



The Soil Quilt Storybook as a Tool in Elementary Education

STUDY RESULTS & FINAL REPORT

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INTRODUCTION

To introduce children to soil health practices and concepts related to sustainability, the South Dakota Soil Health Coalition (SDSHC) coordinated the creation of a storybook titled “The Soil Quilt”, written by Amanda Radke and illustrated by Michelle Weber. Centered around the storybook, the SDSHC collaborated with 3rd-, 4th-, and 5th-grade educators across South Dakota to support classroom activities and conducted in-person read-along events hosted by farmers, ranchers, and conservation professionals. The primary goal of the project was to increase student understanding of the role healthy soil plays in providing our food, shaping our landscape, and sustaining our communities. Nearly 700 educators across the state were contacted, approximately 20 expressed interest and were recruited for the project. 13 events were held at 11 different schools, impacting over 350 total students. In this study, we evaluated three primary outcomes of interest: student perceived knowledge (confidence) levels, interest levels, and demonstrated knowledge levels related to soil health and agricultural topics found in the book. We also assessed teacher perceptions and needs.

The primary finding of the study is that although the reading event did not noticeably impact interest levels in agriculture and soil health-related topics, it did substantially improve student confidence in their knowledge about the topics and moderately improved their ability to demonstrate knowledge on concepts found in the storybook. We also found that students with high amounts of interest in the specific topics of Agriculture and Sustainability, although making up a small percentage of all students surveyed, tended to score higher on the post-event knowledge quiz, but overall interest levels do not correlate. Additionally, students who demonstrated prior knowledge of the topics covered in the book were more likely to succeed in demonstrating higher knowledge about the topics after reading the book as well, suggesting the storybook can be helpful for reinforcing concepts. However, the most predictive factor of post-event quiz score was post-event confidence in the topics.

Based on the results of the teacher and student perceptions of knowledge levels, it may be beneficial to increase education efforts on tilling, wetlands, sustainability, soil health, organic matter, microorganisms, infiltration, conservation districts, carbon, agronomy, and erosion. For improving teaching confidence, sustainability, protecting nature (conservation), and climate change are subject areas that could be focused on. Lastly, student knowledge outcomes do not appear to depend on teacher perceptions, and instead likely are largely influenced by self-perceptions, the reading event itself, and other environmental factors not considered in this study.

Future work will include coordinating educational workshops for teachers centered around utilizing The Soil Quilt book for additional classroom activities, lesson plans, and learning activities, not only for reading and science-related outcomes, but also for subjects such as math, history, and social studies. Additionally, we will work to create pre-made lesson plans, interactive activities, and digital resources on subject matter from the book for instructors to utilize in their classrooms. We also would like to

investigate ways we can increase interest in soil health, agricultural, and sustainability-related topics among students.

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under agreement number 2022-38640-37486 through the North Central Region SARE program under project number YENC24-225. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy.

METHOD

The study followed the following approximate timeline:

- Summer 2024 – Student & Teacher survey development
- Summer, Fall 2024 - Teacher contacting, recruitment, and event scheduling via email
- Fall 2024, Spring 2025 - Pre-surveys completed by students at least one week prior to the event, reading events held, and post-surveys completed by students and teachers within one to two weeks following the event
- Winter 2024, Spring 2025 – Survey & data analysis
- Future (Late 2025 through 2026) – Teacher workshops & additional resource creation

Three different surveys were administered online via SurveyMonkey including a Student PRE-survey, Student POST-survey, and Teacher survey. Printable versions were also developed and made available, but none of the participating teachers opted for these versions. The student surveys assessed three outcomes: perceived knowledge (PK) levels, interest levels (IL), and demonstrated knowledge (DK). PK and IL questions had a 4-point Likert scale from “Not at all...” (= score of 1), “Somewhat...” (= score of 2), “Knowledgeable/Interested” (= score of 3), and “Very...” (= score of 4) for various agricultural and environmental topics introduced in the storybook. DK was assessed with a 10-point “quiz” that included a mix of multiple choice and true/false questions based on content from the book. The maximum total PK score (answering “Very...” for all topics) was 52 points and the maximum total IL score was 24 points. The student pre- and post- surveys were identical except one additional perceived knowledge improvement question in the post-event survey. The goal of the teacher survey was to understand the needs and confidence of teachers regarding educating on topics within the book, gauge interest and availability for workshops, and understand how they perceive student interest and knowledge levels.

After receiving all pre- and post-survey responses, data were cleaned, pre-post survey responses were matched for individual students, scores were assigned to Likert scale responses, and changes in individual scores and total scores for each of the three outcomes components (PK, IL, DK) were calculated. Distributions of scores by topic across the full student sample were visualized using Likert plots. In order to assess and quantify the effect of the reading event on PK, IL, and DK, the following tasks were completed: calculating mean changes in scores by topic; calculating standardized effect size statistics on total scores for each of the three outcome components; and running paired t-tests on total scores for each of the three outcome components. All analysis was completed in R (version 4.2.2) and Microsoft Excel (version 2302).

STUDENT RESULTS

Sample Characteristics

After data cleaning and pre-post matching, there was a total of 272 individual student responses that were analyzed. Only 9 of the 11 total schools had useable pre-post survey data either due to missingness or lack of timeliness of the responses. Of the 272 students:

Age

- 12% 8 years old, 42% 9 years old, 34% 10 years old, 12% 11 years old, one student 12 years old

Grade

- 18% 3rd grade, 63% 4th grade, 19% 5th grade

Gender identity

- 51% boy, 46% girl, 3% preferred not to say

Location

- 38.6% Eastern South Dakota, 45% Central South Dakota, 17% Western South Dakota
- 30% Pierre, 19% Brookings, 17% Fort Pierre, 10% Rapid City, 9% Salem, 6% Winner, 8% Aberdeen, 5% Doland

Class activities

- 30% did additional classroom lessons about The Soil Quilt book
- 15% did the Edible Infiltration activity
- 21% did classroom lessons about farming, sustainability, and/or soil health
- Other topics noted: flooding/droughts, how bees get food for winter

Outcomes of Interest Total Scores Summary

The student surveys assessed three outcomes: perceived knowledge (PK) levels, interest levels (IL), and demonstrated knowledge (DK). PK and IL questions had a 4-point Likert scale from “Not at all...” (= score of 1), “Somewhat...” (= score of 2), “Knowledgeable/Interested” (= score of 3), and “Very...” (= score of 4) for various agricultural and environmental topics introduced in the storybook. DK was assessed with a 10-point “quiz” that included a mix of multiple choice and true/false questions based on content from the storybook. The maximum (answering “Very...” for all topics) total PK score was 52 points and the maximum total IL score was 24 points.

Table S1 provides summary statistics (mean, standard deviation (SD), median, min, max, and interquartile range (IQR)) for pre-event, post-event, and change in total score of each of the three outcomes. Table S2 displays the single frequency distribution histograms for each score type. Looking at the histograms and summary statistics, there is a clear positive shift in scores for PK and DK (changes from right-skewed to more normally distributed), while minimal change for IL (relatively normally distributed both pre and post with nearly identical means, ranges, and IQRs), although post-event does see an increase in frequency of score at the highest bin. For all outcomes, change in score is relatively normally distributed and generally centered around zero for IL and DK, while above zero for PK.

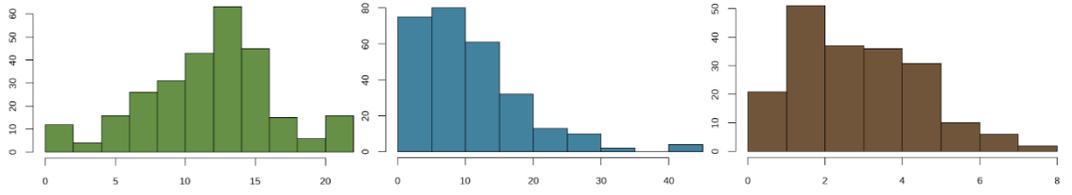
Table S1. Summary statistics of student total scores for each outcome assessed in the surveys; interest level (IL), perceived knowledge (PK), and demonstrated knowledge (DK).

Score Type	Mean (SD)	Median	Min	Max	IQR
PRE-event total IL	12.12 (4.59)	13	0	21	[9, 15]
POST-event total IL	12.71 (5.10)	13	0	21	[9, 16]
CHANGE in total IL	0.52 (5.34)	1	-20	15	[-2, 3]
PRE-event total PK	10.74 (7.91)	9	0	42	[5, 14]
POST-event total PK	18.66 (8.69)	18	0	42	[13, 25]
CHANGE in total PK	8.036 (7.81)	7.5	-24	35	[3, 12]
PRE-event total DK	3.34 (1.66)	3	0	8	[2, 4.75]
POST-event total DK	3.76 (1.75)	4	0	8	[2, 5]
CHANGE in total DK	0.43 (2.07)	0	-5	6	[-1, 2]

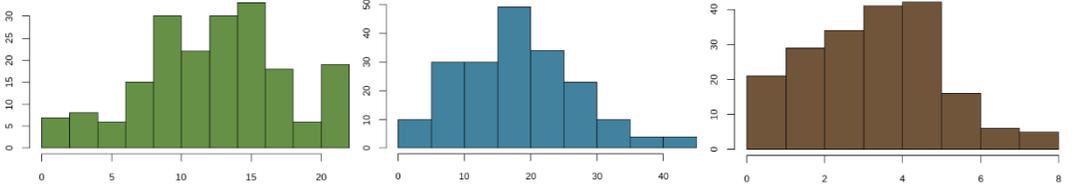
Table S2. Frequency distribution histograms of student total scores for each outcome assessed in the surveys; interest level (IL, green), perceived knowledge (PK, blue), and demonstrated knowledge (DK, brown).

Score Type	Frequency Distributions
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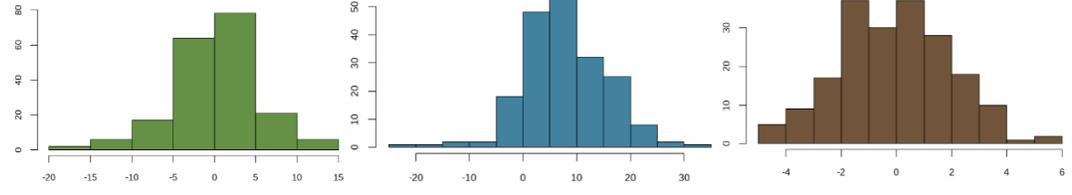
PRE-
event
total IL,
PK, DK



POST-
event
total IL,
PK, DK



Change
in total
IL, PK,
DK



Interest Levels

Figure 1 displays the percentage of all students who answered with the given interest level for each topic (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below. Note that the distribution of color intensity is nearly identical between the pre-event and post-events plots, indicating little change in interest levels as a result of the read-along event. Both pre and post, Sustainability and Agriculture have the least amount of interest, while Caring for Animals and Plants and Protecting Nature have the most amount of interest. While there is little to no obvious change in interest, mean aggregate and individual student levels did improve slightly for the low scoring topics. Similarly, Figure 2 shows the percentage of all students who had the given change in scores for each topic. The score changes are mostly zero with evenly distributed positive and negative change.

Scoring scale:

- Not at all interested = 1
- A little interested = 2
- Interested = 3
- Very interested = 4

Table 1 provides the mean changes in interest level scores for each topic, and Table 2 summarizes the statistical tests performed to assess the difference between pre and post total interest levels (the sum of all individual topics' scores). Statistically, there is no significant difference pre to post for any test. Cliff's delta and t-test confidence intervals cross zero, which indicate the possibility of zero effect, or a negative one. However, mean levels increased for all topics except Caring for Animals, Caring for Plants, and Protecting Nature (which were all highly scored prior to the event).

Overall, the reading event appears to have little to no real effect on student interest levels. This prompts future investigation into the question: How can we improve interest levels in soil health and agricultural topics?

Figure 1. Pre- vs post-event student interest levels by topic, with weighted mean scores



Figure 2. Change in individual student interest levels pre to post by topic

PRE to POST CHANGE in Student Sample Interest Levels

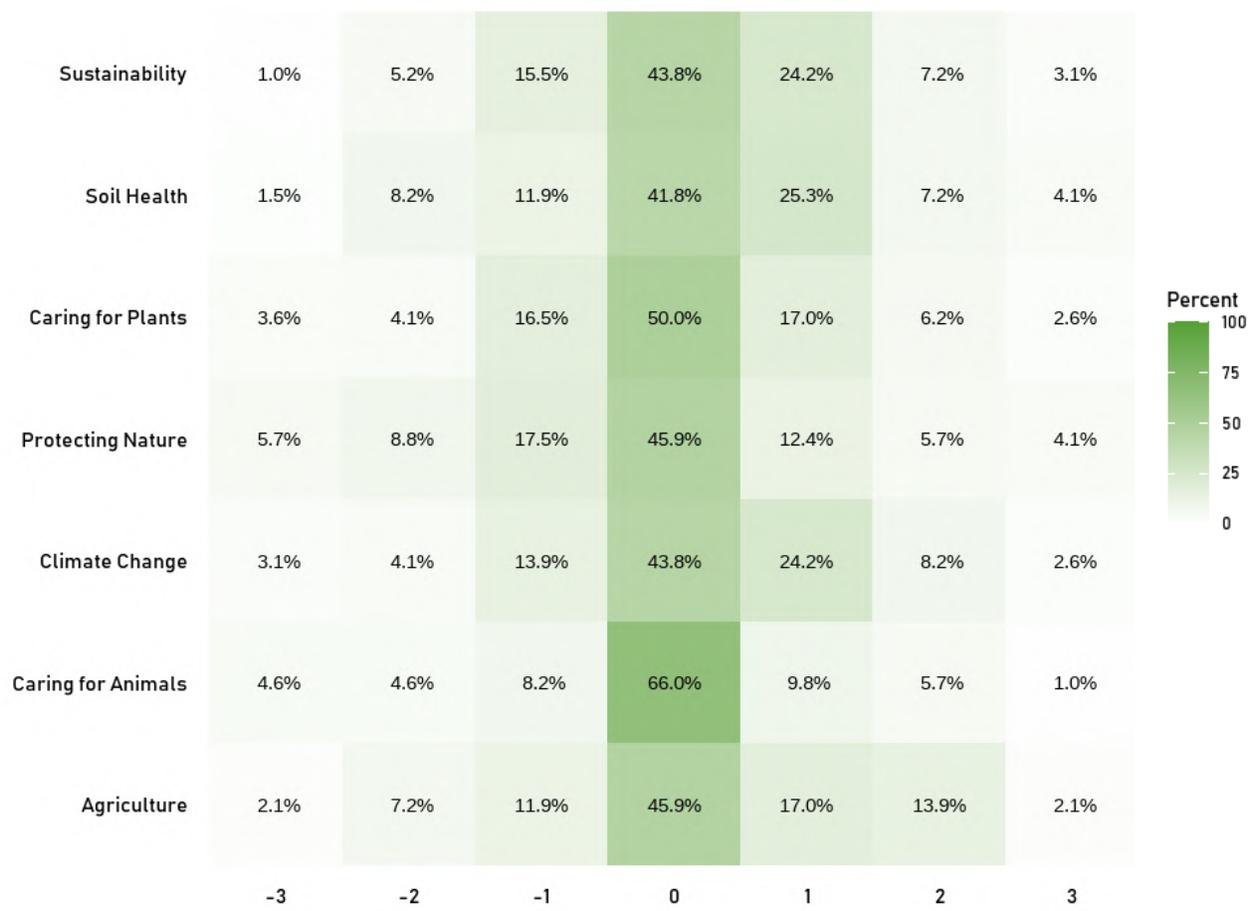


Table 1. Mean change in individual student interest level scores by topic, with pre and post average levels

Topic	Mean diff	Pre-event average level	Post-event average level
Sustainability	+0.19	Not at all interested	A little interested
Soil Health	+0.19	A little interested	A little interested
Caring for Plants	+0.015	Interested	Interested
Caring for Animals	-0.07	Interested	Interested
Protecting Nature	-0.16	Interested	Interested
Climate Change	+0.17	A little interested	A little interested
Agriculture	+0.19	A little interested	A little interested

Table 2. Effect size calculation and paired t-test results comparing pre to post total interest scores

Statistic	Value	95% CI	Size	
Cohen's D	0.12	--	negligible	
Cliff's Delta	0.08	[-0.03, 0.18]	negligible	
Vargha & Delaney A	0.68	--	Medium	
Bayesian Cohen's D	0.12	[0.06, 0.18]	100% small	
	t-value	Mean diff	p-value	
t-test	1.4	+0.52	[-0.23, 1.27]	0.18 (not significant)

Perceived Knowledge Levels

Figure 3 displays the percentage of all students who answered with the given knowledge level for each topic (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below. Note that the distribution of color intensity largely shifts from “Not at all knowledgeable” to “Knowledgeable”, indicating clear change in levels.

Scoring scale:

- Not at all knowledgeable = 1
- A little knowledgeable = 2
- Knowledgeable = 3
- Very knowledgeable = 4

The Dust Bowl, Soil Cover, and Soil Health topics had the greatest increase in perceived knowledge pre to post, Dust Bowl going from having the 2nd lowest (following Agronomy) average to having the 2nd highest (following Farmer’s Market), with a mean increase of 1.4 points. The Wetland and Farmer’s Market topics were high-scoring both pre and post, while Agronomy, Infiltration, and Sustainability remained relatively low-scoring pre to post. Similarly, Figure 4 shows the percentage of all students who had the given change in scores for each topic. The score changes are mostly 0 to around +2 points, and skew largely towards positive change.

Additionally, Figure 5 displays the percentage of all students post-event who answered with the given level of agreement based on the statement, “I know more about [topic] than before.” For all topics, the large majority of students either agree or strongly agree. The statement “I know more about *soil health* than before” had the highest average level of agreement out of the topics asked about, supporting the findings in Figure 3.

Lastly, Table 3 provides the mean changes in PK level scores for each topic, and Table 4 summarizes the statistical tests performed to assess the difference between pre and post total PK levels (the sum of all individual topics’ scores). The results show large effect size estimates for all tests, 100% large effects from Bayesian tests, and no confidence intervals cross zero. The t-test has a very strong ($p < ***0.001$) significance, indicating a real, non-random change in PK pre to post event.

Overall, the results suggest that the reading event had a substantial positive impact on perceived knowledge levels (e.g. confidence in the topics), an effect much larger than on interest levels and demonstrated knowledge (especially the former).

Figure 3. Pre- vs post-event student perceived knowledge levels by topic, with weighted mean scores



Figure 4. Change in individual student perceived knowledge levels pre to post by topic

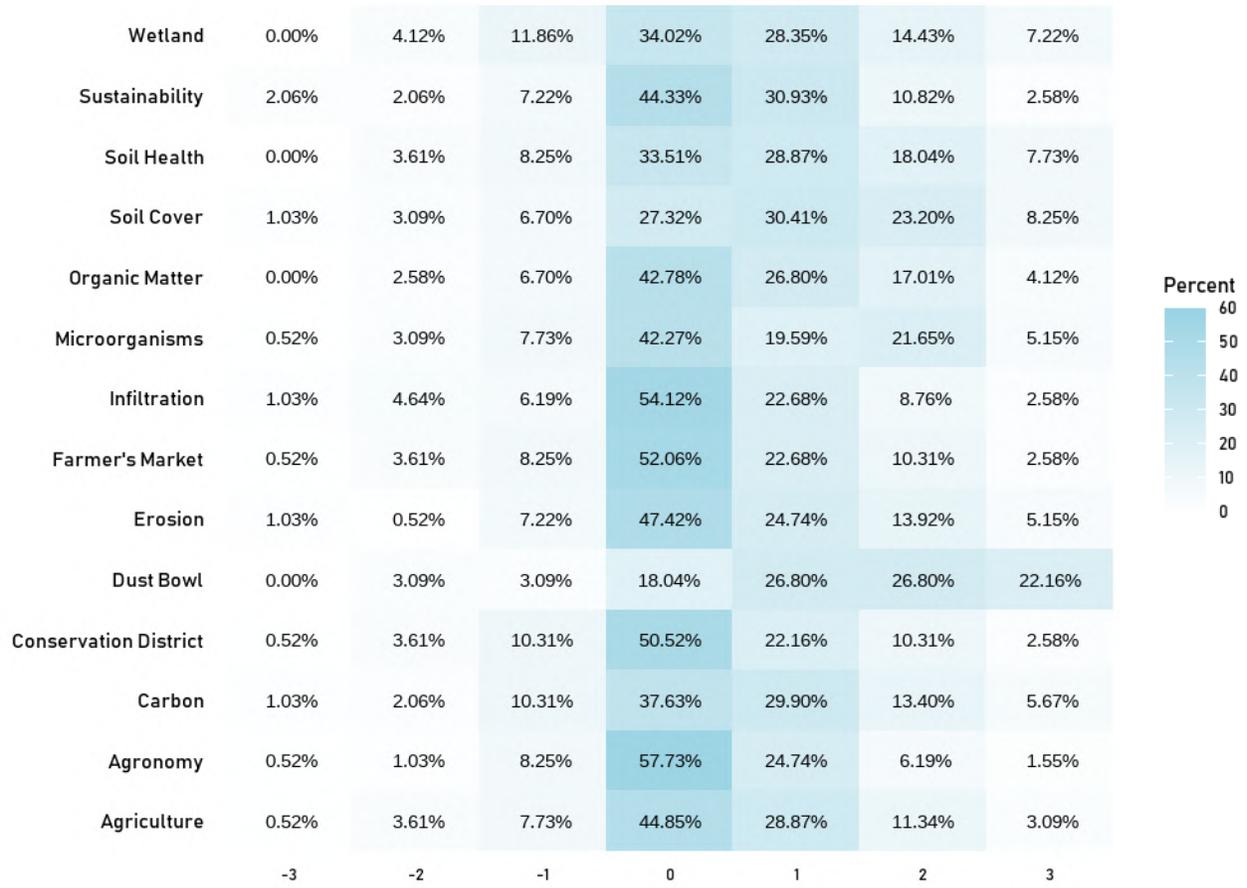


Figure 5. Post-event student agreement with the statement, “I know more about [topic] than before”, with mean scores

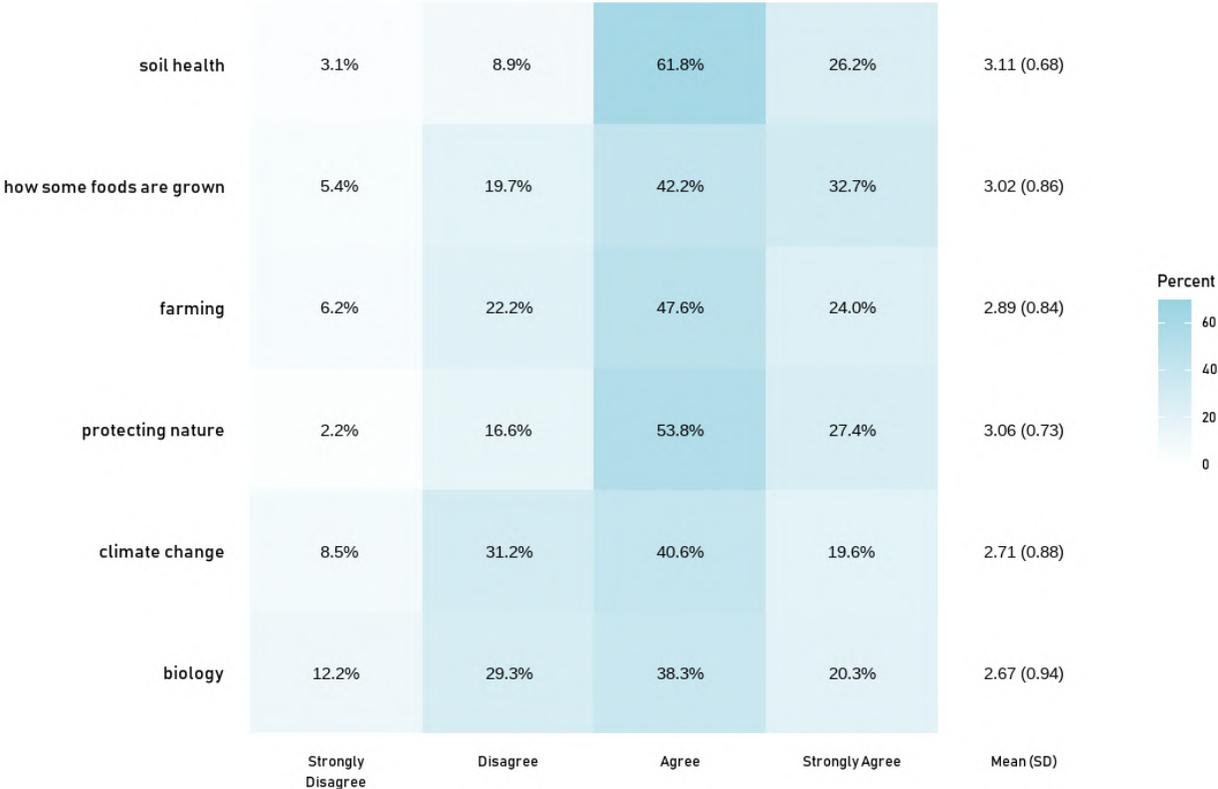


Table 3. Mean change in individual student perceived knowledge level scores by topic, with pre and post average levels

Topic	Mean change	Pre-event average level	Post-event average level
Wetland	+0.59	A little knowledgeable	A little knowledgeable
Sustainability	+0.43	Not at all knowledgeable	Not at all knowledgeable
Soil Health	+0.73	Not at all knowledgeable	A little knowledgeable
Soil Cover	+0.86	Not at all knowledgeable	A little knowledgeable
Organic Matter	+0.61	Not at all knowledgeable	A little knowledgeable
Microorganisms	+0.63	Not at all knowledgeable	A little knowledgeable
Infiltration	+0.29	Not at all knowledgeable	Not at all knowledgeable
Farmer's Market	+0.34	Knowledgeable	Knowledgeable
Erosion	+0.57	Not at all knowledgeable	A little knowledgeable
Dust Bowl	+1.4	Not at all knowledgeable	Knowledgeable
Conservation District	+0.31	Not at all knowledgeable	Not at all knowledgeable
Carbon	+0.56	Not at all knowledgeable	A little knowledgeable
Agronomy	+0.30	Not at all knowledgeable	Not at all knowledgeable
Agriculture	+0.44	Not at all knowledgeable	A little knowledgeable

Table 4. Effect size calculation and paired t-test results comparing pre to post total perceived knowledge scores

Statistic	Value	95% CI	Size	
Cohen's D	2.1	--	large	
Cliff's Delta	0.86	[0.81, 0.89]	large	
Vargha & Delaney A	0.95	--	large	
Bayesian Cohen's D	2.1	[1.9, 2.3]	100% large	
	t-value	Mean diff	p-value	
t-test	29.7	+17.9	[16.7, 19.1]	< 2.2e-16***

Demonstrated Knowledge Levels

Figure 6 displays the percentage of all students who got the given questions correct, incorrect, or marked them as “I don’t know” (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below. Figure 7 shows the same but for total number of questions (out of 10 points max) marked correct, incorrect, or “I don’t know”.

Scoring scale:

- Incorrect = 1
- Correct = 2
- I don’t know = 3

For the multiple-choice portion, the distributions between correct and incorrect for the first three questions (and the average scores) change minimally, but for “crops grown in South Dakota are sent to...”, there is a larger shift from incorrect to correct. Generally, for the true-false questions, there is a large improvement in the percentage of students answering correctly, as demonstrated in the shift away from incorrect and “I don’t know” towards correct. However, the “soil is another name for dirt” and “soil stores carbon dioxide...” questions are exceptions, where students previously answering incorrect appear to shift towards “I don’t know” post-event rather than towards correct. This may indicate students having familiarity with the concept in the statement, but lack of confidence or factual recall (e.g. they were exposed to it in the book, but perhaps it wasn’t a main or clear point). Additionally, the subjects of tilling and wetlands appear to remain a struggle for students both pre- and post-event.

For the totals, there is a clear positive shift pre to post for total correct, a negative shift for total incorrect, and a very slight positive shift for total “I don’t know” (although nearly identical). The number of questions correct with largest percentage of student post-event was 5 points (21.6%), while for pre-event it was only 2 points (26.3%)

Similarly, Figure 8 displays pre- vs post-event change in individual student demonstrated knowledge quiz total scores, with mean change values for number of questions marked incorrect, correct, and “I don’t know”. The results are skewed negatively for incorrect, skewed positively for correct, and evenly distributed for “I don’t know”, aligning with expectations from previous findings that show overall increases in correct answers with decreases in incorrect answers. This and prior figures indicate that most of the decrease in number of total questions incorrect came from the increase in total questions correct rather than an increase in questions marked “I don’t know”.

Lastly, Table 5 provides the mean changes in total questions correct, incorrect, or marked “I don’t know” pre to post, and Table 6 summarizes the statistical tests performed to assess the difference between pre and post total questions correct from the DK quiz. Overall, students answered less total incorrect (mean change -0.47), more total correct (mean change +0.43), and similar amounts “I don’t know” (mean change +0.046) pre- to post-event. The results show small effect size estimates for all tests, though not negligible. The t-test has $p < **0.01$ level significance, indicating there is moderately strong evidence that the improvement in quiz score pre- to post-event is real and non-random. Additionally, none of the

confidence intervals of any test cross zero, suggesting a 100% probably positive effect, even if small in magnitude.

Overall, the results suggest the reading event had a small to moderate, but non-negligible positive impact on student learning through the survey quiz. The impact on demonstrated knowledge levels is higher than on interest levels, but still much lower than on perceived knowledge. Additionally, there is no significant correlation between the total number of classroom activities (the reading event in addition to other lessons, activities, projects etc.) and any of the post-survey quiz scores, total correct, or change in total score correct.

Figure 6. Pre- vs post-event student demonstrated knowledge by question, with weighted mean scores (1 = incorrect; 2 = correct; 3 = I don't know)

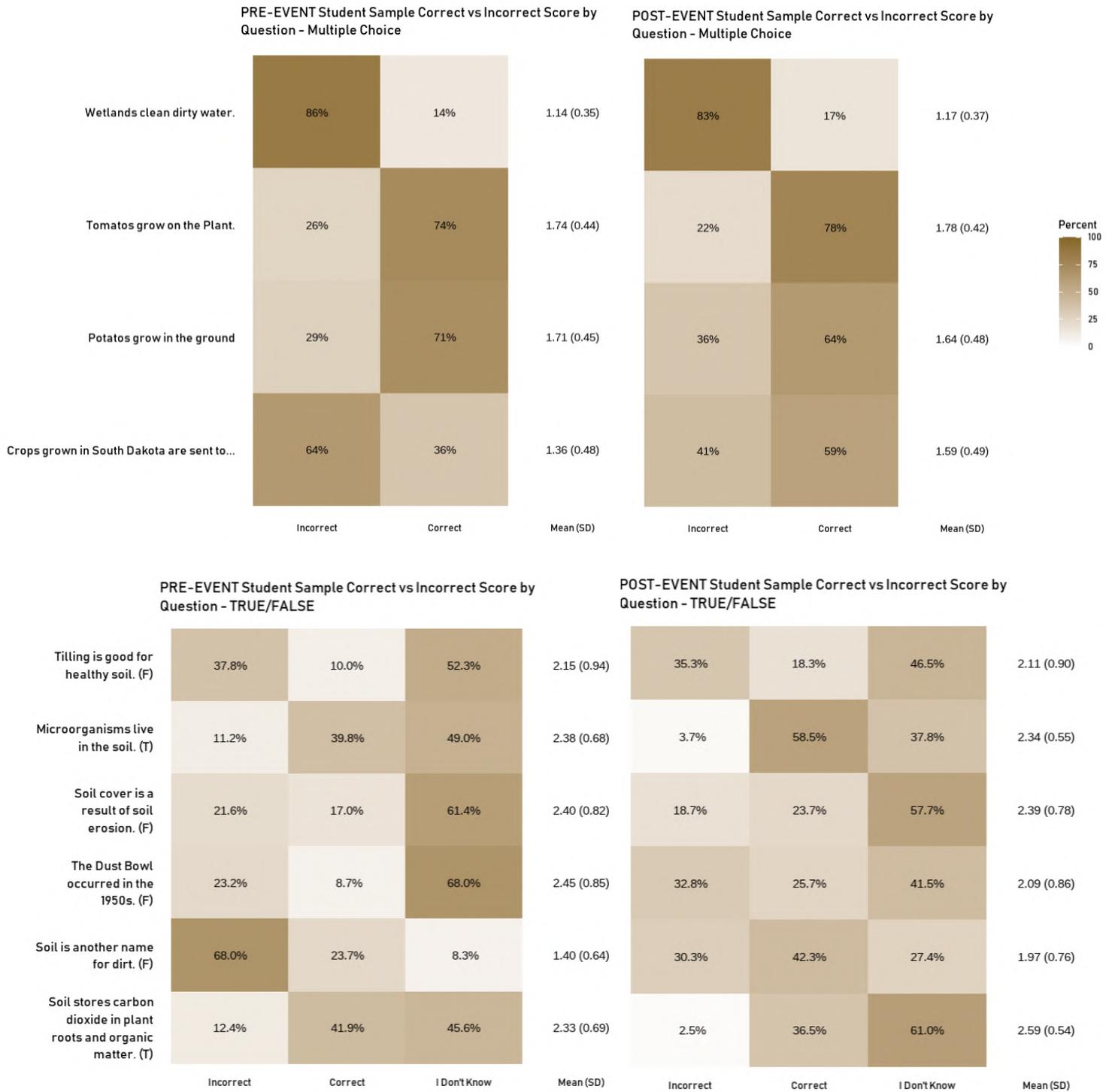


Figure 7. Pre- vs post-event individual student demonstrated knowledge quiz TOTAL scores (max 10 points), with mean number of questions marked incorrect, correct, and “I don’t know”

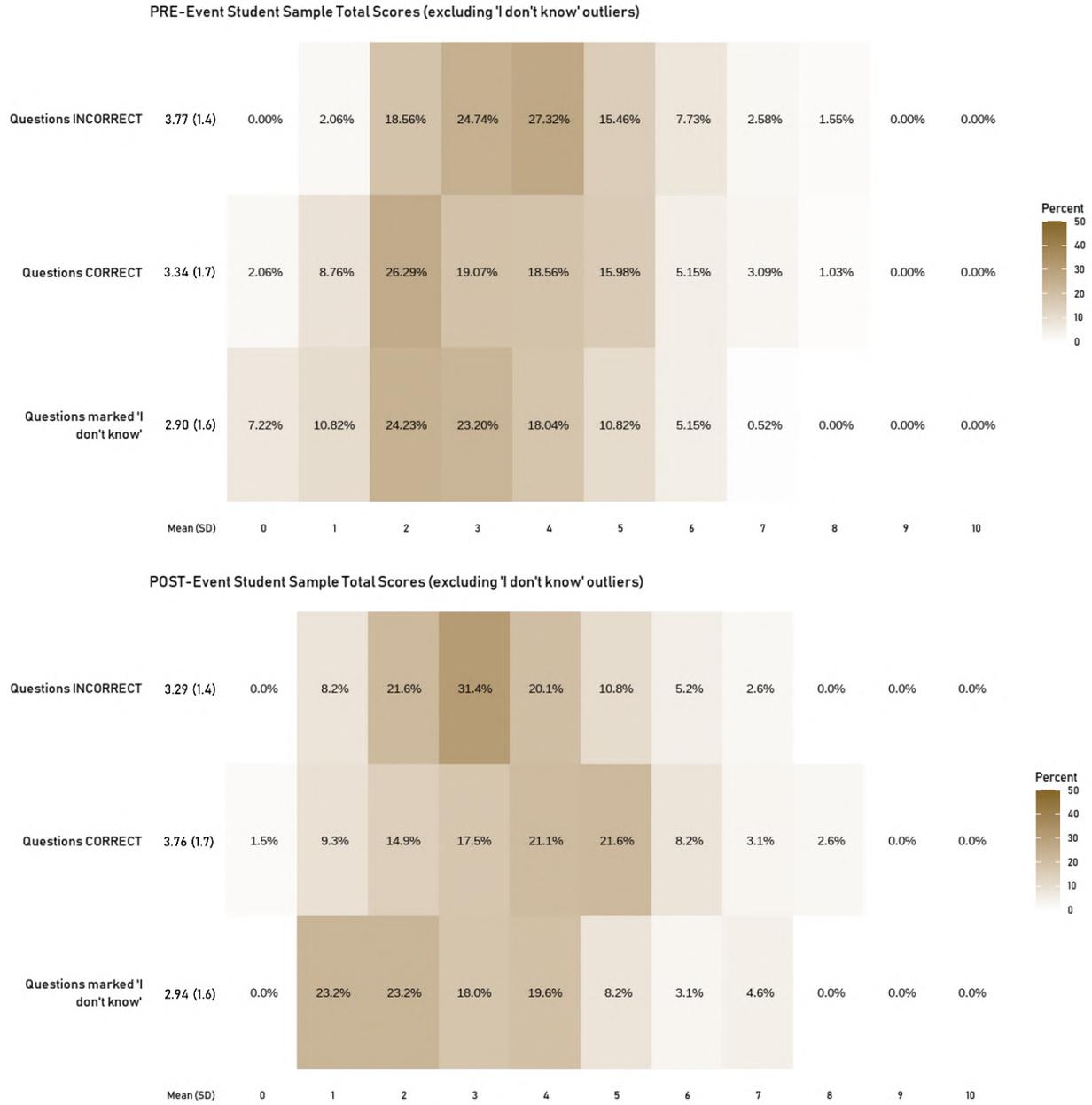


Figure 8. Pre- vs post-event CHANGE in individual student demonstrated knowledge quiz total scores, with mean change values for number of questions marked incorrect, correct, and “I don’t know”

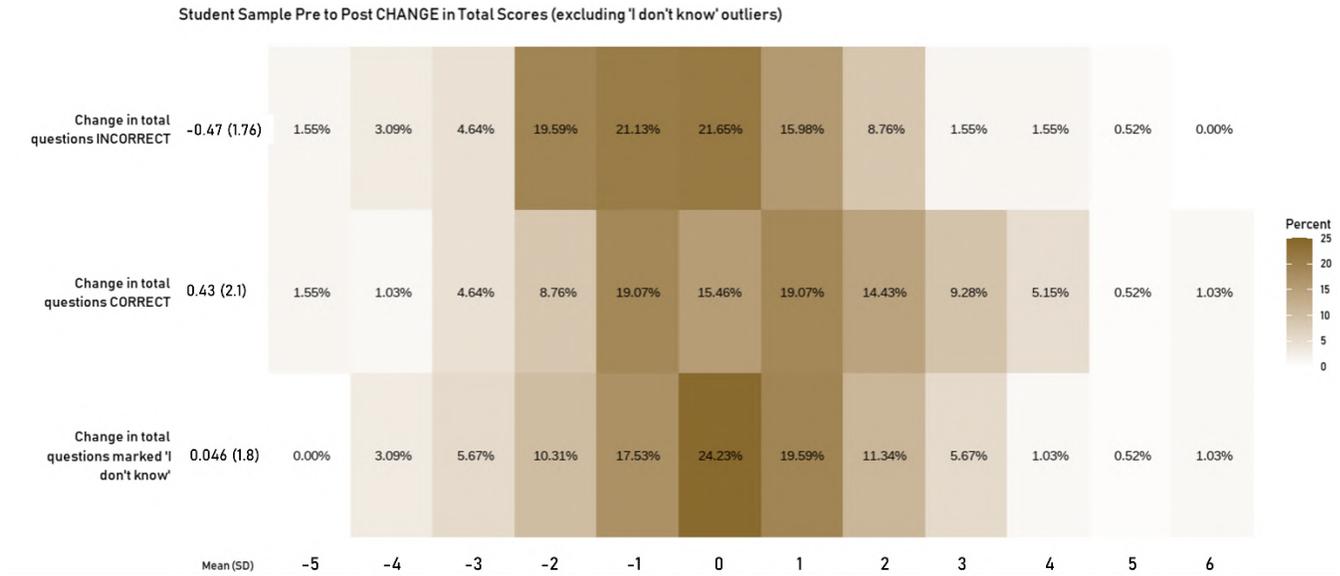


Table 5. Mean change in individual student demonstrated knowledge total number of questions correct, incorrect, or marked “I don’t know”, with pre and post average points

Score type	Mean change	Pre-event average	Post-event average
Questions correct	+0.43	3.34	3.76
Questions incorrect	-0.47	3.77	3.29
Questions marked “I don’t know”	+0.046	2.90	2.94

Table 6. Effect size calculation and paired t-test results comparing pre to post total perceived knowledge scores

Statistic	Value	95% CI	Size	
Cohen’s D	0.28	--	small	
Cliff’s Delta	0.16	[0.055, 0.26]	small	
Vargha & Delaney A	0.58	--	small	
Bayesian Cohen’s D	0.27	[0.24, 0.30]	100% small	
	t-value	Mean diff	p-value	
t-test	2.88	+0.43	[0.13, 0.72]	0.004**

VARIATION & CORRELATION RESULTS

One-Way ANOVA & Linear Model

ANOVA RESULTS

Total post-event perceived knowledge score is the most predictive factor for post-event demonstrated knowledge, followed by School, although school is colinear with Grade and City. Overall, higher grade levels are associated with higher scores, but within a given school, a higher grade level is associated with a lower score. Additionally, the inclusion of additional classroom lessons related to agriculture and the environment (not specifically about The Soil Quilt book) is associated with higher post-event quiz scores, although to a weak degree, and total amount of additional activities is not at all correlated. Table 7 provides a summary of the one-way ANOVA test results.

Table 7. ANOVA test results

Variable	F-value	p-value	Bayes Factor	Strength of Evidence
School	3.33	1.29E-03**	17.0	Strong
Total number of activities (reading event + hands-on activity + class lessons, etc.)	1.75	1.87E-01	0.33	Weak for the null
Additional class lesson completed	5.18	2.38E-02*	1.67	Weak
Age (numeric)	3.77	5.35E-02	0.84	Weak for the null
Grade (categorical)	4.66	1.04E-02*	2.86	Weak
Gender	0.11	8.95E-01	0.08	Strong for the null
Side of state (east vs west-river)	0.26	6.13E-01	0.18	Moderate for the null
City	2.17	3.05E-02*	1.73	Weak
Total post-event interest level score	1.65	2.00E-01	0.33	Weak
Total post-event perceived knowledge score	19.63	1.57E-05***	1094	Extreme
Total pre-event interest level score	1.10	2.95E-01	0.24	Moderate for the null
Total pre-event perceived knowledge score	4.22	4.10E-02*	1.04	Weak
Total pre-event demonstrated knowledge score correct	5.54	1.95E-02*	1.92	Weak

("F" is Significant at p < ***0.001, **0.01, *0.05)

REGRESSION MODEL

To further evaluate how each student characteristic factor may relate to demonstrated knowledge outcomes, a linear regression model was developed with predictor variables chosen based on the ANOVA test results. The final model equation is as follows:

$$\text{Score}_{c_post} = (B_{pk_post} * \text{Score}_{pk_post}) + (B_{c_pre} * \text{Score}_{c_pre}) + B_{school}$$

Where Score_{c_post} is the predicted post-event quiz score correct; B_{pk_post} is the post-event perceived knowledge (PK) coefficient; Score_{pk_post} is the student's post-event total PK score; B_{c_pre} is the pre-event quiz coefficient; Score_{c_pre} is the pre-event quiz score correct; and B_{school} is the school coefficient.

Table 8 provides a summary of the regression model. Note that coefficient estimate magnitudes vary due to differences in scale of total score multipliers (post total PK has max score of 52 while pre-event quiz has max score of 10). The results indicate that some schools have a larger average post-event demonstrated knowledge score than others, but the total PK post-event is the most important and determining factor of post-event quiz points correct, regardless of school, which supports the findings of the ANOVA analysis and correlation tests. Schools above the full student sample mean (3.76 points) are highlighted in green, while those below the mean are in pink. As expected, none of the schools with average scores below the study mean are significant contributors to the model based on their coefficient p-values, meaning that being from one of these schools did not contribute to having a higher score beyond what is already predicted by pre- and post-event PK levels. Additionally, total pre-event demonstrated knowledge (quiz) scores being a moderately significant predictor of post-event demonstrated knowledge scores suggests that if students are able to demonstrate having prior knowledge of the topics covered in the book and quiz, they are more likely succeed in demonstrating knowledge on the topics after the event as well.

Table 8. Regression model summary

Variable (# students)	Mean post score (SD)	Coef. Estimate	Std. Error	t-value	p-value
Total post-event perceived knowledge score	--	0.05	0.01	4.41	1.75E-05***
Total pre-event demonstrated knowledge score correct	--	0.19	0.07	2.54	0.012*
Camelot (44)	3.77 (1.81)	1.71	0.51	3.36	0.001***
Doland (13)	4.71 (0.756)	2.10	0.79	2.64	0.009**
Jefferson (83)	3.84 (1.60)	1.64	0.48	3.38	8.91E-04***
McCook Central (25)	4.83 (1.72)	2.16	0.65	3.33	0.001**
OMT (16)	2.31 (1.32)	0.57	0.56	1.01	0.312

Stanley County (46)	4 (2.07)	1.60	0.59	2.73	0.007**
Valley View (27)	2.9 (1.33)	0.64	0.58	1.10	0.272
Volga Christian (8)	4.38 (1.92)	1.92	0.75	2.55	0.012*
Winner (17)	3.07 (1.38)	0.81	0.62	1.29	0.197

Interest Levels & Demonstrated Knowledge

As expected based on analyses in prior sections, there is no notable or significant correlation between IL and DK by topic or total scores (pre, post, or change in levels) except for two correlation pairs. The difference in total questions correct pre to post & pre-event total interest level score pair are weakly positively correlated at * level significance ($r = 0.13$; $p = 0.0467^*$), meaning there might be some indication that having greater interest in all topics may lead to better improvements in quiz score pre to post. Post-event total questions correct & post-event Agriculture interest level score are also weakly positively correlated to * level significance ($r = 0.17$; $p = 0.0142^*$). As shown in the Likert plot figures in the Interest Levels section, the Agriculture topic interest level again stands out, as it has one of the lowest average amounts of interest, indicating that although there are few students very interested in agriculture, those few students with high interest tend to perform well on the demonstrated knowledge quiz. This suggests that being more interested in the topic of agriculture could lead to greater ability to demonstrate knowledge on the topics of the book.

Interest Levels & Perceived Knowledge

Overall, high levels of interest and high levels of PK are strongly associated both pre- and post-event. Table 9 provides Pearson correlation coefficients and p-values for the mostly strongly correlated perceived knowledge – interest level topic and score types. All have $p < ***0.001$ level significance. All “total” types are post-event unless noted otherwise.

The *interest level* score types that are most frequently strongly associated with any perceived knowledge score types are: pre-event total interest level (21.2% of *** pairs); post-event total interest level (18.2% of *** pairs); post-event Sustainability (15.2% of *** pairs); and post-event Agriculture (12.1% of *** pairs). Interestingly, Sustainability and Agriculture have the two lowest average interest level scores out of all the topics both pre- and post-event, which suggests that although there are few students who are very interested in sustainability and agriculture, these are the students with the most confidence in their knowledge about the concepts presented in the book.

The *perceived knowledge* score types that are most frequently strongly associated with any interest level score types are: post-event total perceived knowledge (18.2% of *** pairs); post-event Agronomy (12.1% of *** pairs); and pre-event total perceived knowledge, post-event Soil Cover, post-event Sustainability, and post-event Wetland (each at 9.1% of *** pairs). While all topics saw improvement in levels pre- to post-event, Agronomy and Sustainability are topics that remained relatively low, indicating that although not many students have high confidence in their knowledge of these two topics, those that do also are more likely to have higher interest in any of the given topics evaluated in the study.

Table 9. Strongest perceived knowledge – interest level correlations ($p < ***0.001$ level significance) by individual topic (33 total pairs)

Perceived Knowledge Topic & Score Type	Interest Level Topic & Score Type	Correlation	p-value
Agriculture, total	Agriculture, total	0.39	8.97E-09
Total perceived knowledge, pre-event	Total interest level, pre-event	0.35	3.13E-08
Sustainability, pre-post difference	Sustainability, pre-post difference	0.35	3.52E-07
Agronomics, total	Agriculture, total	0.34	7.61E-07
Farmer's market, total	Total interest level, pre-event	0.34	1.12E-06
Sustainability, total	Sustainability, total	0.32	2.69E-06
Total perceived knowledge, post-event	Agriculture, pre-post difference	0.32	2.88E-06
Total perceived knowledge, post-event	Total interest level, post-event	0.32	3.34E-06
Agriculture, pre-post difference	Agriculture, pre-post difference	0.31	6.45E-06
Total perceived knowledge, post-event	Sustainability, total	0.31	8.64E-06
Wetlands, total	Total interest level, pre-event	0.30	2.02E-05
Sustainability, total	Sustainability, pre-post difference	0.29	2.32E-05
Total perceived knowledge, post-event	Total interest level, pre-event	0.29	2.50E-05
Soil Cover, total	Total interest level, post-event	0.27	9.02E-05
Total perceived knowledge, post-event	Climate change, total	0.27	0.00011
Dust Bowl, total	Total interest level, pre-event	0.27	0.00014
Soil Health, total	Total interest level, post-event	0.26	0.00018
Agriculture, pre-post difference	Sustainability, pre-post difference	0.26	0.00021

Infiltration, total	Sustainability, total	0.25	0.00030
Agronomics, total	Sustainability, total	0.25	0.00037
Agronomics, total	Total interest level, post-event	0.25	0.00041
Total perceived knowledge, pre-event	Agriculture, total	0.25	0.00042
Total perceived knowledge, post-event	Soil health, total	0.25	0.00042
Soil Cover, total	Soil health, total	0.25	0.00046
Total perceived knowledge, pre-event	Sustainability, total	0.24	0.00057
Wetlands, total	Total interest level, post-event	0.24	0.00059
Organic matter, total	Total interest level, post-event	0.24	0.00069
Sustainability, total	Climate change, total	0.24	0.00070
Wetlands, total	Soil health, total	0.24	0.00081
Agronomy, total	Total interest level, pre-event	0.23	0.00084
Soil Cover, total	Protecting nature, total	0.23	0.00087
Carbon, total	Climate change, total	0.23	0.00089
Carbon, total	Total interest level, pre-event	0.23	0.00093

Note: all totals are post-event unless indicated otherwise

Figure 9 displays a correlation matrix including perceived knowledge – interest level pairs with at least $p < *0.05$ level significance. Size indicates magnitude of correlation, and color indicates magnitude and direction of correlation (blue = positive, white = zero, green = negative). Perceived knowledge and interest level topics are abbreviated as follows:

Perceived knowledge abbreviations	Interest abbreviations
ag = Agriculture	ag = Agriculture
agro = Agronomy	sust = Sustainability
cd = Conservation District	soil = Soil Health

db = Dust Bowl

ero = Erosion

fm = Farmer's Market

i = Infiltration

mo = Microorganisms

om = Organic Matter

sc = Soil Cover

sh = Soil Health

sus = Sustainability

carbon = Carbon

cons = Conservation (Protecting
Nature)

climate = Climate Change

plant = Caring for Plants

nature = Protecting Nature

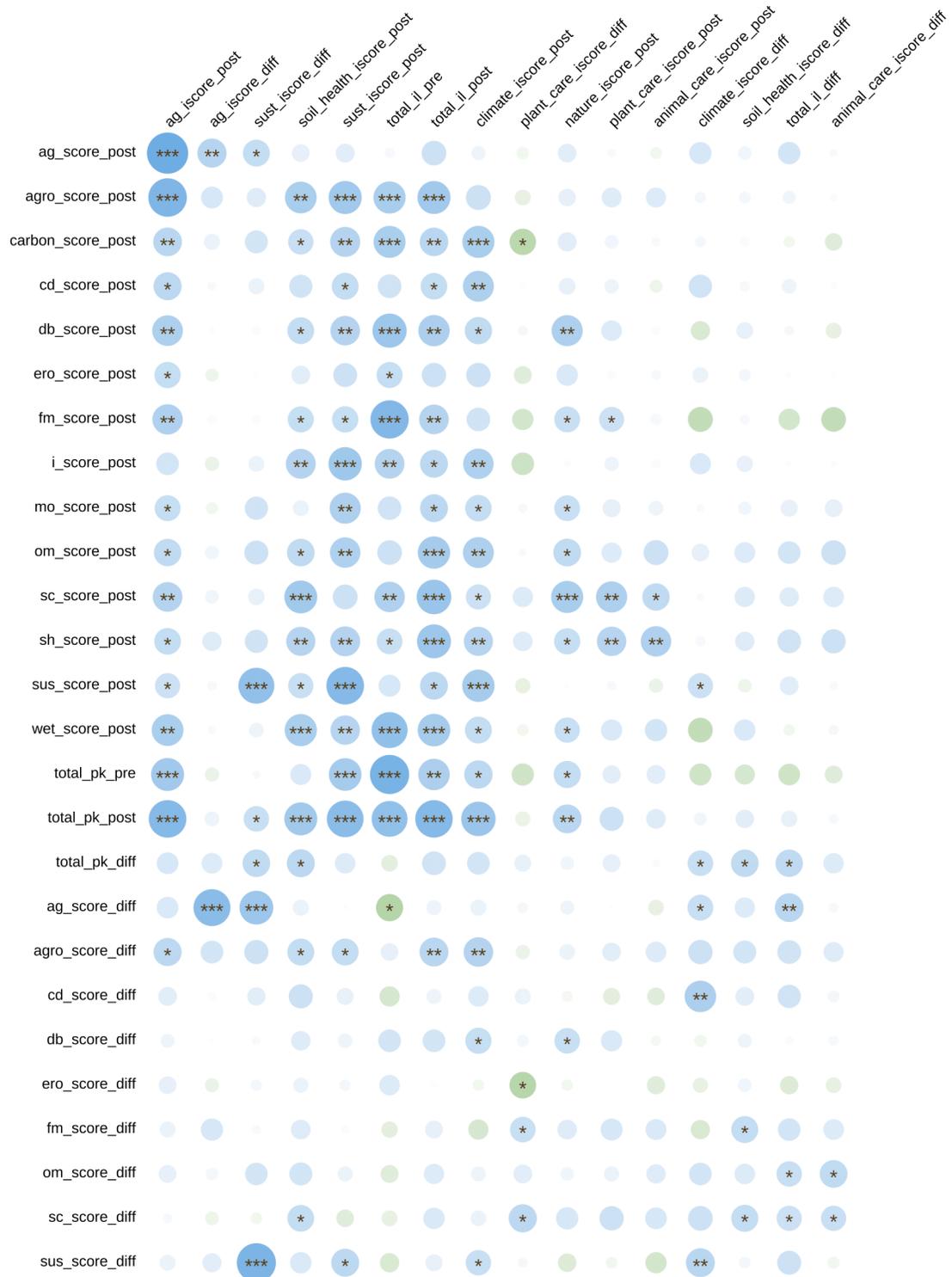
animal = Caring for Animals

“diff” indicates that the value is the difference between the post-event rating and the pre-event rating for the given topic

“total” indicates the sum of all topic ratings

All correlation pairs with at least * level significance were positive except three: Agriculture perceived knowledge pre-post difference & total interest levels pre-event; Erosion perceived knowledge pre-post difference & Caring for Plants interest level pre-post difference; and Carbon perceived knowledge total score post event & Caring for Plants interest level pre-post difference. This first is likely just a random results, and the latter two likely are due to the large absolute interest rating in Caring for Plants both pre- and post-event, leading to a negative pre-post difference.

Figure 9. Correlation matrix including all significant perceived knowledge – interest level pairs. Size indicates magnitude of correlation, color indicates magnitude and direction of correlation (blue = positive, white = zero, green = negative)



Perceived Knowledge & Demonstrated Knowledge

Table 10 provides Pearson correlation coefficients and p-values for the most strongly correlated pairs between the perceived knowledge topics and demonstrated level quiz score correct. All have $p < 0.001$ level significance. All “total” types are post-event unless noted otherwise.

Higher PK is associated with higher total DK scores for all topics, except the statement “I know more about protecting nature than I did before.”, which is negatively associated with total post-event scores correct to a weak significance. This would indicate that the small percentage of students who did not agree with this statement tended to score higher on the post-event quiz, possibly implying that they already had high confidence in their knowledge about protecting nature prior to the event, which subsequently helped on quiz performance. Additionally, higher total perceived knowledge levels are very strongly associated with higher post-event total (and change in) questions correct ($r = 0.30$; $p = 1.57E-05$). Out of the individual topics, higher perceived knowledge levels about the Dust Bowl topic is the most strongly associated with higher total post-event scores correct ($r = 0.32$; $p = 3.70E-06$), followed by Agriculture ($r = 0.29$; $p = 2.94E-05$), Soil Cover ($r = 0.25$; $p = 2.94E-04$), and Microorganisms ($r = 0.25$; $p = 4.64E-04$), as are any of the improved perceived knowledge scores (x_score_diff).

Table 10. Strongest perceived knowledge – demonstrated knowledge score correct correlations ($p < 0.001$ level significance)

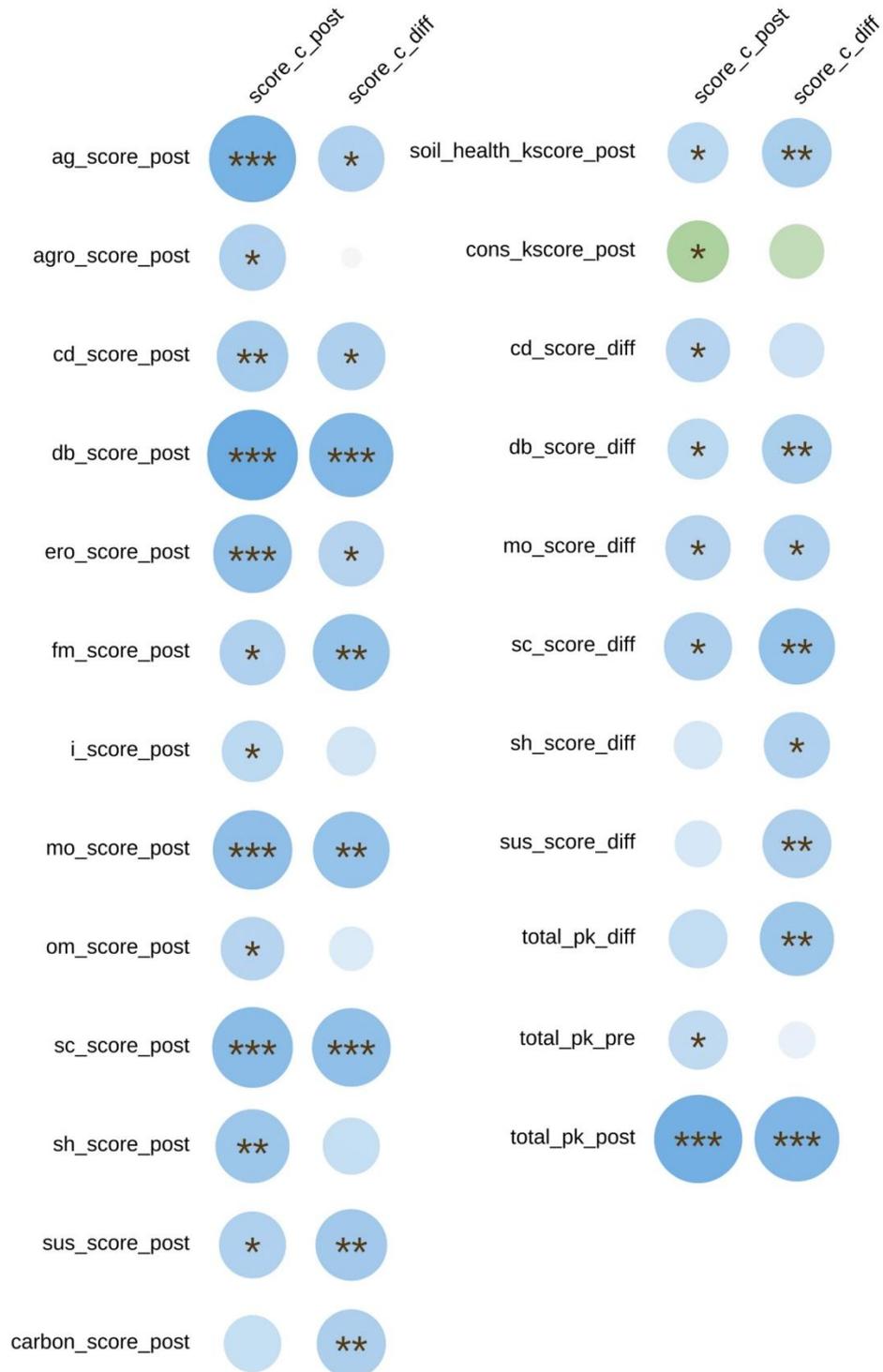
Perceived Knowledge Topic & Score Type	Demonstrated Knowledge Score Type	Correlation	p-value
Total perceived knowledge, post-event	Score correct, total	0.33	2.04E-06
Dust Bowl, total	Score correct, total	0.32	3.70E-06
Agriculture, total	Score correct, total	0.29	2.26E-05
Dust Bowl, total	Score correct, pre-post difference	0.28	7.79E-05
Total perceived knowledge, post-event	Score correct, pre-post difference	0.26	2.02E-04
Soil Cover, total	Score correct, total	0.25	2.94E-04
Microorganisms, total	Score correct, total	0.25	4.64E-04
Soil Cover, total	Score correct, pre-post difference	0.24	6.25E-04
Erosion, total	Score correct, total	0.24	6.26E-04

Note: all totals are post-event unless indicated otherwise

Figure 10 displays a correlation matrix including perceived knowledge – post-event total and change in questions correct pairs with at least $p < *0.05$ level significance. Size indicates magnitude of correlation, and color indicates magnitude and direction of correlation (blue = positive, white = zero, green = negative). PK topic abbreviations are the same as in the previous section, and DK topics abbreviations are as follows: score_c_post = total number of demonstrated knowledge quiz questions correct post-event; and score_c_diff = change number of demonstrated knowledge quiz questions correct pre- to post-event.

Generally, post-event PK scores themselves are more strongly associated with total post-event DK score correct than with improvement in score correct (score_c_diff), while post-event PK score improvement (x_score_diff) is more strongly associated with improvement in score correct than with total score correct. This implies that in absolute terms, having high perceived knowledge is associated with having a high quiz score, so some students may not have seen score improvements because they had high confidence and demonstrated knowledge both pre- and post-event. This observation also suggests that having a greater increase in PK levels may lead to a greater increase in the number of questions answered correctly, so students who improved PK in the topics also likely improved DK scores, regardless of the absolute number correct (they still could be low- moderate-scoring both pre and post).

Figure 10. Correlation matrix including all significant perceived knowledge – demonstrated knowledge score correct pairs. Size indicates magnitude of correlation, color indicates magnitude and direction of correlation (blue = positive, white = zero, green = negative)



TEACHER RESULTS

Sample Characteristics

There were a total of 13 teacher responses analyzed. The sample characteristics are the following:

Gender identity

- 100% female

Teaching experience

- 18.8 average number of years teaching (SD: 10.3)
- Median 17 years
- Ranges from 3 to 33 years

Grade level

- 46% 4th grade
- 23% 3rd grade
- Two teachers teach both 3rd and 4th grade
- One teacher teaches both 4th and 5th grade
- One teacher teaches 5th grade

Location

- 46% Eastern SD, 31% Central SD, 23% Western SD
- Four from Pierre, three from Brookings, and one from each of Doland, Fort Pierre, Rapid City, Salem, Volga, and Winner

Perceptions of Student Knowledge

Figure 11 displays the percentage of all teachers who answered with the given student knowledge level for each topic (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below.

Scoring scale:

- Not at all knowledgeable = 1
- Only slightly knowledgeable = 2
- Moderately knowledgeable = 3
- Very knowledgeable = 4

Teacher perceptions of student knowledge overall directionally align with student self-perceptions by topic but shifts towards lower knowledge levels than the actual student responses, as indicated by similar, slightly lower average scores for most topics. For example, for all topics except Farmer's Market and Agriculture, zero to one teacher responded with "Very knowledgeable", whereas at least some students for all topics indicated that they are very knowledgeable. However, two notable exceptions to the general alignment between teachers and students are the topics of Erosion and Agriculture, where large portions of students responded "Not at all knowledgeable/I've never heard of this" while only one teacher did for Agriculture, and none did for Erosion. This suggests that erosion could be a topic that teachers discuss in class, but that students struggle to comprehend, retain, and/or recall the term later.

Based on the results of the teacher and student perceptions of knowledge levels, it may be beneficial to increase education efforts on topics including sustainability, soil health, organic matter, microorganisms, infiltration, conservation district, carbon, agronomy, and erosion.

Figure 11. Post-event teacher perception of student interest levels with weighted mean scores, by topic



Perceptions of Student Interest

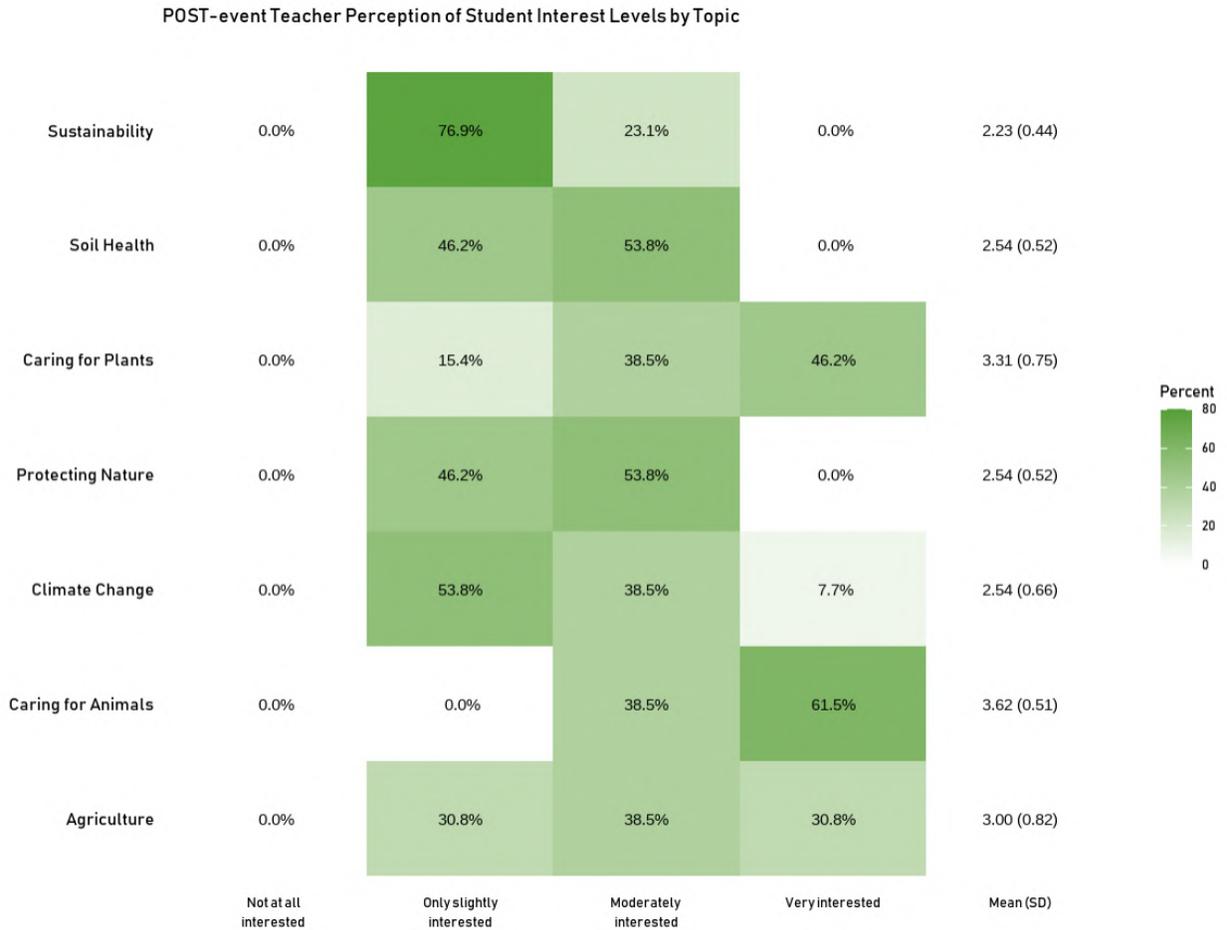
Figure 12 displays the percentage of all teachers who answered with the given student interest level for each topic (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below.

Scoring scale:

- Not at all interested = 1
- Only slightly interested = 2
- Moderately interested = 3
- Very interested = 4

Notably, by having no “Not at all interested” responses, teacher perceptions of student interest levels skew more positively than the actual student responses, but the general color distribution and averages by topic are similar (e.g. higher for topics like Caring for Plants, Caring for Animals, and lower for Sustainability). There is one large discrepancy for the Protecting Nature topic, however, where the teachers largely underestimated student interest. No teachers responded with students being “Very interested” (with an average score at 2.54), while nearly 50% of students did so post-event (with an average score at 3.07). Teachers also largely overestimated student interest in the topic of Agriculture (3.00 teacher average vs 2.44 student average).

Figure 12. Post-event teacher perception of student interest levels with weighted mean scores, by topic



Teaching Confidence

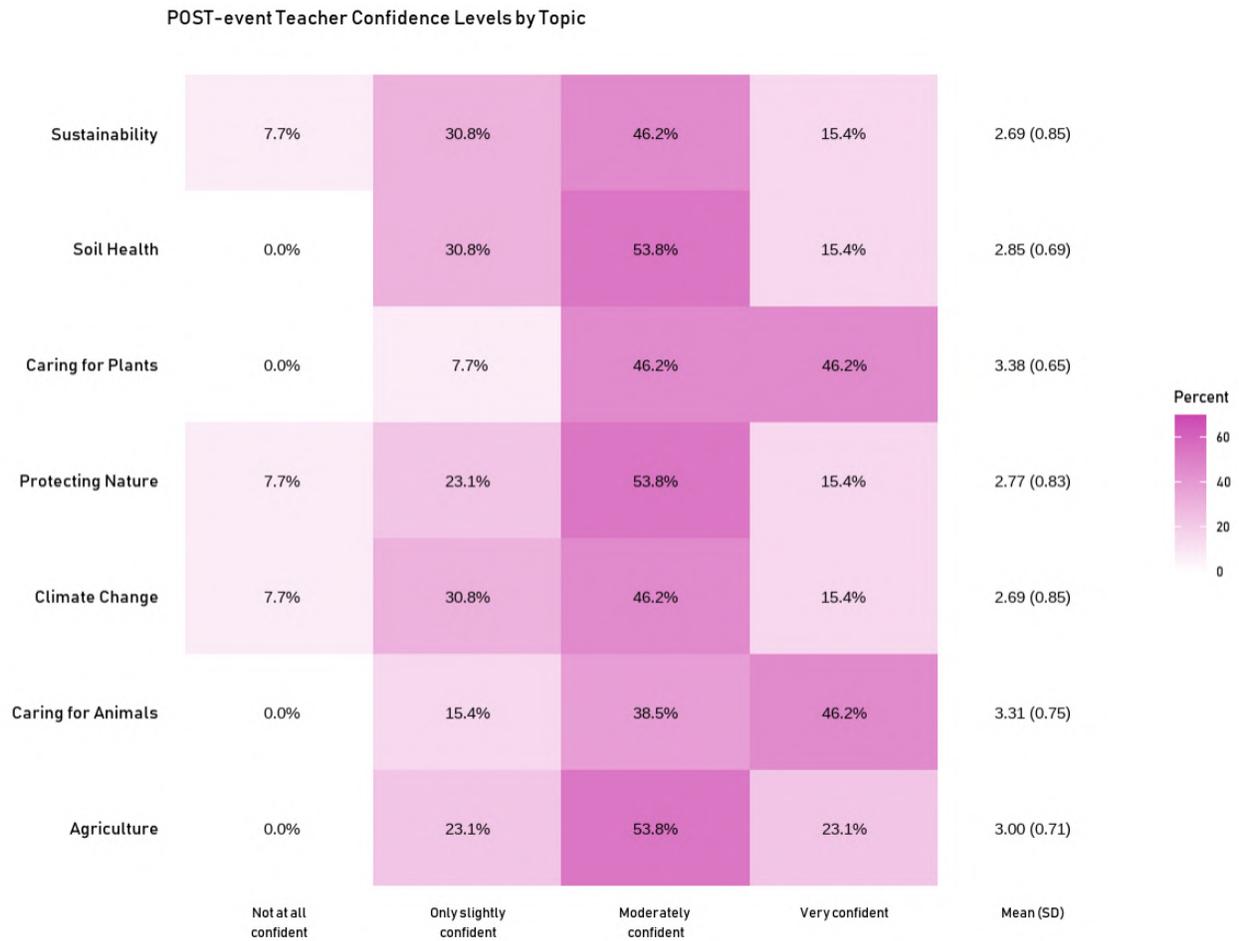
Figure 13 displays the percentage of all teachers who answered with the given confidence level for each topic (darker color indicating a greater percentage), as well as weighted mean scores based on the scale below.

Scoring scale:

- Not at all confident = 1
- Only slightly confident = 2
- Moderately confident = 3
- Very Confident = 4

Interestingly, the two topics with the highest levels of confidence (Caring for Plants and Caring for Animals) are also the topics with the highest levels of interest among students. This could be explained by a general affinity towards, societal appreciation of, or more life experiences related to caring for plants and animals (e.g. having pets, house plants, gardens, etc.) by children and adults alike, thus leading to elevated confidence and interest compared to other topics. Sustainability, Protecting Nature (conservation), and Climate Change are subject areas that could be focused on for improving teaching confidence.

Figure 13. Post-event teacher confidence levels with weighted mean scores, by topic



Correlations with Student Outcomes by Topic

Table 11 provides Pearson correlation coefficient and p-values results for all teacher-student outcome pairs with significance at $p < ***0.001$ (strong correlations). It is notable that the only two student-response topics that are strongly correlated with any teacher responses are the Dust Bowl and Agriculture topics, and all score types are for Agriculture are PK scores whereas for Dust Bowl they are DK scores. The vast majority of score types of the teacher responses are their perceptions of student knowledge or teaching confidence, apart from the Agriculture topic, which emerges in two pairs as a perception of student interest levels score. There does not appear to be a bias in any particular subject area for the teacher score types.

These results suggest that generally, in classes where teachers had more confidence in teaching on the noted subject areas and where they perceived higher knowledge levels among their students, the students tended to perform better on the Dust Bowl question in the post-event quiz, and the students tended to have high perceived knowledge about Agriculture and/or saw larger improvements in perceived knowledge about the topic pre- to post-event. One notable pair is post-event class average & how food grows demonstrated knowledge pair, which implies that scoring correctly on the “___ are grown in the ground” question largely contributed to having an overall higher average score correct for a given teacher’s class. Among the pairs in Table 11, only two have negative correlations, neither of which with clear explanations nor implications.

Based on these results, ANOVA, and regression model testing, however, total teacher confidence levels, perception of student knowledge levels, and perception of student interest levels are not strongly predictive of or associated with student total post-event demonstrated knowledge scores. This suggests that student knowledge outcomes are not dependent on teacher perceptions, and instead are largely influenced by self-perceptions, the reading event itself, and other environmental factors not considered in this study.

Table 11. Strongest teacher – student post-event interest level, perceived knowledge, and demonstrated knowledge correlations ($p < ***0.001$ level significance) by individual topic (22 total pairs)

TEACHER Topic & Score Type	STUDENT Topic & Score Type	Correlation	p-value
Total knowledge of students	Dust Bowl, demonstrated knowledge	0.32	1.34E-04
Total teaching confidence	Dust Bowl, demonstrated knowledge	0.31	1.76E-04
Conservation district, knowledge of students	Dust Bowl, perceived knowledge	-0.31	1.61E-05
Climate Change, teaching confidence	Dust Bowl, demonstrated knowledge	0.31	2.32E-04

Protecting Nature, teaching confidence	Dust Bowl, demonstrated knowledge	0.31	2.32E-04
Agriculture, interest of students	Dust Bowl, demonstrated knowledge pre-post difference	-0.30	2.23E-05
Organic Matter, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.30	3.67E-05
Soil Health, teaching confidence	Dust Bowl, demonstrated knowledge	0.29	4.29E-04
Sustainability, teaching confidence	Dust Bowl, demonstrated knowledge	0.29	4.65E-04
Erosion, knowledge of students	Dust Bowl, demonstrated knowledge	0.29	5.85E-04
Soil Cover, knowledge of students	Dust Bowl, demonstrated knowledge	0.29	6.59E-04
Erosion, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.28	7.78E-05
Microorganisms, knowledge of students	Dust Bowl, demonstrated knowledge	0.28	7.37E-04
Agriculture, teaching confidence	Dust Bowl, demonstrated knowledge	0.28	9.44E-04
Conservation District, knowledge of students	Dust Bowl, demonstrated knowledge pre-post difference	-0.27	1.47E-04
Class average post-event total correct	How food grows, demonstrated knowledge	0.27	1.79E-04
Total knowledge of students	Agriculture, perceived knowledge pre-post difference	0.26	2.57E-04
Soil Cover, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.25	4.71E-04
Conservation district, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.25	4.81E-04
Wetland, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.25	6.01E-04
Sustainability, knowledge of students	Agriculture, perceived knowledge pre-post difference	0.25	6.43E-04

Agriculture, knowledge of students	Agriculture, perceived knowledge	0.24	8.34E-04
Agriculture, interest of students	Agriculture, perceived knowledge	0.24	9.34E-04

Needs & Feedback

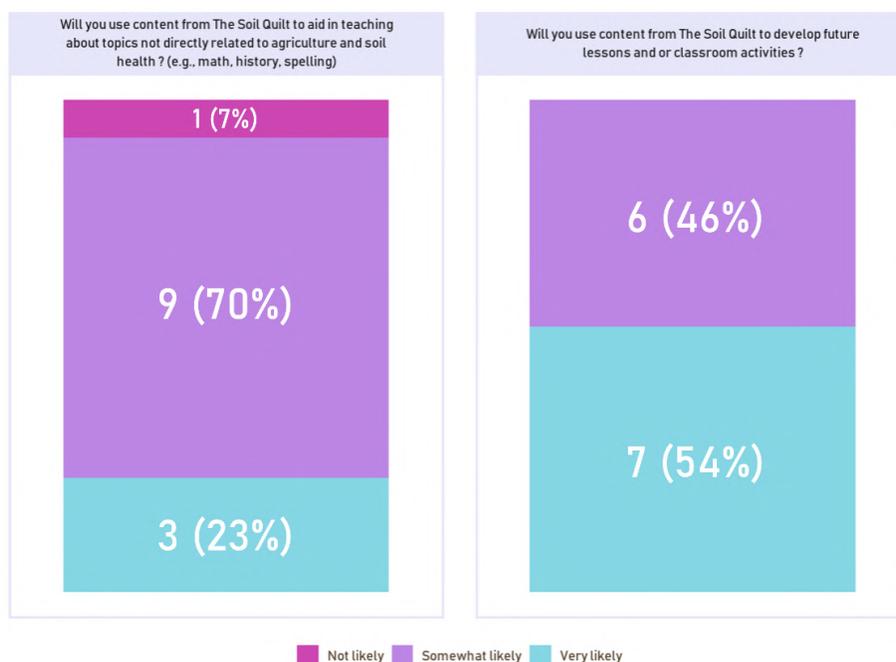
TEACHING RESOURCES & PLANS

To the question, “What resources would you need to improve your confidence in teaching about the topics from the previous question? (Select all that apply.)”:

- 12 out of 13 would like pre-made lesson plans and interactive activities
- 12 out of 13 would like interactive digital resources (ex. computer/tablet games, apps, online modules, videos, etc.)
- 10 out of 13 would like teacher training events / workshops
- 9 out of 13 would like more educational stories like The Soil Quilt
- One additional comment was made: “I'd be willing to help with educational stories. Must fit with grade level standards. The Sanford Underground Lab has designed amazing, phenomenon-based units that are great models. The flooding and drought one goes well with soil health ideals.”

Overall, teachers are likely to use content from The Soil Quilt for future class activities. Figure 14 displays the count and percentages of teachers who are not likely, somewhat likely, and very likely to use The Soil Quilt again in their classrooms. 12 out of 13 teachers responded that they are either somewhat or very likely to use content from The Soil Quilt book to help in teaching on topics not directly related to agriculture, like math, history, and spelling. All teachers responded that they are likely to use content from the storybook to develop future class activities, with over half saying they are very likely to do so.

Figure 14. Teacher likelihood of utilizing content from *The Soil Quilt* in future class lessons or activities



EDUCATIONAL WORKSHOP INTEREST

Figure 15 displays teacher preferences for future workshops on utilizing The Soil Quilt in their classrooms and teaching about related topics. Overall, teachers are likely to attend educational weekday workshops within one hour commuting distance, especially if they are provided with stipends, meals, and/or other teaching materials and gifts to attendees. Full day, weekday times are most-preferred, with over half of teachers responding very likely to attend. While workshops outside of one-hour commuting distance were least preferred, this could be improved by offering travel stipends. Other suggestions included holding workshops in conjunction with other conferences (similar to what SD EPSCoR/Black Hills State does with the SD Science and Math teachers conference) and offering continuing education and graduate credits with the workshops.

Figure 15. Teacher likelihood of attendance for various workshop offerings and schedules



CONCLUSION

In this study, we evaluated student perceived knowledge, interest, and demonstrated knowledge levels related to soil health and agricultural topics found in The Soil Quilt storybook, as well as assessed teacher perceptions and needs. Primarily, we found that after holding reading events centered around the book, student confidence in their knowledge about the agricultural, soil health, and sustainability-related topics substantially improved, and their ability to demonstrate knowledge through a quiz on content in the book improved moderately. However, the reading events did not noticeably impact interest levels in the topics assessed, and total interest levels were not correlated with quiz outcomes. The most predictive factor of post-event demonstrated knowledge quiz scores was total post-event student confidence in the topics, although students who demonstrated having prior knowledge of the topics covered in the book were more likely to succeed in demonstrating higher knowledge about the topics after reading the book as well, suggesting the storybook can be helpful for reinforcing concepts.

Based on the results of the study, we recommend increasing education efforts on sustainability, soil health, organic matter, microorganisms, infiltration, conservation districts, carbon, agronomy, and erosion. For improving teaching confidence, sustainability, protecting nature (conservation), and climate change are subject areas that could be focused on. We also must highlight the importance of ensuring students feel confident in their understanding of these topics and increase efforts to expose them to the concepts early on in their education to foster a sense of familiarity that can be reinforced through classroom lessons and activities.

This study provides important insight and advances our goal to help increase youth understanding of the role healthy soil plays in providing our food, shaping our landscape, and sustaining our communities, especially through narrative, story-based tools like The Soil Quilt. Future work will include coordinating educational workshops for teachers centered around utilizing the storybook for additional classroom activities, lesson plans, and learning activities, not only for reading and science-related outcomes, but also for subjects such as math, history, and social studies. Additionally, we will work to create pre-made lesson plans, interactive activities, and digital resources on subject matter from the book for instructors to utilize in their classrooms. We also would like to investigate ways we can increase interest in soil health, agricultural, and sustainability-related topics among students.

The Soil Quilt Project study was funded in part by the SDSHC and NCR-SARE Youth Educator Grant project number YENC24-225.

APPENDIX A. LINKS

Student PRE-survey: https://www.surveymonkey.com/r/soilquilt_student_PRE

Student POST-survey: https://www.surveymonkey.com/r/soilquilt_student_POST

Teacher survey: https://www.surveymonkey.com/r/soilquilt_teacher

The Soil Quilt Project ArcGIS Web Experience:

<https://experience.arcgis.com/experience/0fef0486a9f1408fabe0432b767d1cf8/>