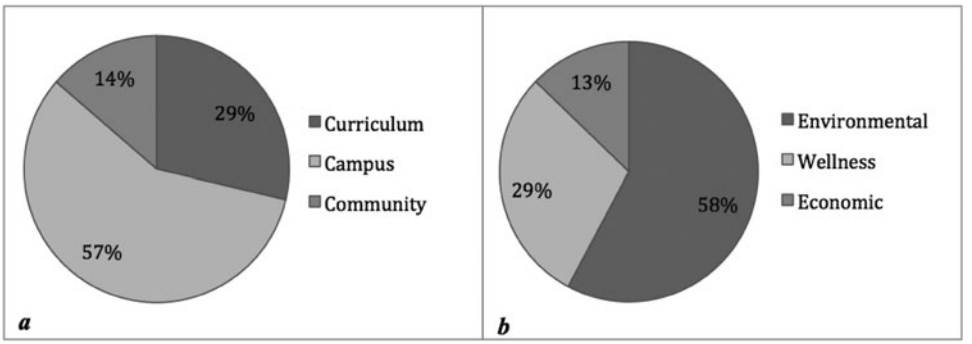

FIGURE 3 (a) Percentage of the 289 total projects within each of the three scales of our interconnectedness metric; (b) Percentage of the 289 total projects within each of the three sustainability foci.

interconnectedness ratio for this entire school would be 0.7 (7 interconnections / 10 projects = 0.7).

RESULTS

We analyzed our coding effort in three ways. First, we categorized the types of projects that were being undertaken by all of the Green Ribbon Schools in our study. Next, we determined the extent of interconnectedness of different types of projects by calculating project-interconnectedness ratios. Finally, we determined the extent of interconnectedness of each school's Green Ribbon program by calculating each school-interconnectedness ratio. Figure 3 shows the percentage of projects in each of the three educational scales, and in each of the three sustainability foci. We also categorized projects into scale/focus categories, as seen in Table 2. This categorization of

TABLE 2
Number of Sustainability Projects Per Sustainability Area and Corresponding Project-Interconnectedness Ratios

Sustainability areas	*Number of projects*	*Number of interconnections*	*Project-interconnection ratio*
Curriculum/environmental	56	50	0.9
Curriculum/wellness	23	10	0.4
Curriculum/economic	5	4	0.8
Campus/environmental	84	47	0.6
Campus/wellness	51	38	0.7
Campus/economic	31	14	0.5
Community/environmental	27	6	0.2
Community/wellness	11	4	0.4
Community/economic	1	0	0.0
Total	289	173	0.6

projects into the nine scale/focus categories provides a snapshot of how Green Ribbon Schools are approaching sustainability education. These statistics are, of course, influenced by local and state regulations, and by the funding available to schools to implement sustainability changes. For example, public schools (i.e., those maintained at public expense to serve a community) find it more difficult to incorporate sustainability into their curriculum than do private schools (i.e., a school maintained by a private group to in turn serve that group) that do not need to meet explicit state and federal testing standards. Also, the geographical distribution of our data set influenced the types of projects available to schools. For example, Green Ribbon Schools in the southwest and southern United States implemented campus gardens more frequently than schools in the northern latitudes do to the favorable climate during the school year.

The majority of Green Ribbon projects in the 59 schools focused on the environment, at scales of the curriculum and the campus. Wellness-related Green Ribbon projects also represented a large portion of schools' sustainability efforts, as 85 of the 289 projects focused on wellness across all three scales. The most common types of wellness projects were campus-wide exercise programs, the sourcing of organic foods for school lunches, the offering of health and wellness classes beyond state and federal requirements, the offering of after-school healthy-cooking workshops for students' families, and the design and implementation of safe commuting programs. More wellness projects were initiated at the campus scale than at the curriculum or community scales. Fewer economic-sustainability projects were implemented in the 59 schools than in the other two sustainability foci. A total of 37 out of 289 Green Ribbon projects focused on economic efficiency. A majority of those projects were focused on the campus. Campus/Economic projects in the 59 Green Ribbon Schools included Energy Star certifications, energy saving operation and maintenance plans, energy efficient building retrofits. Very few schools implemented economic projects at the curriculum or community scales.

After categorizing Green Ribbon projects into scale/focus categories, we calculated the interconnectedness ratio for each of the nine scale/focus categories, shown in Table 2 as the project-interconnectedness ratios. To do this, we counted the total number of interconnections for all projects across all schools within each of the nine scale/focus categories. We summed these interconnections for each scale/focus category and divided this sum by the total number of projects in each corresponding scale/focus category. In no scale/focus category was the number of project interconnections greater than the number of projects. This resulted in project-interconnectedness ratios that were between 0 and 1. These ratios give us insight into how different types of projects are applied across all schools in our study.

Finally, we calculated the interconnectedness ratio for each school, or the school-interconnectedness ratio. To do this, we summed the total number of projects at each school that comprised their Green Ribbon program, and the total number of interconnections at each school, and then divided the number of interconnections at each school by their total projects. Twenty-five of the 59 Green Ribbon Schools have interconnectedness ratios of less than 0.6. A ratio of less than one means that a school has more projects operating within a single category than they have operating across categories. A ratio of more than one means that a school's Green Ribbon projects extend across at least one category on average. The higher the interconnectedness ratio, the more interconnected a school's Green Ribbon program. As seen in Figure 4, the majority of schools had interconnectedness ratios of less than one.

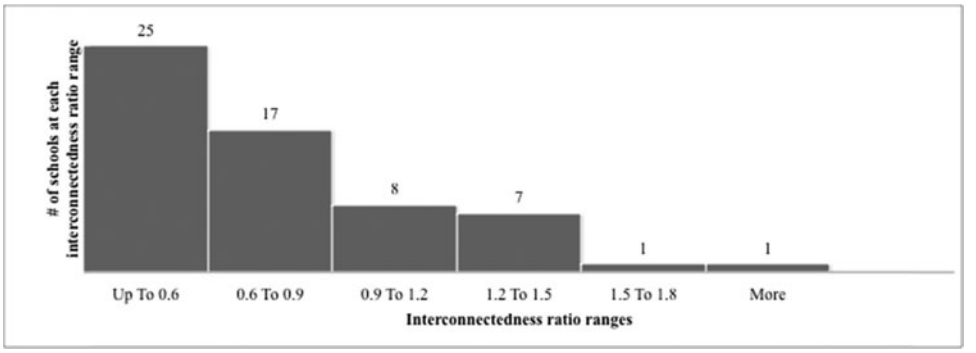

FIGURE 4 School-interconnectedness ratio distribution. This histogram shows the interconnectedness ratios for each school in our study.

DISCUSSION

In this section, we explore the key themes that emerged in our results. We provide an analysis of differences between the ability of different types of projects to promote interconnected Green Ribbon programs. We also examine why and how some schools achieve high interconnectedness ratios while other schools pursue sustainability education without integrating projects across scales; we discuss the difference between these approaches. To guide this inquiry and evaluation, we ask a number of key questions, these include:

- What types of Green Ribbon projects lend themselves to interconnection across different types of schools programs, and why?
- What types of Green Ribbon Schools achieve high levels of project interconnectedness, and what types of schools do not, and why?
- What common factors are shown to increase the interconnectedness of schools' Green Ribbon programs?

Interconnectedness of Green Ribbon Projects

A majority of Green Ribbon Schools in our study focused on implementing projects that would "green" their campuses. The terms "green" and "greening" were used throughout many schools' descriptions of their projects, however the terms were often ambiguous and most of these types of projects fell within the environmental/campus category. Typically, these projects were showcased and they were very visible to students and to the public. Examples included solar panels, windmills, tree planting initiatives, and outdoor classrooms. Often, schools received grants from both public and private organizations that allowed them to implement these environmental/campus projects. A list of common environmental/campus projects from schools in our study is shown in Table 3. These types of projects were moderately interconnected to other sustainability areas, with an average interconnectedness ratio of 0.6. This means that just over half of all environmental/campus projects were interconnected to other sustainability areas. Examples of these interconnections included science teachers who often used the school's solar panel project in

TABLE 3
Types of Environmental/Campus Projects Implemented at Green Ribbon Schools

Type of project	*Level of interconnectedness*
Natural lagoon wastewater treatment systems school for onsite treatment	High
National Wildlife Federation Certified schoolyard habitats	High
Green roofs	High
Renewable energy projects including solar panels and windmills	High
Inclusion in the Department of Energy's Wind for Schools Program	High
LEED green design certifications	Medium
On-campus compost systems	Medium
Rainwater harvesting systems	Low
Reduced trash collections	Low
Grey water plumbing systems	Low
Annual audits of plumbing and irrigation systems to prevent water leaks and identify opportunities for water savings	Low
Recycling programs	Low
Cafeteria waste reduction programs utilizing reusable plates, cups, and utensils	Low

lessons about electricity. These lessons typically included a comparison of different types of energy production so students could better understand environmental tradeoffs. The same was true for most habitat restoration and water saving initiatives. Science curriculum almost always incorporated, to some extent, environmental/campus projects.

On the opposite end of the environment/campus category were recycling projects; as one of the most popular types of environmental/campus projects, they were rarely incorporated or used in any other scale/focus category. Campus-wide recycling efforts were typically initiated by a charismatic teacher, or by a school's environmental club (or equivalent). The schools often cited recycling projects as one of their biggest sustainability achievements, but personal interviews with teachers showed these projects were often very difficult to sustain due to the lack of interconnectedness into any other part of the school. Similarly, sustainability-training projects for teachers were very popular among the schools. Training projects usually targeted either classroom "greening" techniques, or new on-campus technologies such as solar panels and windmills. This training typically provided information to teachers, but it did not provide the materials and resources necessary for teachers to incorporate the information into lessons or projects.

The least interconnected Green Ribbon projects were in the community-focused categories. The schools in our analysis often used community resources to educate students about sustainability. This process typically occurred through environmental education curriculum that accessed community resources through field trips, but these efforts were typically "extractive" in the sense that the schools were not interacting or "giving back" to community resources such as farmers' markets, nature preserves, or civil services. Teachers would often organize field trips as part of their environmental/curriculum sustainability efforts. These field trips would allow students to learn about their larger environment, but rarely did teachers initiate ongoing projects in the community that could be regularly used in curriculum. Therefore, many projects were interconnected to the community, but community projects were not often interconnected to other sustainability

areas. After-school clubs' efforts accounted for a majority of community-oriented Green Ribbon projects within the schools we analyzed. Examples included ongoing partnerships with local and state land preservation groups including the Audubon Society, the Nature Conservancy, and state park services. Through these partnerships, after-school clubs would devote time to projects including trail maintenance, trash pickups, and riparian restorations. The clubs would also often host experts from these organizations at their schools to give lectures or symposia to other students at their schools. Table 4 provides a list of common projects in the community-focused sustainability area.

Interconnectedness of Green Ribbon School Programs

As shown in Figure 4, 25 of the 59 schools in our analysis have an interconnectedness ratio less than 0.6. This means that approximately half of the projects undertaken by the schools in this group exist in isolation from the rest of the school. Interestingly, it seems that schools that obtain Green Ribbon certifications and that are highly interconnected rely on only a few, highly interconnected projects. Alternatively, schools that were able to gain a Green Ribbon certification without implementing interconnected projects typically implemented a larger number of isolated projects. Figure 5 shows this trend, which we found by plotting the number of projects at each school by the school's interconnectedness ratio. Schools with fewer projects often had higher interconnectedness ratios.

We attempted to determine which types of Green Ribbon Schools achieved high levels of project interconnectedness, and which types did not, and why. It seems the types of projects

TABLE 4
Types of Community Projects at Green Ribbon Schools

Type of project	*Ease of interconnectedness*
Student groups analyze, clean, and reclaim local riparian habitats	High
Schools host annual sustainability conferences	High
Schools partner with local universities to provide mentors to students	Medium
After-school clubs create community awareness campaigns to protect local endangered species	Medium
Schools host annual Earth Day celebrations for their communities	Medium
Student groups conduct community service by participating in the school's civic engagement programs, and working with nonprofits that focus on environmental issues	Medium
Schools host architects, designers, and builder visitors, to discuss community green design	Medium
Schools partner with other local K–12 schools to share and disseminate sustainability best practices to other area schools	Low
Schools incorporate intergenerational tutoring centers, senior centers, parent resource centers, and police sub-stations	Low
Schools host gang intervention services with local police departments	Low
Schools offer GED programs for parents and community members	Low
Schools host "Reuse Centers" that allow the community to drop off clothing, books, and classroom supplies that they don't need; the school then donates items to needy families	Low

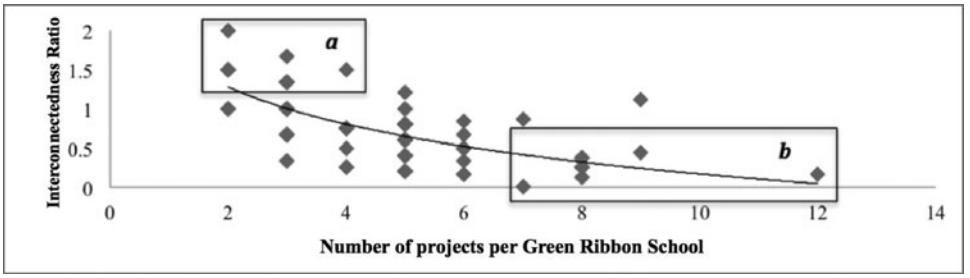

FIGURE 5 School-interconnectedness ratio trend in sustainable schools in the ED-GRS program, $r^2 = 0.43$.

that were most successfully interconnected across categories within our study were initiated in either schools' curricula or on schools' campuses with a focus on student health. Most schools that initiated these types of projects relied on resources from the surrounding campuses and communities. This reliance, combined with the problem solving nature of sustainability, often led schools to initiate service projects where students would engage with their community to both learn and to improve their community's well-being. Student wellness interventions typically involved the construction of outdoor learning environments; many of these projects also promoted the interaction between schools and communities to source local, organic produce. However, the types of schools pursuing interconnected projects were in a minority. The 17 Green Ribbon Schools, whose projects were most interconnected with interconnectedness ratios of 0.9 and above, typically fell into one of two groups. These schools were,

1. newly constructed and designed with a "vision of sustainability," and they were typically promoted as a flagship of the local school district, or were
2. small private or charter schools with strong leadership.

These unique schools represent the majority of schools in box "a" in Figure 5. We saw no evidence of differences in school interconnectedness across groupings of high schools, middle schools, and elementary schools.

It is apparent that much of a school's ability to take a whole-school approach to sustainability education is based upon the organization and culture of that school. Deal and Peterson (1999) describe this culture and organization as the set of rules, traditions, norms, and expectations that dictate everything from educational outcomes to camaraderie among teachers and staff. We found that charter and private schools were more interconnected than larger public schools, and this difference seems to stem from differences in the underlying organization of these two types of schools. Many of the schools represented in box "b" in Figure 5 were typically large, and public. Many of these schools serve urban populations, and therefore serve either demographically mixed student bodies, or relatively homogenous, minority populations. Most of these schools have long histories in the communities that they serve. The size of these schools, and their histories seem to have made it difficult for the schools to integrate Green Ribbon projects that cross disciplines and schools. These seem to be the barriers to interconnected Green Ribbon programs in many of the least interconnected schools in our study. Many of the least interconnected schools have implemented rigorous recycling projects, but they failed to educate the students and community on the need for recycling because those administrators or teachers driving the project do not possess

the resources or time to do so. Another example—natural science classes often adopt curriculum designed to teach students how natural resource extraction can degrade the environment. However, this curriculum was rarely coupled with the economics or health curriculum that could explain how societies develop or why humans extract natural resources in the first place.

It was apparent through our interviews with teachers and administrators that less interconnected Green Ribbon programs also lacked administrative management for sustainability education. Principals and other administrators play significant roles in creating cultures of change in schools. They, more than other educational stakeholders, can establish new values and norms (Riehl, 2000). While the school administrators in our study often supported their school's Green Ribbon program, many of the projects within these programs were not interconnected throughout the school because administrators often failed to push Green Ribbon projects into other categories. Many administrators in less interconnected schools seemed to fail to create a sense of urgency about the need for sustainability education, according to teachers in schools with less well interconnected Green Ribbon programs. They typically left the creation of a sustainability vision and the project management in the hands of teachers and students, rather than taking leadership responsibilities. While these school administrators did often tout and reference their Green Ribbon programs, they typically failed to communicate, or they miscommunicated the vision of the programs. In some schools, administrators created barriers to interconnected sustainability education in the form of unfulfilled funding and support promises to teachers and students.

The interview data we collected from teachers and school administrators helps clarify the differences between Green Ribbon programs at different types of schools in our study. To gain insight into these differences, we separated the schools we analyzed into three broad groupings, based upon their level of interconnectedness (>0.9, 0.9-0.6, <0.6). While different types of schools fell into each of the three groupings, a majority of schools in the >0.9 category were private or charter schools, and a majority of schools in the <0.6 category were large public schools, typically located in urban settings. Medium-sized rural or suburban schools made up the largest percentage of schools in the 0.9–0.6 grouping. We present general statistics for each of these school typologies in our study in Table 5; our definitions of school types are quite broad due to the wide variety of schools that achieved Green Ribbon certifications, but there are obvious differences between the three types. The largest differences are the student populations served, and the student/teacher ratios.

We asked teachers and administrators within each grouping (>0.9, 0.9–0.6, <0.6) various questions about their Green Ribbon programs to verify our direct content analysis coding, and to better understand how the opportunities and barriers to interconnected Green Ribbon programs faced by different types of schools. We coded their responses to multiple questions and looked for themes and trends in their answers across the different groupings and types. One question in particular provided rich insight into differences between Green Ribbon programs across different groupings. We asked teachers and administrators to simply define the Green Ribbon program at their school, and then we coded their responses by clustering like statements into groups within each interconnectedness-ratio grouping, and defining the common theme within each cluster. We then looked for similarities and differences across the three groupings. Table 6 provides an analysis of differences between the Green Ribbon programs of the three groupings of schools. It can be seen that schools in each grouping envision sustainability education differently. Schools in the least interconnected group seem to approach sustainability as an additional undertaking, instead of a new educational paradigm. Moderately interconnected

TABLE 5
School Typologies

School type		
Large public	*Medium public*	*Charter/private*
Typically located in urban settings	Typically located in suburban or rural settings	No common setting
Ranked <50% in math and reading testing scores compared to all other state schools	Ranked >75% in math and reading test scores compared to all other state schools	Ranked >90% in math and reading test scores compared to all other state schools
Student body size of >400	<400 students enrolled school	<200 students enrolled in school
>50% of the student population is non-white	>70% of the student population is white/Caucasian	~50% of the student population is non-white
>50% of students qualify for free or discounted student lunches	<25% of students qualify for free or discounted student lunches	<50% of students qualify for free or discounted student lunches
Student/teacher ratio is ~20:1	Student/teacher ratio is ~20:1	Student/teacher ratio is <15:1

schools approach their Green Ribbon programs much like the least interconnected schools, using additional projects and adding new classes to their traditional curriculum. A large divide exists between the most interconnected schools and the moderately interconnected schools in terms of their approaches to sustainability education. Schools with high interconnectedness ratios most often view their Green Ribbon programs as a paradigm shift, away from traditional curriculum. Many of these schools developed vision statements defining their approach to sustainability education, and they recount these visions in faculty meetings and in grant applications.

Factors Shown to Increase the Interconnectedness of Schools' Green Ribbon Programs

While most of the schools in the most interconnected grouping in Table 6 were either private or charter, there were some highly interconnected schools that did not fit this model. Our new metric allowed us to identify those schools with the most highly interconnected Green Ribbon programs. We analyzed similarities between these highly interconnected programs to determine which factors may increase interconnectedness. Of course, for any one school, outlining a specific vision for a school's Green Ribbon program is a process that needs to be undertaken by administrators, teachers, students, and local stakeholders. However, our analysis identified a number of key features that characterize the highly interconnected Green Ribbon Schools. Each of these factors were shown to be present among highly interconnected programs in each of the three school

TABLE 6
Sustainability Education Themes in Different School Groupings

	What is sustainability at your school?	
School grouping	*Theme*	*Representative examples from interviews*
>0.9	Interdisciplinary problem-based learning	Sustainability programs are an approach to education that teaches students to identify problems in communities, and then teach students to effectively address those issues in different ways through cross-disciplinary problem-based learning.
	Increases in interschool communication	Sustainability programs have increased the "contact points" between disciplines, and between disciplines and administrators; there are more open lines of communication.
	A vision of education	Sustainability is a vision of education that goes beyond environmental concerns, it is an approach to education that links problems in our society to our curriculum, in hopes of finding solutions to our problems
	Shifts in educational goals	Sustainability programs become more complex each year; they have forced teachers to ask students "what does it really mean to be sustainable?" This question appears often in curriculum and learning objectives across disciplines.
0.9-0.6	Modifications in curriculum	Sustainability programs consist of specific lessons in different classes. Each discipline decides how their will incorporate sustainability into their department, and they report back to the administration.
	Additional class offerings	Specific sustainability classes are the center of sustainability programs.
	Interdisciplinary project-based learning	Sustainability programs focus on linking students to the outdoors to understand environmental issues through projects and curriculum.
	Additional projects in classrooms and extracurricular programs	Sustainability programs consist of many different components, including the morning announcements, weekly newsletters and electronics and clothing drives that raise awareness about schools' sustainability projects.
<0.6	Flagship projects	Sustainability programs teach kids the value of "reuse, recycle, and reduce."
	Guide to changing educational standards	Sustainability programs help schools adopt new state and federal education standards, designed to increased problem-based learning in schools.
	Disciplinary project-based learning	Sustainability curriculum, distributed by school administrators, helps teachers update their curriculum by increasing the relevancy of classroom projects to students.
	Disciplinary problem-based learning	Sustainability programs operate within science departments, where students are taught why resource development harms the environment.

typologies described in Table 5:

- School administrators require sustainability education to be considered in all schoolwide decisions;
- Schools build and maintain reciprocal community partnerships with local governments, NGOs, and citizens;
- Problem-solution-based learning and participatory learning guides curriculum development;
- Schools emphasize the importance of grant writing;
- School administrators work to open and maintain communication and good relationships with district level administrators;
- School administrators emphasize interdisciplinary curriculum development;
- Teacher development projects provide time and support for teachers to design problem-solution-based curriculum;
- School stakeholders develop and display a vision statement defining their sustainability program; and
- School administrators monitor and evaluate sustainability education projects that inform the school's next steps.

CONCLUSION

Over the past decade, environmental educational researchers have called for increased interconnectedness of our K–12 curriculum across disciplines and into the larger community (Beddoe et al, 2009). These calls have come under different names; solution-based learning, sustainability education, situated learning, and active learning are all attempts to develop educational paradigms that engage with subjects rather than passively present students with information. All these approaches call for interdisciplinary curriculum. However, to date, education is very disciplinary in the United States (Moore, 2005). The links between the environment and economics, mathematics, literature, etc., are not presented to students in a school's typical curriculum (Clark & Button, 2011). This traditional paradigm is often reinforced by state educational standards upon which schools are compared. This results in students who are able, in some cases, to succeed in standardized examinations but who cannot apply their education to solve problems in the real world. Sustainability education tries to address this deficiency. It requires students to not only understand problems, but to understand solutions in the context of complex communities. Our analysis has drawn insights into the types of sustainable projects that are most often interconnected to multiple educational components in hopes of overcoming the path-dependency of the disciplinary paradigm.

Our metric is part of a tool set that can be used by schools and policy makers to measure progress toward sustainability education. In its current form, teachers and administrators can apply the metric to their own schools and track changes in their sustainability programs from year to year. However, more research is needed to develop a self-reporting method that can overcome the data-consistency challenges we faced when attempting to compare schools. There are many challenges associated with the use of self-reported data in the comparison of schools. For example, certain projects may be highlighted and others may be left out of an application depending on which school entity or groups is involved in compiling information. Validation

and verification of self-reported data is a resource-intensive endeavor, but some of these challenges can be overcome through the design and implementation of a self-reporting scheme that emphasizes the importance of relationships between sustainability projects throughout schools.

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