Assessing Educator Perceptions of Garden-Based Learning in K–12 Science Education

Christopher Riggs, Danielle N. Lee

Abstract

Garden-based learning (GBL) curricula represents a pedagogy that increases student exposure to nature and connects them to engaging activities for higher classroom achievement. GBL is proposed to enhance student science self-perceptions, engagement, and desired outcomes in science learning and identity by connecting students to relatable, hands-on, and authentic learning experiences through a felt sense of place. Saint Louis Metro Area K–12 science educators were asked to describe their students’ self-perceptions, engagement, and outcomes in science and possible teaching experiences with GBL. Experienced Saint Louis Metro Area garden educators offer authentic, hands-on activities that increase feelings of belonging, competence, and autonomy in science. GBL strongly encourages positive behavioral and emotional student interactions with science lessons by providing an outdoor space that hosts exciting and relatable topics that expand students’ perceptions of their local environment, community, and themselves.

Keywords: garden-based learning; place-based learning; self-determination theory; science engagement; K–12 schools.

Introduction

Garden-based learning (GBL) is a teaching strategy that utilizes available school grounds and buildings to create school gardens to increase biological diversity and complexity for student education (Brink & Yoast, 2004; Ruiz-Gallardo et al., 2013, Jagannathan et al., 2018). School gardens can come in a variety of shapes (from traditional row crops to nontraditional raised-bed polycultures), styles (hydroponics to organic), and sizes (from herbs pots on a windowsill to half acre plots), yet all have a common theme around growing plants for learning purposes (Patchen et al., 2016; Pounders, 2010). School gardens may help teachers foster students’ sense of responsibility and their environmental education and encourage positive environmental attitudes (Skelly & Bradley, 2007). A meta-analysis of 48 studies (1990–2010) in the United States summates the direct positive benefits that GBL offer students in science, math, and language arts achievement along with indirect effects of regulating student emotions and behaviors (Williams & Dixon, 2013). It is further suggested that GBL programs may help attenuate educational reforms that devalue creativity, play, group problem solving, and outdoor educational experiences in favor of intensified classroom time to increase standardized test scores (Moore et al., 2015).

Self-Determination Theory

To help explain the effective factors in GBL, Skinner and colleagues (2012) created a model of motivation in the garden supported by self-determination theory, a psychological theory that considers personal and social factors that support intrinsic motivation (Ryan & Deci, 2017). In this model, educators facilitate engagement through their quality of communication with students. By supporting caring relationships, providing structured classrooms, and giving instruction that supports autonomy (such as giving choices and making learning relevant), educators create an environment that nourishes students’ fundamental psychological needs. The need to feel belonging (relatedness), efficacious in the world (competence), and congruent with authentic interest (autonomy) are three psychological self-perceptions that, when taken together, predict student’s engagement in academic work (Ryan & Deci, 2017; Skinner et al., 2012).

Purpose of the Study

The primary purpose of this study is to expound on GBL as an intrinsically motivating and engaging pedagogy that increases science achievement by comparing GBL and non-GBL science educators’ perceptions of their students in science. Our survey measures are extrapolated and adjusted from Williams and colleagues’ (2018) validated survey of motivation and engagement in garden activities to address K–12 science educators (see Appendix 1 in the Supplemental Material available with the online version of this.
article. By comparing the responses of GBL and non-GBL science educators to the same question set, we generate more evidence of the positive benefits of this program. Further, we describe how GBL and non-GBL participating schools in the Saint Louis metro area are distributed according to socioeconomic status and how our survey results may impact students from underresourced schools. This study may assist educators in their decisions to integrate this learning modality into their curriculums.

Hypothesis

GBL provides an intrinsically motivating, engaging, and academically nourishing science curriculum. This study tests this hypothesis by assessing teachers’ perceptions of their science students through a regional survey that measures three constructs: students’ science self-perceptions of relatedness, competence, and autonomy; students’ behavioral and emotionally engaging and reengaging interactions in science activities; and teachers’ desired student outcomes in science composed of science learning and identity. We then compare science educators’ perceptions of students who have GBL opportunities and those who do not. We predict that educators with students in GBL will report increased measures in study constructs in comparison to those without access to this learning modality.

Methods

The study population consisted of local K–12 educators, from both public and private schools, who taught science between 2015 and 2020 across the statistical Saint Louis metro area defined by the U.S. Census (2014). The Saint Louis metro area is a bistate region that includes counties in Missouri (Franklin, Jefferson, Lincoln, Saint Charles, Saint Louis, Saint Louis City, and Warren), and counties in Illinois (Bond, Calhoun, Clinton, Jersey, Macoupin, Madison, Monroe, Saint Clair) all within a 100 km radius of Saint Louis City, MO (see Appendix 2 in the Supplemental Material available with the online version of this article). A survey was created and published online and educators were asked to evaluate their students’ science self-perceptions, science engagement, and science outcomes. The survey was constructed to take approximately 10 minutes to finish to maximize study participant engagement and completion. Recruitment was conducted via social media, electronic newsletters, and emails to nonprofit STEM educational organizations and STEM educational representatives at local two- and four-year universities.

Science Self-Perceptions, Engagement & Outcomes

Assessment

The survey contains Likert scale questions with rating from 1 to 5 (where 1 is “not at all”, 3 is “undecided/unsure,” and 5 is “very much”). Likert item questions are factored into three Likert scales of students’ science self-perceptions, science engagement, and science outcomes.

The science self-perceptions scale has three components in intrinsic motivation: relatedness—comprised of three Likert items that ask educators about students’ feelings about belonging in science; competence—composed of three Likert items that ask educators about students’ efficacy in science; and autonomy—three Likert items that ask educators about students’ being connected to school science on a personal and authentic level.

The science engagement scale is about engagement and reengagement in science activities. Engagement in science activities is measured with six items of reported observations of positive student emotional and behavioral interactions in science with negative items being reverse coded. Reengagement in science activities is measured with two items asking if students either persisted or gave up when confronted with challenges, with negative items being reverse coded.

The science outcomes scale is about student science learning and science identity. Three science learning items measured educators’ perceptions about what students learned in science, while three science identity items measured educators’ perceptions of student aspirations of becoming a scientist.

Cronbach’s alpha (α) is used to show a measure of internal consistency or interrelatedness of responses given to multiple Likert items in a single scale (Warmbrod, 2014). The higher the value for α (on a 0 to 1 scale where 0 is absolutely no relationship among items and 1 being a total relationship), the higher the confidence that items are defining the same trait. Determining α during the study allows for appropriate adjustments to Likert items (e.g., changing the wording and or adding an item) to increase reliability of survey measures.

Finally, Likert scale scores were created by summating the score of individual Likert items in a Likert scale and dividing them by the total number of Likert items, also known as the mean-item summated score. All Likert items in a Likert scale are considered to have equal weight in the Likert scale continuum. Likert scale data, presented as mean ± SD, was then compared between science educators who teach with GBL and those who do not and factored between elementary, middle, and high school grade levels to further determine potential trends among different age groups. A two-way ANOVA was used to determine the differences between the means followed by a Tukey HSD (honestly significant difference) when appropriate.

Socioeconomic Status

Public schools are analyzed according to the percentage of the student population participating in the National School Lunch Program (NSLP), which is a proxy for its students’ socioeconomic status. The National Center for Education Statistics (Aud et al., 2010) set school poverty levels as a percentage of the student body eligible to participate in the NSLP program: low is 0%–25%; low-mid is 25.1%–50%; mid-high is 50.1%–75%; high is 75.1%–100%. Schools represented by study participants are factored across the elementary, middle, and high school levels and by the NSLP participation level they occupy. We then compare these schools by the presence of a GBL program and the absence of a GBL program.

Results

We surveyed 113 local science educators, with 87% (n = 92) fully completing the survey. All study participants are science educators from the Saint Louis statistical metro area, representing Missouri (n = 41) and Illinois (n = 51), who teach at elementary school (n = 23), middle school (n = 30), and high school (n = 39) levels. Among the study participants, 53 worked at public K–12 schools and 39 at private K–12 schools.

Saint Louis metro area GBL and non-GBL science teachers’ evaluations of students’ science self-perceptions (GBL teachers, n = 30, Cronbach’s α = 0.81, non-GBL teachers, n = 62, Cronbach’s α = 0.8) indicate that GBL teachers rate their students higher for
science self-perceptions ($F_{1,91} = 4.13, \* P < 0.05$). There was no significant difference across grade levels or interactions between GBL and grade levels ($F_{2,91} = 1.13, P = 0.33, F_{2,91} = 0.25, P = 0.33$, respectively) (Figure 1).

Saint Louis metro area GBL and non-GBL science teachers' evaluations of students' science engagement (GBL teachers, $n = 15$, Cronbach's $\alpha = 0.84$, non-GBL teachers, $n = 62$, Cronbach's $\alpha = 0.84$) suggest a difference in student science engagement across grade levels, ($F_{2,76} = 5.37, \** P < 0.01$), with a post-hoc Tukey HSD of grade levels: elementary–middle, $P < 0.019$, elementary–high, $P < 0.007$, and middle–high, $P = 0.5$, revealing elementary students are more engaged in science than middle or high school students (Figure 2); however, there is no significant difference in science engagement between GBL and non-GBL students or interactions between GBL and grade level ($F_{1,76} = 1.17, P = 0.28, F_{2,76} = 1.17, P = 0.52$, respectively).

Saint Louis metro area GBL and non-GBL science teachers' evaluations of students' science outcomes, (GBL teachers, $n = 30$, Cronbach's $\alpha = 0.74$, non-GBL teachers, $n = 62$, Cronbach's $\alpha = 0.75$) report no significant differences across any comparisons: GBL versus non-GBL status ($F_{1,91} = 0.2, P = 0.65$), grade level ($F_{1,91} = 1.9, P = 0.15$), or interaction of GBL status and grade level ($F_{2,91} = 1.35, P = 0.26$).

○ Descriptive Results of Socioeconomic Status & GBL

Fifty-three public schools in the Statistical Saint Louis metro area are represented in this survey, (MO, $n = 27$, and IL, $n = 25$; GBL schools, $n = 22$, and non-GBL schools, $n = 31$). Based on the percentage of students enrolled in the NSLP program, 28 schools would be described as low poverty, and 25 as high poverty schools. A breakdown among grade levels shows high poverty elementary schools, followed by low poverty middle schools, participated in GBL programs more than other groups (Table 1).

○ Discussion

GBL is an extracurricular activity that connects the classroom to the natural world, where teaching applications of the scientific method...
Science Engagement

Generally, our study participants indicated that elementary school students demonstrate significantly more engagement in science than middle and high school students. Science educators’ perceptions of student science engagement scores across K–12 grade levels suggest that as students’ progress in education they become less engaged in their science classes (Figure 2). This aligns with a recent nationwide poll of K–12 educators reporting steady declines in classroom engagement from elementary to high school (Hodges, 2020). Middle school is a transition period that portends decreased engagement and loss of perceived value of the importance of learning in school (Wigfield et al., 2015). Higher average scores for GBL science educators’ perceptions of middle school student science engagement are a positive signal that GBL may be creating opportunities to alleviate this decline. Adopting GBL in secondary school science may help mitigate anxieties, improve relationships within schools, and improve overall well-being (Ruiz-Gallardo et al., 2013). Extracurricular programs that actively cultivate students’ perceived autonomy, such as GBL, may be a necessity for early adolescents, as perceived autonomy in this age group is found to strongly predict academic engagement (Nikou & Economides, 2018). Engagement further builds perceived self-efficacy and confidence in science, which is supported by Solberg (2018) documenting these effects in elementary girls transitioning to middle school participating in an aerospace outreach program designed with engaging hands-on learning experiences.

These results suggest that GBL increases student science engagement by providing a physical space as a contextual anchor for science lessons (Singleton, 2015). Early childhood educational leaders such as Piaget, Dewey, and Wilber emphasized connecting practical elements of learning to intellectual pursuits in the classroom by connecting to childhood curiosity and active engagement (Singleton, 2015; Burt, 2016). If GBL serves as a context for place, then students may be more engaged in science taught with GBL because they are encouraged to explore the world and connect their discoveries to lessons in class. These authentic interactions include environmental, social, and cultural dimensions that awaken their unique talents and guide their preferences in learning.

Science Outcomes

Science outcomes indicate levels of science learning and science identity. They can be used to gauge students’ belief in their affective learning and interest in science. GBL science educator perceptions of elementary school students in the Saint Louis metro area show
positive trends toward increased science outcomes (Figure 3); however, overall grade-level differences are negligible between GBL and non-GBL science educator groups. Williams and colleagues (2018) posit these outcomes in science as desired factors in student performance and achievement in science classes and personal interest in pursuing science as a successful and meaningful career. Many studies document the positive effects of GBL on student science achievement (Klemmer et al., 2005; Skinner et al., 2012; Williams & Dixon, 2013; Patchen et al., 2016); however, Jagannathan et al. (2018) also found uneven results when comparing GBL and non-GBL students’ science achievement and concluded that there might be a school effect, grade-level effect, or interaction of grade level and school on science achievement that accounts for lack of differences.

Describing Socioeconomic Status & GBL
The NSLP program provides food assistance for students whose household income is 130%–185% below the federal poverty guideline (Harwell & Lebeau, 2010). The percentage of the student population participating in a school’s NSLP program is a proxy for its students’ socioeconomic status because their eligibility is often determined by their household income, with student populations having more than 50% NSLP program participation being defined as high poverty schools (Aud et al., 2010). Numerous studies document the association between high poverty and student achievement (Klemmer et al., 2005; Patchen et al., 2016; Rozek et al., 2019).

There were more non-GBL schools than GBL schools in middle and high school at the high poverty level represented in the study (Table 1). Our results suggest GBL programs may foster a supportive pedagogy for low-income middle and high school students, as educators believe that their students have benefited emotionally and behaviorally from garden experiences, and our results contribute to similar findings in studies of adolescent students in GBL (Skinner et al., 2012; Ruiz-Gallardo et al., 2013; Williams et al., 2018). Moreover, a recent analysis in over 1000 economically diverse high school classes found that students in low socioeconomic brackets may be assisted academically through emotionally regulating activities before given high-stakes examinations (Rozek et al., 2019).

Study Limitations & Future Research
Overall, this study measures three Likert scale variables: science self-perceptions, science engagement, and science outcomes. Each scale contains subscales that can be measured separately to give better descriptions of motivational experiences in science and science achievement. For example, educators can see their students relating more to science through GBL, but simultaneously they may feel they are less competent than non-GBL peers. Williams and colleagues (2018) address this concern by independently measuring relatedness, competence, and autonomy. This study measures a single scale created by combing subscales, due to considerations of survey completion time.

There are no significant differences between GBL and non-GBL science educators’ perceptions of desired student science outcomes; however, there may be other cofactors influencing this metric. In their analysis of GBL on regional science achievement, Ray and colleagues (2016) found higher science grades in GBL-participating 5th graders when controlling for the NSLP program but no impacts of GBL when controlling for race. Designing a future study controlling for demographic effects on GBL is recommended to more accurately describe science outcomes in identity and learning across the Saint Louis metro area.

This study compares explanatory variables between science educators teaching with GBL and those who do not. It does not attempt to make causative explanations between measured variables. Future studies could make comparative predictions of variables between GBL science educators and non-GBL educators and longitudinal studies of student pretest and posttest differences. For this study, we were unable to secure university institutional review board approval, or the approval of each school district, school principal, or parental consent in order to petition for this data. With limited time and resources to answer our research questions, we opted for a general approach. Moreover, a few schools in this survey have only GBL as an extracurricular activity, but their count and distribution among socioeconomic classes are too low to compare appropriately. Future studies would focus on these GBL-only schools and compare to schools that hosts additional school programs.

This study included a sufficient number of participants to give a regional view of student performance metrics in science self-perceptions, engagement, and outcomes as judged by experienced K–12 science educators. However, sample sizes were uneven across GBL and non-GBL study participants at the grade level. Notable low participation of high school GBL science educators (n = 4) versus high school level non-GBL science educators (n = 35) is similar to a synthesis report of 48 studies that found GBL programs concentrated at the elementary and middle school levels (Williams & Dixon, 2013). A specific analysis of high schools teaching with GBL would help explain this trend and better investigate its potential benefits to older students.

○ Conclusion
Experienced K–12 science educators who teach with GBL perceive their students with higher science self-perceptions and science engagement than their non-GBL peers. Low-income students’ academic performance may especially benefit from the emotionally regulating activities gardening provides. Future studies would modify the questionnaire for a better estimate of desired outcomes in science achievement to find potential differences between GBL and non-GBL educators across the region. As the Saint Louis metro area is economically diverse, with numerous cultural identities and differing resource needs and objectives, it may be helpful to evaluate students among differing demographics directly with the same metrics used in this study to better understand GBL as a teaching platform in K–12 science education.

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DANIELLE N. LEE (danilee@siue.edu) is an assistant professor in the Department of Biological Sciences at Southern Illinois University—Edwardsville. Edwardsville, IL 62026. CHRISTOPHER RIGGS (criggs@stlcc.edu) was a graduate student in the Department of Biological Sciences at Southern Illinois University—Edwardsville and is now an adjunct professor with Saint Louis Community College. Saint Louis, MO 63110.