Science in the Learning Gardens (SciLG): Factors that Support Racial and Ethnic Minority Students' Success in Low-Income Middle Schools, 2014-2017

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Project Goals

1. To design and implement Science in the Learning Gardens (SciLG) curriculum that aligns with Next Generation Science Standards (NGSS), using school gardens as learning contexts in grades 6, 7, and 8.
2. To investigate the extent to which SciLG project activities predict students' STEM identity, motivation, learning, and grades in science using a model of motivational development.

Setting
SciLG is implemented in grade 6 (2014-15), grade 7 (2015-16), and grade 8 (2016-17) in two urban schools. It is supported by science teachers and a multidisciplinary team of university educators and community members.

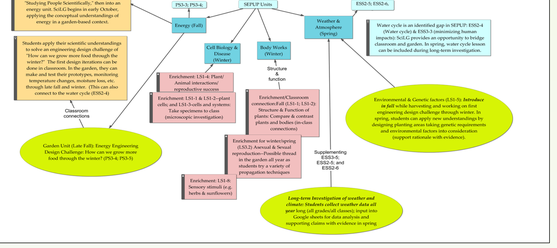
CURRICULUM DESIGN
NGSS-aligned, culturally-responsive

INSTRUCTION
Garden as milieu for learning
Hands-on, experiential, small groups

RESEARCH
Motivation and engagement
Science learning outcomes

Grade 6 2014-2015 → Grade 7 2015-2016 → Grade 8 2016-2017

SAMPLE 6th Grade SciLG Map



Theory of Change
By offering curricular and instructional experiences informed by motivational processes (relatedness, competence, autonomy, purpose) as described by self-determination theory, SciLG intends to support students' **STEM identity, science engagement**, **science learning and achievement**.

Research Questions *(RQs)*

RQ1: Concurrent effects of garden experiences on science outcomes
Do students' experiences (of relatedness, competence, autonomy and purpose, engagement and re-engagement) in SciLG gardening activities predict four science outcomes (STEM identity, science-class engagement, science learning, and science class grades)?

RQ2: Longitudinal effects of garden experiences on science outcomes
Do effects of experiences in SciLG gardening activities in the Spring predict the four science outcomes the next Fall?

Methods

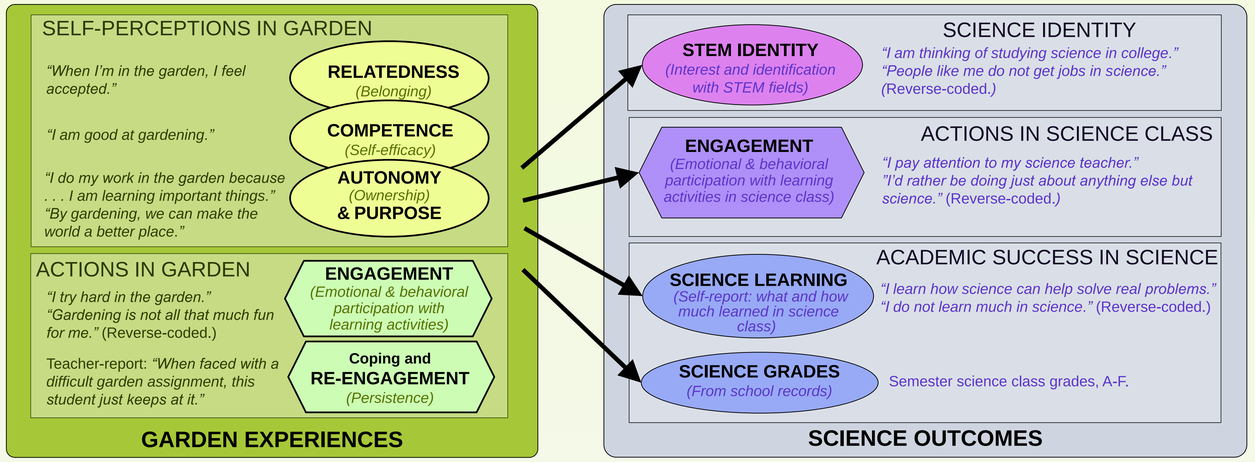
Participants
- Cohort of 113 students during Spring of 6th grade year and Fall of 7th grade year.
- 59% female.
- 25% Asian, 2% Black, 26% Latino/Hispanic, 27% White, 18% Multiple ethnicities, 1% other ethnicities.
- 82% free or reduced lunch; 51% students' home language non-English.

Design
- Surveys administered in Spring of one school year and Fall of the next year in science classes by trained researchers/volunteers.
- Students and their science teachers rated agreement with Likert-type survey items (ranging from 1-5) assessing motivational processes in SciLG gardening activities and science class *(see "Research Model and Measures").*
- Science class grades collected from school records.

Research Model and Measures

This study and its measures were based on a model of motivational development drawn from self-determination theory (see "*References*"), illustrated in the figure below.

- Science grades were obtained from school records and recoded to a standard 0-4 scale where A = 4 and F = 0.
- All other constructs and sub-constructs were based on student- and/or teacher-report survey items. These used a Likert-type scale ranging from 1-5 (where 5 was "very true for me" and 1 was "not at all true for me"). Negative items were reverse-coded.
- Examples of items can be found in the model figure, below. Indication of data sources, number of items, Cronbach's alpha, descriptive statistics, and inter-construct correlations can be found in the "*Preliminary Analysis*" tables below.



Results

Preliminary Analysis 1: Descriptive Statistics and Scale Information

Construct, *Sub-construct*	# of items	Spring Mean	Spring S.D.	Spring α	Fall Mean	Fall S.D.	Fall α
***Predictor:* Garden Experiences (Total)**	34	3.898	.780	.942	--	--	--
Self-perceptions: Relatedness, Competence, Autonomy & Purpose (Student-report)	*20*	*3.780*	*.898*	--	--	--	--
Garden Engagement (Student-report)	*12*	*3.959*	*.804*	--	--	--	--
Garden Re-engagement (Teacher-report)	*2*	*3.985*	*1.154*	--	--	--	--
Four Science Outcomes:							
STEM Identity *(Student-report)*	9	3.218	1.034	.916	3.396	.892	.897
Science Engagement *(Student-report)*	12	3.835	.924	.920	3.815	.819	.907
Science Learning *(Student-report)*	7	3.815	1.030	.919	3.799	.998	.895
Science Grades *(School records)*	n/a	3.088	.939	*n/a*	3.367	.987	*n/a*

Note. *n* = 113. Abbreviations: "S.D." standard deviation; "α" Crohnbach's alpha. Science grades ranged from 0 ("F", lowest) to 4.0 ("A", highest). All other constructs could range from 1 ("not at all true") to 5 ("very true"). Negative items reverse-coded.

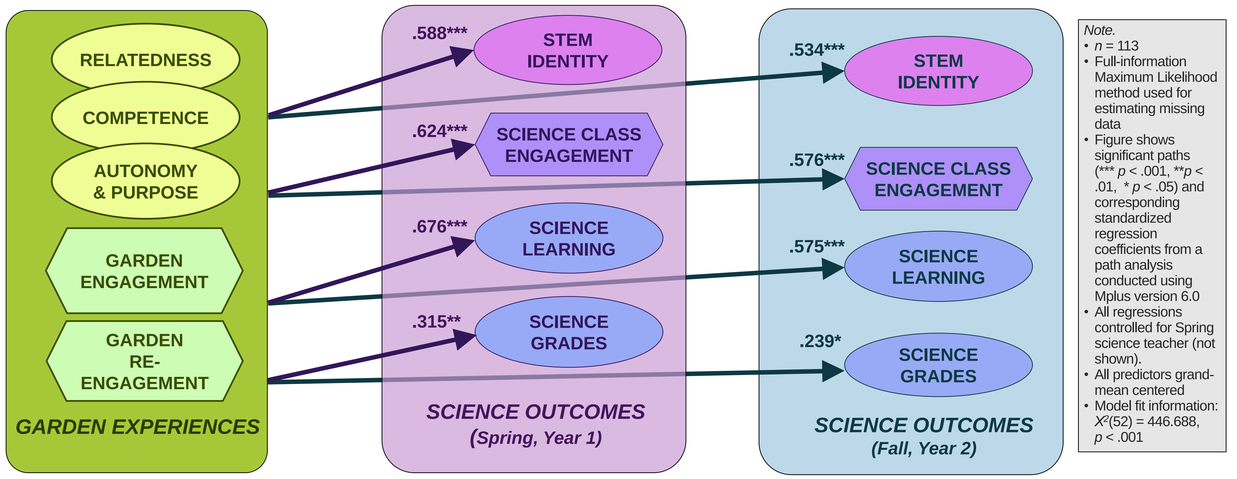
Preliminary Analysis 2: Inter-construct Correlations

Construct	Time point	Garden Experiences	STEM Identity (Spring)	Science Eng. (Spring)	Science Learning (Spring)	Science Grade (Spring)
Garden Experiences	Spring	--				
STEM Identity	Spring	.589	*.371*			
	Fall	.505				
Science Engagement	Spring	.672	.571	*.479*		
	Fall	.510	.384			
Science Learning	Spring	.701	.643	.837	*.521*	
	Fall	.542	.327	.463		
Science Grades	Spring	.267**	.300**	.228*	.221*	*.538*
	Fall	.187*	.163(*n.s.*)	.208*	.207*	

Note. *n* = 113. *p* < .001 unless indicated: ** *p* < .01, * *p* < .05, (*n.s.*) not significant. Cross-time stabilities shown in italics on diagonal.

Analysis

RQ1: Students' Spring garden experiences significantly predicted all four science outcomes, concurrently.



Note.
- *n* = 113
- Full-information Maximum Likelihood method used for estimating missing data
- Figure shows significant paths (*** *p* < .001, ** *p* < .01, * *p* < .05) and corresponding standardized regression coefficients from a path analysis conducted using Mplus version 6.0
- All regressions controlled for Spring science teacher (not shown).
- All predictors grand-mean centered
- Model fit information: $X^2(52) = 446.688$, *p* < .001

RQ2: Students' Spring garden experiences also significantly predicted all four science outcomes the next Fall.

Summary of Findings

This study explored the extent to which SciLG activities seemed to support diverse students' science outcomes, both concurrently and over time.

Findings for RQ1: When examining the study's first cohort of students in the Spring of their 6th grade year, a combined measure of **students' motivational processes in SciLG gardening activities** was a significant and positive predictor of four hypothesized science outcomes. That is, SciLG activities in the garden appeared to transfer back into the science classroom (via **grades, learning, and motivation)** and help students' **identification with** the **STEM** field at large.

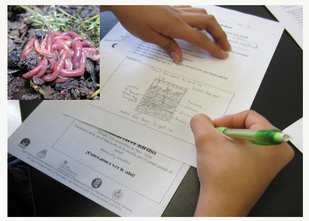
Findings for RQ2: The 6th graders' Spring SciLG gardening experiences also significantly predicted their four science outcomes in the Fall as 7th graders. That is, despite adjourning for summer vacation and entering new science classrooms, it seemed that students' Spring gardening experiences served as positive resources for their science motivation and achievement as they began the next school year.

Discussion

Strengths
- SciLG uses quantitative research to document the outcomes of its hands-on, experiential, NGSS-aligned gardening curriculum; a sample of highly-diverse, largely low-income middle school students are followed over a three-year period, from 6th to 8th grade.

Limitations and Future Studies
- Small sample size limits generalizability of findings to other schools and samples, hence results should be interpreted accordingly.
- Ongoing studies will follow the cohort into their 7th and 8th grades, with a focus on detecting the *processes* by which SciLG gardening activities might support science outcomes.

Implications
- This study offered preliminary support for SciLG garden activities promoting STEM equity. Participating in SciLG activities seemed to help diverse students not only garner interest in STEM fields, but also think of themselves as individuals who could be successful and valued as STEM contributors.
- The findings lent support for the current motivational model, based on self-determination theory, as a means for capturing the "active ingredients" of SciLG activities.



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Any opinions, findings, and conclusions or recommendations are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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